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Forest Research Branch

GROWTH TRENDS IN SPRUCE AND FIR STANDS IN CENTRAL NEWFOUNDLAND

by

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Résumé en français

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ABSTRACT

Data from two measurements, ten years apart, of 376 one-fifth acre permanent sample plots provided the basis for preparing preliminary variable-density growth tables. Softwood-volume growth rates are given for relatively young pulpwood stands of black spruce and balsam fir. Tables may be used for growth prediction when the following stand information is known: average age at breast height, height index, spruce fir ratio, and merchantable softwood volume at beginning of forecast period. Statistical checks plus independent field tests indicate satisfactory prediction accuracy. Following a second remeasurement the tables will be revised.

RÉSUMÉ

Des données recueillies à la suite de deux mesurages dendrométriques, pris à dix ans d'intervalle dans 376 places-échantillons permanentes d'une superficie d'un cinquième d'acre chacune, ont servi à la préparation de tables provisoires d'accroissement pour des peuplements de densités variables. Les taux d'accroissement en volume chez les résineux ont trait à des peuplements relativement jeunes d'épinette noire et de sapin baumier propres à fournir du bois à pâte. Les tables peuvent servir à calculer d'avance l'accroissement en volume de peuplements donnés, à condition de connaître les données suivantes: l'âge moyen à hauteur de poitrine, l'indice de hauteur, la proportion d'épinette et de sapin, et le volume des conifères de valeur marchande au commencement de la période de prévision. Des vérifications statistiques, d'une part, et d'autre part, des essais effectués en forêt, prouvent que les prévisions à l'aide de ces tables sont assez exactes. Les tables feront l'objet d'une révision, après une deuxième série de mesurages.

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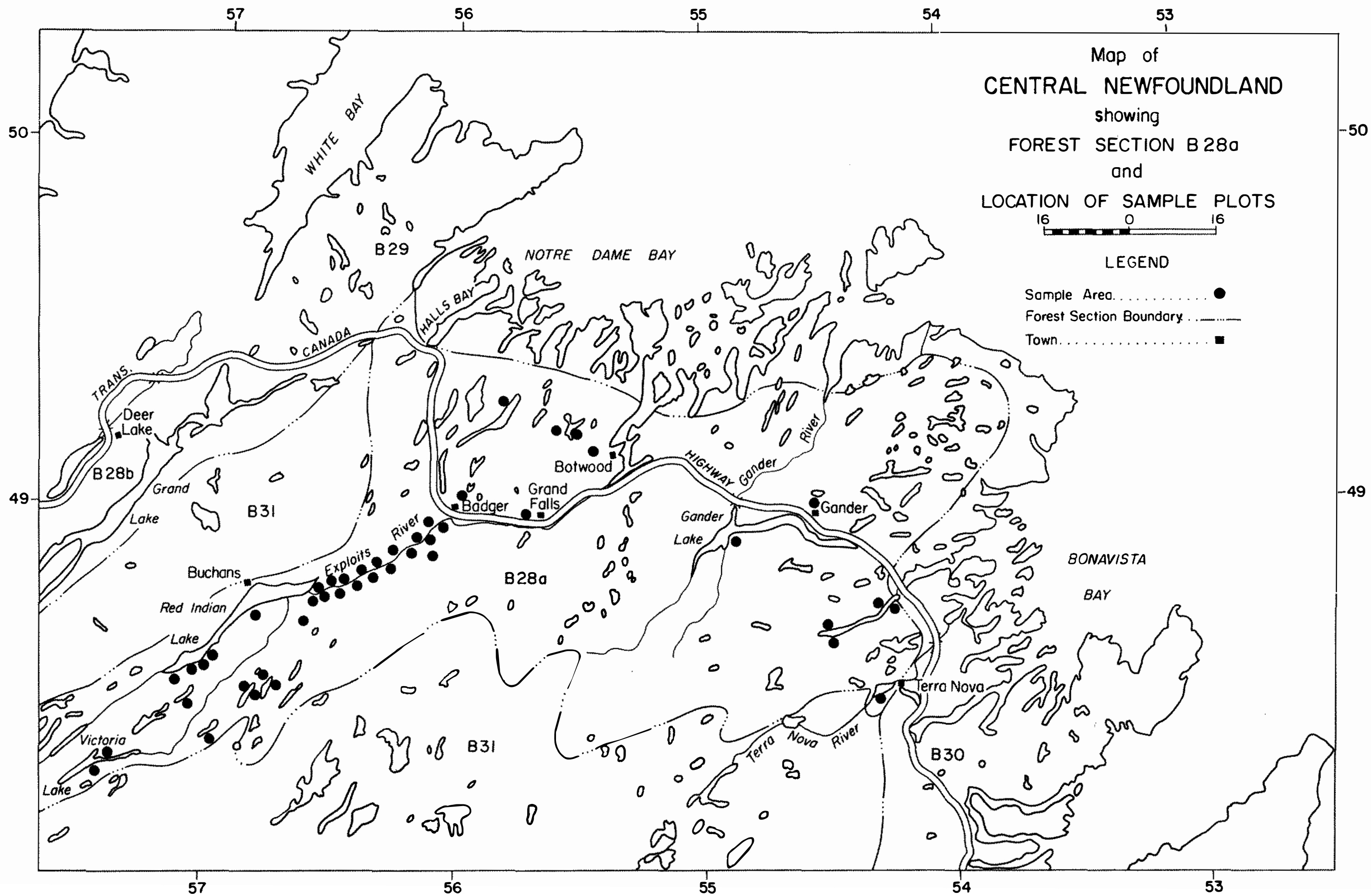

Map of
CENTRAL NEWFOUNDLAND
showing
FOREST SECTION B 28a
and
LOCATION OF SAMPLE PLOTS
16
0
16
LEGEND
Sample Area
Forest Section Boundary
Town
57
56
55
54
53
50
49
WHITE BAY
B29
NOTRE DAME BAY
HALLS BAY
TRANS. CANADA
HIGHWAY
Deer Lake
B28b
Grand Lake
B31
Botwood
Badger
Grand Falls
Gander River
Gander
Gander Lake
Buchans
Exploits River
B28a
Red Indian Lake
BONAVISTA BAY
Terra Nova
Terra Nova River
Victoria Lake
B30

Growth Trends in Spruce and Fir Stands in Central Newfoundland[1]

by

R. S. van Nostrand[2]

INTRODUCTION

Intensive growth studies began in Newfoundland with the establishment of approximately 1,200 one-fifth acre semi-permanent growth plots in the central part of the Island (see Frontispiece) during 1947 and 1948. A remeasurement of the plots in 1957 and 1958 provided a ten year increment which was used as a basis for constructing a set of growth tables which give softwood volume growth rates of relatively young stands representing a range of densities and height indices. This was accomplished by using the directing-curve, or trend-line method to determine changes in basal area for each of four height-index classes. For each plot the basal areas at establishment and at remeasurement were plotted on a graph of basal area on age, and the two points joined by a line. Thus a series of these lines represented basal area changes for the range of densities and ages sampled by the plots. Values read from these curves were converted to volume using a table of volume-basal area ratios prepared from the plot data. The growth tables are in merchantable cords of softwoods per acre, and apply to the spruce and fir forest types, and to the spruce and fir component of mixed-wood stands having less than seventy-five per cent hardwood by basal area.

Even-aged stands of spruce or fir exceeding seventy years of age at breast height are not common in central Newfoundland, and so the number of plots sampling such stands is very limited. Because the sampling was confined mainly to relatively young stands, where current increment was still high, no rotation ages can be established.

The tables can be used to predict the growth of stands falling within the range of sampling. However, they are not yield tables of the usual form in that they give no stand information for individual forest types and no rotation age. Rather they forecast yield on the basis of certain stand information to be obtained independently. This information is: (1) merchantable cords per acre at start of forecast period; (2) height index of the stand; (3) average age at breast height and (4) stand composition.

GENERAL DESCRIPTION OF CENTRAL NEWFOUNDLAND

This part of Newfoundland forms Forest Section B-28a—Grand Falls Section, as described by Rowe (1959). The Section occupies the plateau of central-northern Newfoundland and contains the greatest area of productive forest land in the province. It is bounded on the south and west by highland moss barrens, on the east by parts of the Burin, Avalon and Bonavista Peninsulas, and on the north by a narrow maritime strip (see Frontispiece).

[1] Department of Forestry, Canada, Forest Research Branch Contribution No. 605.

[2] Research Officer, Department of Forestry, Forest Research Branch, St. John's, Newfoundland.

Climate

The climate is characterized by moderate summer and winter temperatures, with relatively high annual precipitation well distributed throughout the year. The growing season generally begins in the latter half of May.

The following meteorological data have been obtained from the Atlas of Canada (Anon. 1957.).

The total annual precipitation varies from 35 inches along the coastal section to 46 inches toward the interior of the Island. The mean annual snowfall is 110-120 inches. The number of days with mean daily temperatures above 42°F varies from 140 to 160.

The approximate mean daily seasonal temperatures are as follows: January—20°F; April—33°F; July—60°F; October—43°F.

The approximate mean annual minimum temperature is −15°F. The approximate mean annual maximum temperature is 80°F.

Physiography

Information on the topography and geology of the region is taken largely from a report by Damman[1].

The area is characterized by a flat to rolling topography with an abundance of lakes and bogs throughout. The major portion has an elevation between 250 and 700 feet above sea level, with the level of the land rising gradually toward the southwest. The three main rivers, the Exploits, Gander and Terra Nova flow in a northeasterly direction and their watersheds comprise the major part of the area.

The underlying rocks are mainly acidic, and they consist almost entirely of sedimentary and metamorphic rocks such as shale, slate, sandstone and schists. Granite and diorite outcrops are frequent and these harder rocks usually form the centre of the monadnocks which are found scattered throughout the area.

The entire Island has been severely glaciated and stony till covers practically the whole region. The soil texture varies to some extent, but is mostly a sandy loam to loam. The most common of the water-lain soils are the glaciofluvial sand and gravel deposits occurring sporadically in the valleys of the larger rivers; these soils, however, cover relatively little area. Alluvial soils can be found along all brooks and rivers, but are usually confined to narrow fringes along the drainage channels. Lacustrine deposits, although rare, can be found around some of the lakes.

The Forest

The forests are composed mainly of coniferous species dominated by balsam fir, *Abies balsamea*[2] and black spruce, *Picea mariana.* White birch, *Betula papyrifera* is generally distributed throughout the region and also occurs in fairly extensive pure stands, especially in the vicinity of Red Indian Lake and Hall's Bay. Aspen, *Populus tremuloides* appears frequently as a pioneer species on some cutover and burned areas, while balsam poplar, *Populus balsamifera* appears only occasionally. Two other species, white spruce, *Picea glauca* and white pine, *Pinus strobus* are found throughout the region. In Section B-28a red pine, *Pinus resinosa* is found only in the Terra Nova area.

Extensive logging and pulpwood cutting on the Exploits River watershed have contributed to the predominance of balsam fir in the western part of the Section. This extensive cutting, plus limited recent fire disturbances have resulted in a wide distribution of younger age classes. Many of the stands on old cut-overs are of a multi-aged nature due to varying degrees of utilization. On the other

[1] Damman, A. W. H. 1959. Some Forest Types of Central Newfoundland, Project NF-20. Department of Forestry Forest Research Branch. (To be published).

[2] Nomenclature for tree species taken from Native Trees of Canada, (Anon., 1961).

hand, in the eastern part, fire has played the major role resulting in a predominance of even-aged black spruce firetype stands. The greater part of these latter forests resulted from two large fires in 1897 and 1904.

In undisturbed forests, balsam fir stands occupy all soils except those which are nutrient poor and very wet or very dry. These latter soils are common throughout the Section as heath barrens and peat bogs, and are usually occupied by open stands of poor quality black spruce.

SAMPLING METHODS AND BASIC COMPILATION

General Sampling Techniques

The sampling unit was a semi-permanent one-fifth acre plot. Data from the establishment and one ten-year remeasurement of 376 plots were used to construct the growth tables. The distribution of the plots by sub-type, initial age-class, and height index class is given in Table I. It will be noted that sampling is particularly weak for stands in the older age classes on the better sites.

Data collected at each measurement included a diameter tally of living trees by species and one-inch diameter classes. At remeasurement all dead trees were blazed so that mortality could be determined at future remeasurements. Blazing was not carried out during plot establishment. Only the height, diameter and age data collected at remeasurement were used in the analysis. Height and diameter measurements were taken from the ten largest trees of the major softwood species on each plot, and age was taken from the five largest. When there were two major species five of each were examined. This growth information provided the means of preparing an individual height diameter curve for each major species on each plot, and of determining the height age index of each plot.

TABLE 1. NUMBER OF PLOTS BY SUBTYPE, AGE CLASS AND HEIGHT INDEX CLASS

Subtype	Initial Age Class	Height Index Class				
		26–35	36–45	46–55	56+	All
Black Spruce*	16- 25	—	—	11	3	14
	26- 35	2	10	12	6	30
	36- 45	8	31	46	13	98
	46- 55	4	21	28	12	65
	56- 65	4	5	1	—	10
	66- 75	—	4	—	—	4
	76- 85	2	4	1	—	7
	86- 95	1	1	1	—	3
	96-105	2	2	—	—	4
	106-115	4	3	—	—	7
	Total	27	81	100	34	242
Balsam Fir**	16- 25	—	—	1	1	2
	26- 35	—	7	8	4	19
	36- 45	—	7	13	4	24
	46- 55	6	15	19	9	49
	56- 65	1	7	12	5	25
	66- 75	1	2	3	—	6
	76- 85	1	1	1	—	3
	86- 95	1	—	3	—	4
	96-105	—	—	1	—	1
	106-115	1	—	—	—	1
	Total	11	39	61	23	134
	Grand Total	38	120	161	57	376

*Black spruce comprised more than fifty per cent of the merchantable softwood basal area.
**Balsam fir comprised more than fifty per cent of the merchantable softwood basal area.

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Diameter Tally

The accuracy of plot diameter tallies, at remeasurement, was checked on approximately ten per cent of the plots. The following results were obtained:

Average error in basal area (arithmetic)— 3.3 per cent
Average error in basal area (algebraic) —+0.8 per cent
Standard error of estimate —±4.6 per cent

Plot Age Determination

All increment borings for age determination were taken at breast height (4.5 feet), and these ages have been used throughout all compilation and analysis. It was hoped that this procedure would eliminate effects of much of the initial suppression common in stands of cutting or windthrow origin.

Height Diameter Relationships

Summaries of the plot height diameter data were made by species, one-inch diameter classes, and ten-foot dominant height classes. All sample trees in each plot were assigned to a height class on the basis of the dominant height index of the plot, rather than on an individual tree basis. The harmonized curve technique (Dwight, 1937) was employed to produce reference height diameter curves by even ten-foot heights for each of black spruce, white spruce and balsam fir (Figures 1, 2, and 3).

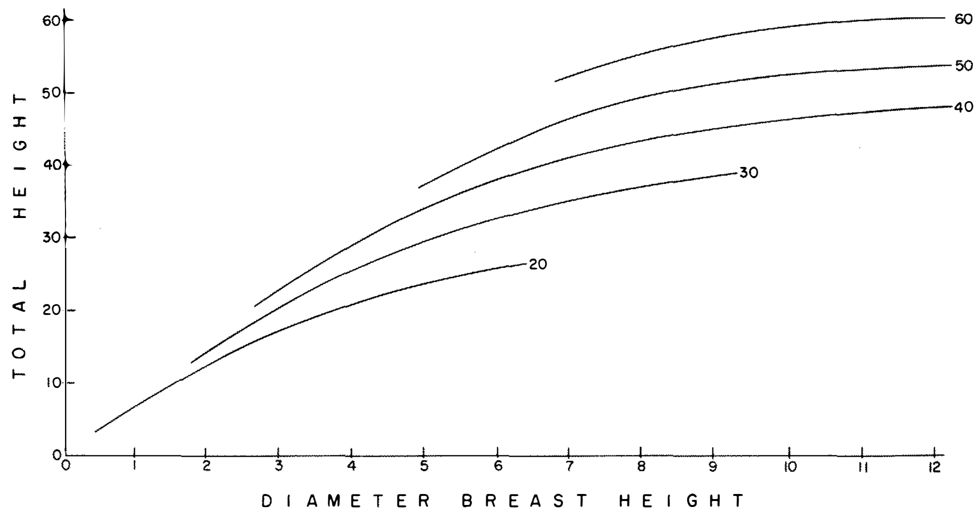

Figure 1. Black spruce height/diameter by dominant height classes

Individual height diameter curves were obtained for each major softwood species on each plot by entering the appropriate set of reference curves with the average height and diameter of the largest trees for that species. Curves prepared for black spruce were also used for larch.

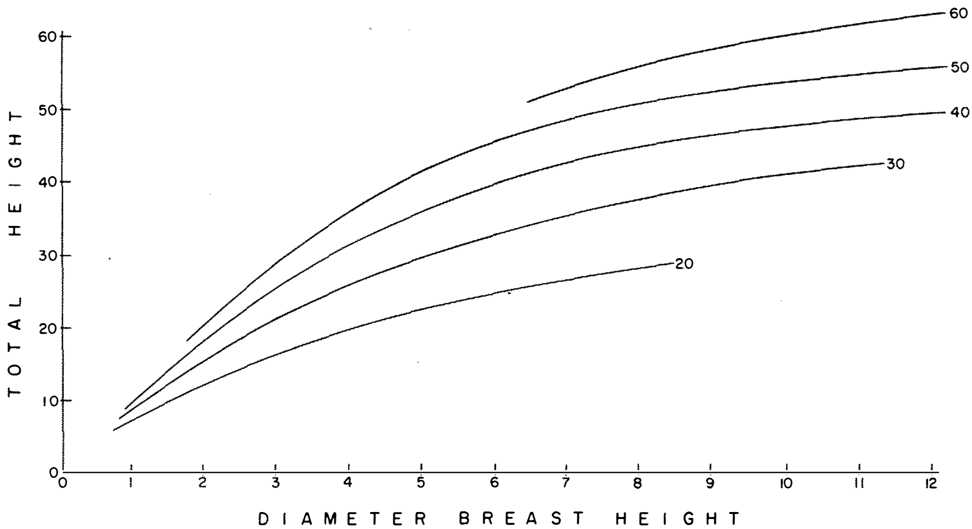

Figure 2. Balsam fir height/diameter by dominant height classes

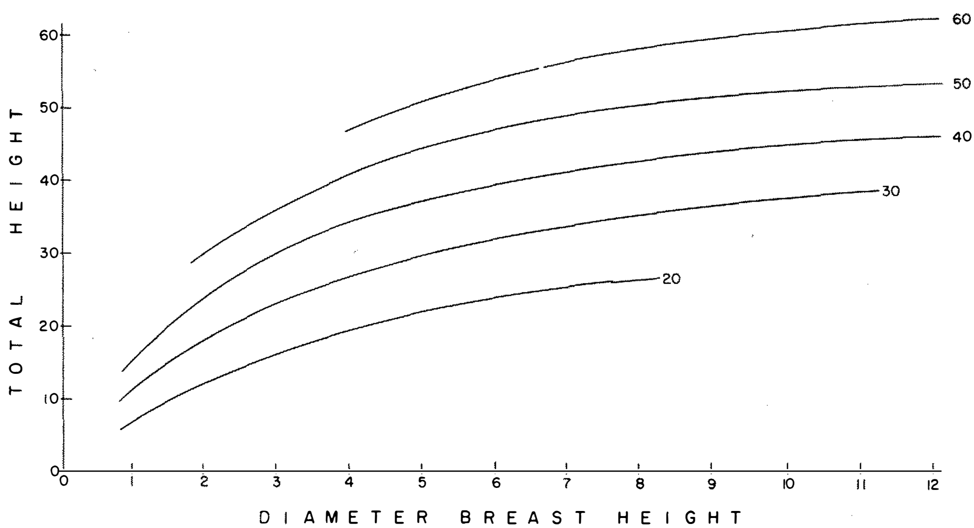

Figure 3. White spruce height/diameter by dominant height classes

Standard Volume Tables

Standard volume tables for merchantable volume in cubic feet were prepared as follows:

1. Variations in form class associated with variations in diameter and height were determined for black spruce and balsam fir by a three variable analysis (Bedell, 1948).
2. Form class values for each one-inch diameter class and ten-foot height class were used with form class volume tables (Anon, 1948) to prepare standard volume tables for the two species, (see Tables 9 and 10).

Volume tables prepared for black spruce were also used for white spruce and larch.

Height Age Relationships

The site classification of plots was done on a mathematical height-age basis, rather than by an ecological concept. However, the disproportionate representation of plot ages among the sites precluded any attempt at producing reliable curves from plot data. Thus, stem analysis information was collected for the purpose of preparing height-age index curves (Figures 4 and 5).

Height index was assigned to a plot by means of the tree of average basal area of the predominant softwood species, which almost invariably was either black spruce or balsam fir. Therefore stem analysis measurements were confined to these two species on trees of average basal area for the particular stand being sampled. For each tree, selected ring counts were made at four-foot intervals from the top downward until the rings totalled fifty or breast height was reached. Ring counts were also made at breast height, and at one-quarter and one-half heights above breast height when these positions were below the fifty year count.

An attempt was made to select sufficient trees so that four ages, at intervals of approximately thirty years, were represented for each of three height index classes, with class intervals of approximately ten feet at one hundred years. However, for both species sampling was incomplete, notably from older stands on the better sites.

From the data a graph of height/age was constructed such that an individual height-index class was represented by a continuous series of lines from the oldest age class sampled to the youngest, with the upper end of the trees from one age interval roughly overlapping the lower end of the trees of the next higher age interval. Through these trend lines a single freehand curve was drawn.

Because of inadequate data this procedure was carried out only for the middle height index class of each species. The resulting curve was anamorphosed to a straight line and used as a basis for constructing curves which passed through even ten-foot heights at one hundred years of age. (Bruce and Schumacher, 1950). The shape of these anamorphosed curves conformed very closely to the incomplete series of trend lines.

Height index was defined as the height of the tree of average basal area (calculated from trees in the four-inch diameter class and above) at one hundred years of age, and was determined as follows:

1. The average height of the largest trees, and the diameter of the tree of average basal area, were determined for the predominant softwood species.
2. The average height was used to determine the appropriate reference height-diameter curve. From this curve a height was obtained for the tree of average diameter determined in (1) above. This was called the index height.
3. This index height was then applied to the height-age index curves, above the plot age, and the height index at one hundred years read.

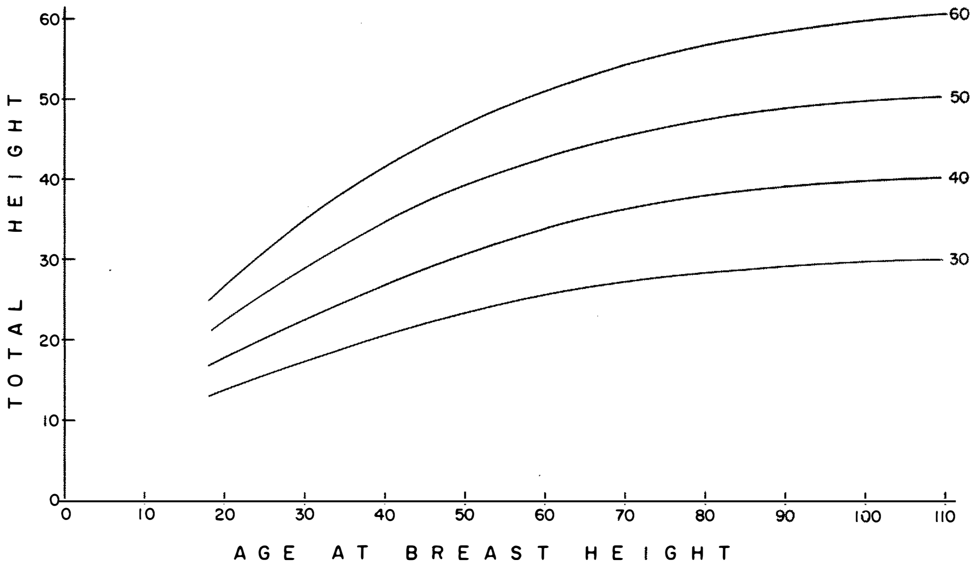

Figure 4. Black spruce height/age index curves

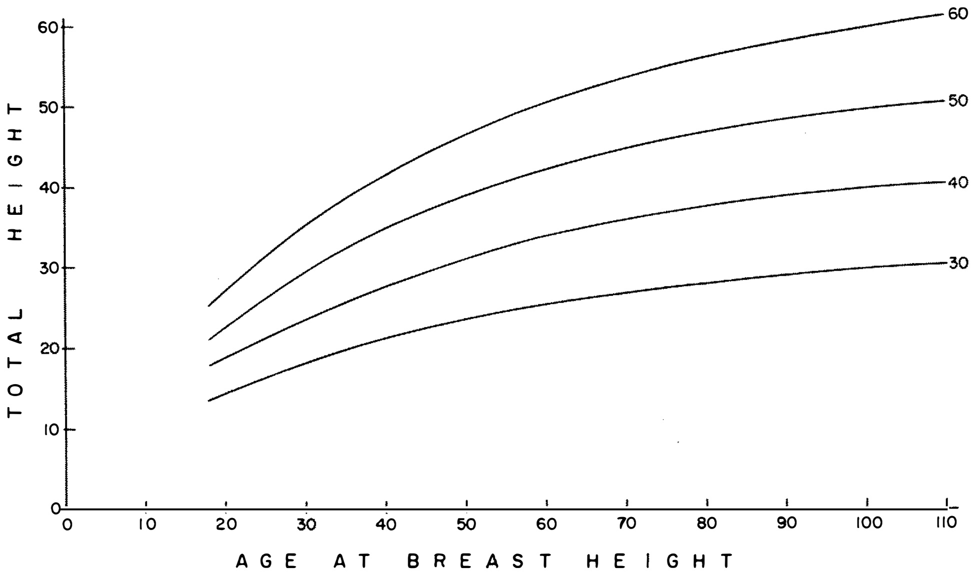

Figure 5. Balsam fir height/age index curves

Height-index may also be determined from measurements of height and age of average crop trees. The average age and height of these trees would then be applied directly to the appropriate height-age index curve. Limited checking to determine the differences in results of the two methods showed almost no difference in fire-type black spruce stands, but some fluctuation in balsam fir stands. Therefore, it is recommended that the first method, outlined above, should be used.

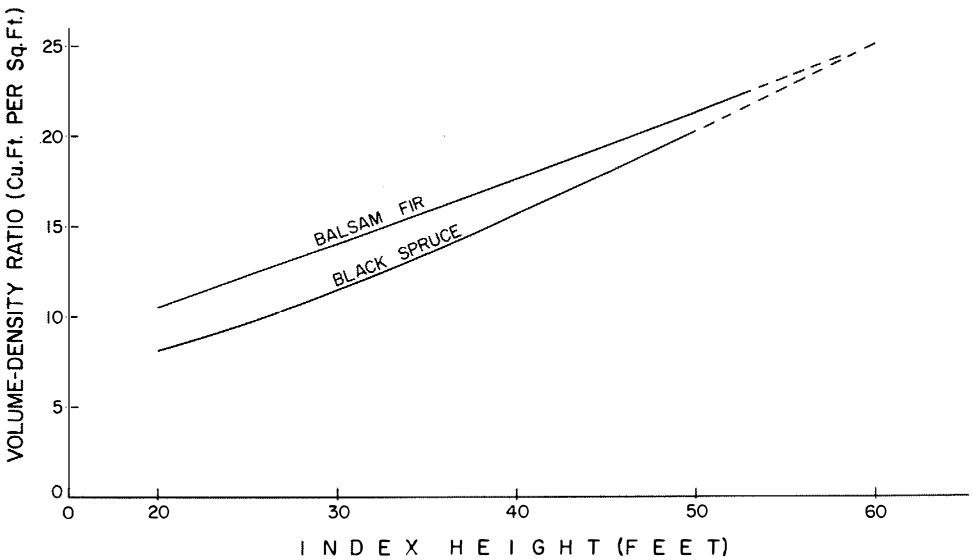

Figure 6. Volume density ratio/index height for black spruce and balsam fir

Volume Density Ratios

Ratios of merchantable softwood volume in cubic feet to merchantable softwood basal area (trees in the four-inch diameter class and above) were calculated separately for the black spruce and balsam fir subtypes.
(See Table 1 footnotes.) The procedure for determining these ratios was as follows:

1. For each of the two subtypes a single curve of volume density (basal area) ratio on index height was prepared (Figure 6).
2. From each curve of the height-age index series, (Figures 4 and 5) values of height at each decade were taken. Each height was applied to the appropriate curve of Figure 6 to obtain a volume-density ratio. These ratios were then plotted over the ages corresponding to the height taken from the height-age index curves to produce a graph of volume density ratio on age for each of the two species, (see Figures 9 and 10). The volume density ratios in Table 8 were derived directly from these figures.

Values of cubic feet per square foot of basal area were converted to cords per square foot by assuming that eighty-five cubic feet of solid wood equals a rough cord.

CHANGE IN BASAL AREA AND VOLUME

The directing-curve, or trend-line method, of determining changes, with age or height, of various parameters is not new. It is one of the standard European methods of preparing yield curves, and was used by Mulloy (1947) to show changes in stand density index.

TABLE 2. BLACK SPRUCE GROWTH TABLES

MERCHANTABLE SOFTWOOD VOLUME IN CORDS PER ACRE

(One cord equals 85 cubic feet of solid wood.)

Breast Height Age	Height Indexes 23-35					Height Indexes 36-45				
20	—	—	—	—	—	—	—	—	2.2	3.9
30	—	—	—	1.3	2.1	—	1.4	2.9	5.5	8.6
40	—	—	1.8	3.1	4.5	1.3	4.0	6.8	11	15
50	—	1.9	3.9	5.8	—	3.5	8.3	13	18	22
60	—	3.6	6.4	8.7	—	7.2	14	20	25	—
70	—	—	—	—	—	11	20	26	—	—
80	—	—	—	—	—	—	—	—	—	—
Breast Height Age	**Height Indexes 46-55**					**Height Indexes 56+**				
20	—	—	1.6	3.9	6.6	1.0	2.0	3.8	5.6	7.8
30	—	3.2	6.2	9.3	14	3.3	6.2	9.5	13	17
40	2.2	7.3	12	17	24	6.8	12	18	23	29
50	4.9	13	20	27	34	11	19	27	35	43
60	8.4	19	29	37	—	16	23	33	—	—
70	—	—	—	—	—	—	—	—	—	—
80	—	—	—	—	—	—	—	—	—	—

TABLE 3. BALSAM FIR GROWTH TABLES

MERCHANTABLE SOFTWOOD VOLUME IN CORDS PER ACRE

(One cord equals 85 cubic feet of solid wood.)

Breast Height Age	Height Indexes 26-35					Height Indexes 36-45				
20	—	—	—	—	1.8	—	—	—	1.7	3.0
30	—	—	1.6	3.1	4.7	—	1.4	2.5	4.4	6.6
40	—	1.4	3.7	6.0	8.5	2.0	4.0	6.3	10	14
50	1.0	3.8	6.7	10	13	5.9	10	14	19	25
60	2.6	6.8	—	—	—	11	20	25	31	—
70	5.1	—	—	—	—	17	28	—	—	—
80	7.8	—	—	—	—	—	—	—	—	—
Breast Height Age	**Height Indexes 46-55**					**Height Indexes 56+**				
20	—	—	1.5	2.9	5.4	—	—	1.5	3.8	8.0
30	—	2.1	4.3	7.2	13	1.7	3.9	7.6	12	19
40	2.8	6.5	11	18	26	4.9	10	17	24	32
50	7.1	16	24	32	40	9.2	19	28	38	47
60	15	27	37	44	—	14	29	—	—	—
70	23	37	46	—	—	20	—	—	—	—
80	—	—	—	—	—	—	—	—	—	—

In this study the method was used to prepare a series of curves showing changes with age, in basal area of merchantable softwoods, for each height-index class of the black spruce and balsam fir subtypes. For each plot the initial basal area and basal area at remeasurement were plotted over age, and lines were drawn to join the two points representing each plot. From the resulting series of lines the pattern of basal area change was determined. Through each series of these trend lines five freehand curves were drawn in such a manner that they covered the approximate range of basal areas represented by the trend lines, and were spaced equidistant at the fifty-year age line on each chart, (see Figures 11 to 18). The purpose of the five lines is to provide a basis for interpolation of values covering the range of basal areas and ages sampled. No attempt was made to produce the curves beyond the limit of sampling.

The basal area values used in the procedures outlined above were simply the raw field data. No attempt was made at cross harmonization within, or between height index classes, and no adjustments were made to the individual basal areas in order that their values would correspond to the mid-point level in the height index class. For these reasons interpolation may be made only for basal area growth trends, and not for height index within a height index class.

The growth tables (Tables 2 and 3) showing changes in volume with age for each height index class, were obtained by multiplying the values from the curves of basal area change by the appropriate value of volume density from Table 8. These growth tables are presented graphically in Figures 7 and 8 to facilitate, where necessary, interpolation for age and volume. Similar tables and graphs, showing volumes in cubic feet, should be made by substituting the appropriate values from Table 5.

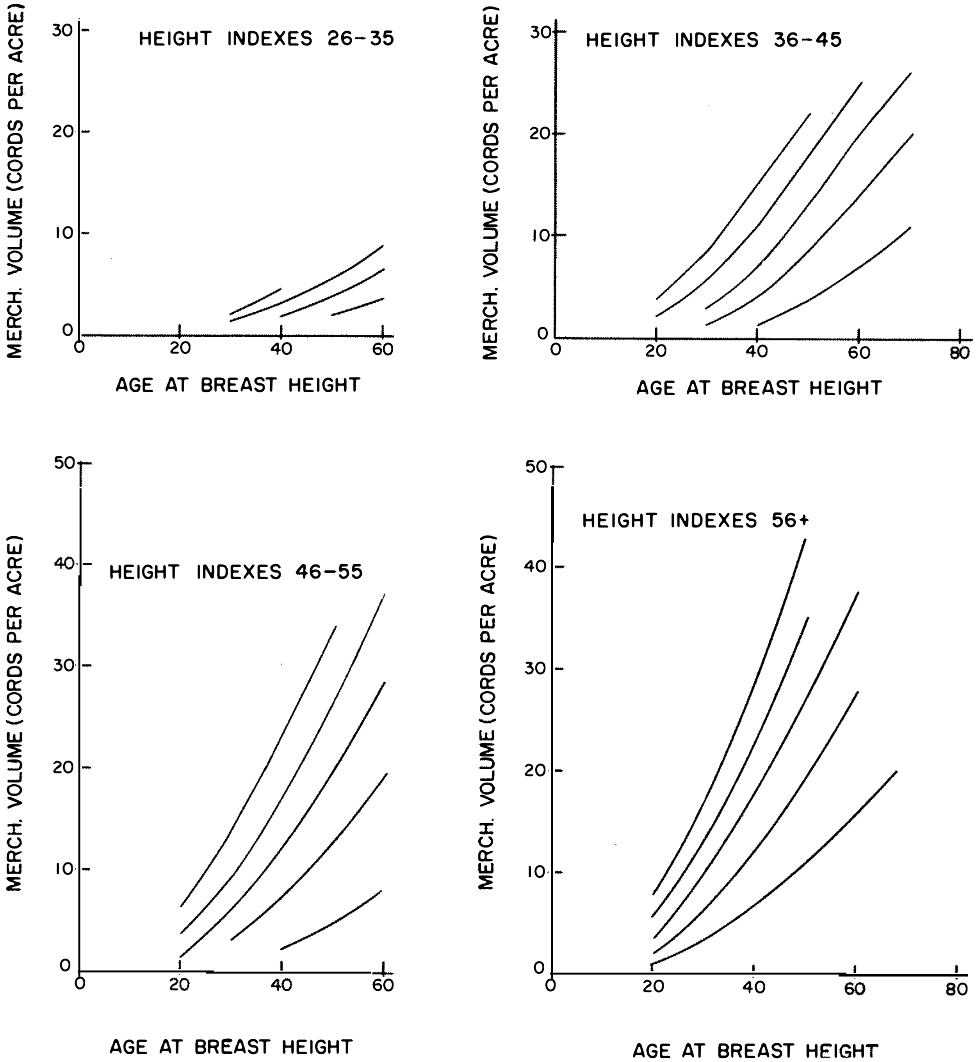

Figure 7. Black spruce growth charts. Merchantable softwood volume in cords per acre

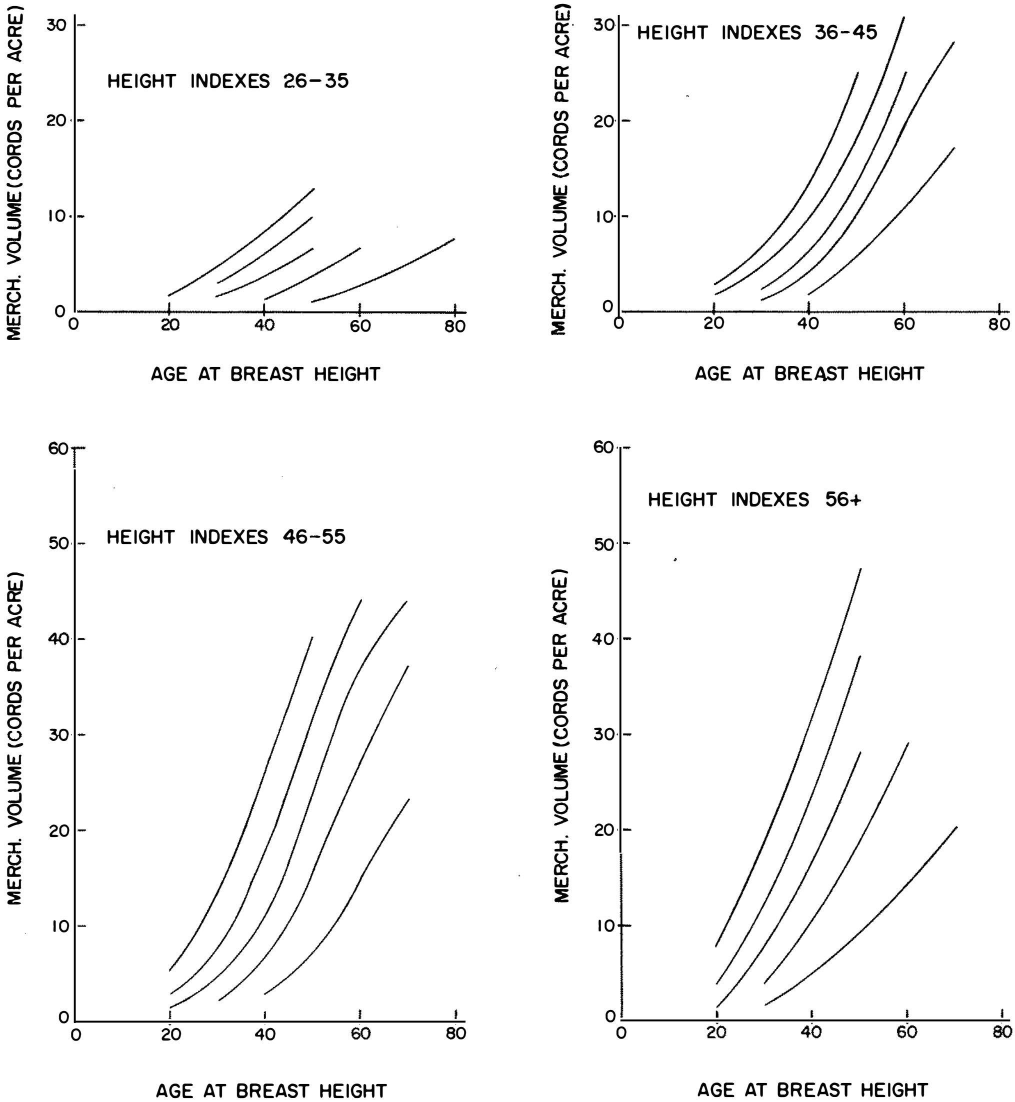

Figure 8. Balsam fir growth charts. Merchantable softwood volume in cords per acre

THE GROWTH TABLES AND THEIR APPLICATION

The growth tables and graphs presented show the trends of change in volume with age for relatively young stands of varying basal areas. The volumes given are per acre values, in cords, of merchantable softwoods in the four-inch diameter class and above, based on utilization standards of a top inside bark diameter of three inches and a stump height of one foot.

To use the tables or graphs for predicting future volumes the following stand information must be known:

1. Average age at breast height at beginning of forecast period.
2. Height index
3. Subtype: whether black spruce or balsam fir.
4. Merchantable softwood volume in cords per acre at beginning of forecast period.

To provide a forecast, the volume at the beginning of the forecast period is entered at its corresponding age in the appropriate graph; the trend of the curve is then followed to the forecast age and the volume read off. This forecast volume may also be determined by interpolating within the tables. For the reasons given in the previous section, interpolation for height index is not justified.

Since the volumes include only softwood trees above the three-inch diameter class, the same forecast is given stands which have the same present merchantable volume, but which may have very different densities of softwoods below merchantability. Thus, actual performance of individual samples may differ greatly from the predicted values. For this reason the tables are intended for use on extensive areas from which a number of samples are taken to determine an average prediction.

Various refinements could have been made to the tables, particularly with regard to different combinations of spruce and fir, but these would undoubtedly have led to a complex set of tables requiring complicated calculations to determine forecasts of unwarranted precision. Therefore, it is felt that with the data which are available at present, the form of tables and graphs presented represents the best combination of ease of use with reasonable accuracy, particularly since they are to be used primarily to forecast increment over extensive forest areas.

A point to remember is that the tables allow for the mortality associated with the normal development of forest stands, but no allowance has been made for abnormal loss of wood volume through catastrophic disturbances. For this reason safety allowances developed in accordance with the prospective users best judgement are an absolute necessity.

RELIABILITY OF GROWTH TABLES

A statistical test to determine the accuracy of forecast volumes was carried out for plots used to prepare the tables. Only plots supporting more than one cord per acre at establishment were used in the test. The standard error of the mean of the forecast volumes was determined for the group of plots in each subtype and height index class. Table 4 shows the statistical accuracy of a ten year forecast at the ninety-five per cent level of probability.

TABLE 4. STATISTICAL ACCURACY OF A TEN-YEAR FORECAST IN PER CENT

Subtype	Height Index Class	Error of Forecast Volume*	Error of Forecast Increment*	No. Plots Used
Black Spruce	26 - 35	± 7.58	± 21.05	13
	36 - 45	± 5.64	± 14.11	54
	46 - 55	± 3.62	± 8.62	70
	56+	± 5.48	± 13.26	24
Total				161
Balsam Fir	26 - 35	± 5.35	± 10.06	5
	36 - 45	± 5.14	± 11.54	27
	46 - 55	± 4.49	± 10.38	47
	56+	± 6.25	± 14.68	20
Total				99

*Standard errors of the mean, at the 95 per cent level of probability, expressed as percentages of the mean remeasurement volume or increments.

In addition to the above statistical test three sets of permanent sample plot data were used to provide independent checks of the growth tables. These data together with the test results are described below.

1. Seventeen one-fifth acre sample plots which were established in 1948 and 1949, were remeasured in 1961. Eight of these plots were located in western Newfoundland (Forest Section B-28b) which is outside the area for which the growth tables are intended to be used. These eight plots are almost entirely balsam fir with original ages ranging from 30 to 39 years (at breast height), and height indexes ranging from 48 to 58.

The remaining nine plots which are located in central Newfoundland, are almost entirely black spruce with original ages ranging from 26 to 32 years (at breast height), and height indexes ranging from 39 to 45

Average deviations of the forecast volumes from the actual volumes at the end of the forecast period, appear in Table 5.

TABLE 5. RESULTS OF TEST NUMBER 1

Period of Growth and Location	No. of Yrs.	Volume in Cords Per Acre			Av. Deviation of Forecast		
		Beginning of Period	End of Period	Forecast from Tables	Cords Per Acre	Per cent of Vol. at End of Period	Per cent of Period Increment
1948-1961 (West Nfld.)	13	12.86	31.36	27.74	−3.62	−11.5	−19.6
1949-1961 (Central Nfld.)	12	3.76	10.36	9.37	−0.99	− 9.5	−15.0

2. Seventeen one-fifth acre plots, established in central Newfoundland in 1947, were remeasured early in 1957 as part of the ten year remeasurement plan, and again in the fall of 1961, so that actually five growing seasons had elapsed since the 1957 remeasurement.

This makes it possible to provide three separate increment predictions for each plot: (1) for the five years 1957 to 1961; (2) for the ten years 1947 to 1957; and (3) for the fifteen years 1947 to 1961. The ten year increment has of course been incorporated in the construction of the yield tables. All plots but one are comprised of more than fifty per cent balsam fir. The 1947 ages range from 34 to 78 years (at breast height), and height-indexes range from 30 to 55, with the majority in the 36 to 45 class.

Average deviations of the forecast volumes from the actual volumes at the end of each forecast period, appear in Table 6.

TABLE 6. RESULTS OF TEST NUMBER 2

Period of Growth	No. of Yrs.	Volume in Cords Per Acre			Av. Deviation of Forecast		
		Beginning of Period	End of Period	Forecast from Tables	Cords Per Acre	Per cent of Vol. at End of Period	Per cent of Period Increment
1957-1961	5	14.65	18.35	18.29	−0.06	− 0.3	− 1.6
1947-1957	10	7.47	14.65	14.41	−0.24	− 1.6	− 3.3
1947-1961	15	7.47	18.35	18.01	−0.34	− 1.9	− 3.1

3. The final test involves a one-acre block of fire-type black spruce in central Newfoundland. This block is the control in a set of four blocks established in 1925 as an experiment in thinning. Since its establishment it has been cruised in 1932, 1949 and 1960. The block had an average age at breast height of 45 years in 1960 (60 years total age), and a height index of 52.

Deviations of the forecast volumes from the actual volumes, at the end of each forecast period are shown in Table 7.

TABLE 7. RESULTS OF TEST NUMBER 3

Period of Growth	No. of Yrs.	Volume in Cords Per Acre			Deviation of Forecast		
		Beginning of Period	End of Period	Forecast from Tables	Cords Per Acre	Per cent of Vol. at End of Period	Per cent of Period Increment
1932–1949	17	3.8	13.3	14.5	+ 1.2	+ 9.0	+12.6
1949–1960	11	13.3	22.6	23.0	+ 0.4	+ 1.8	+ 4.3
1932–1960	28	3.8	22.6	24.5	+ 1.9	+ 8.4	+10.1

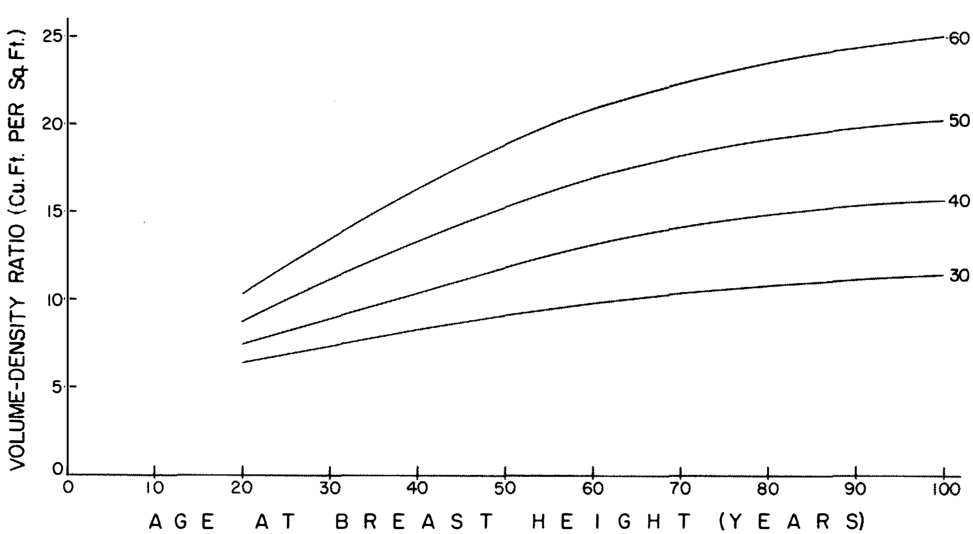

Figure 9. Volume-density ratio/age by height index black spruce

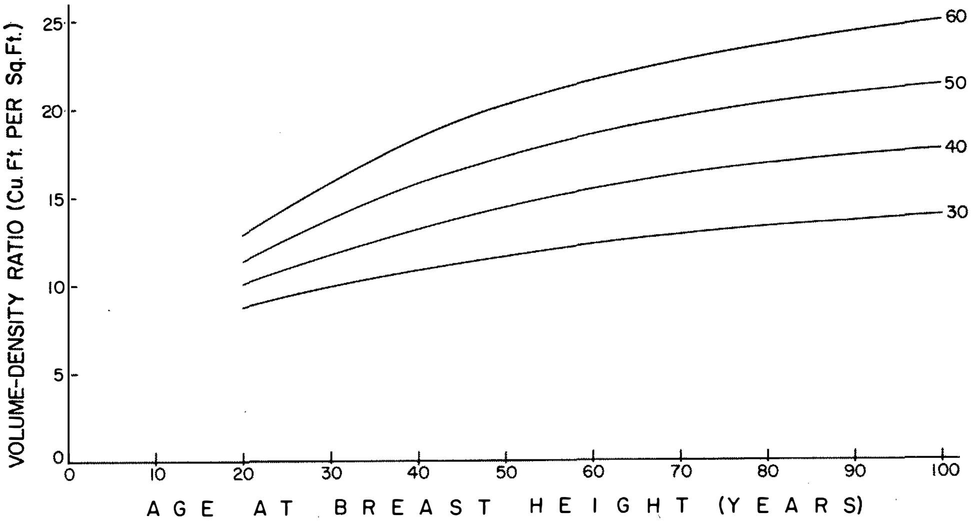

Figure 10. Volume-density ratio/age by height index balsam fir

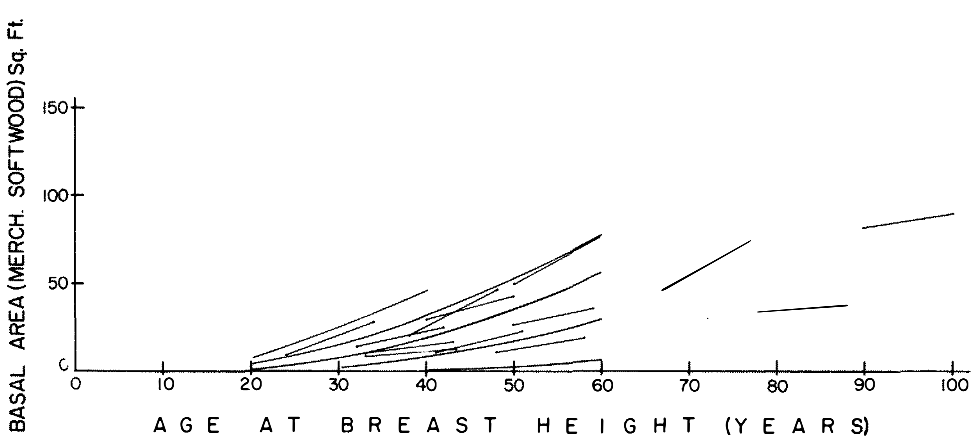

Figure 11. Basal area/age height indexes 26-35 black spruce

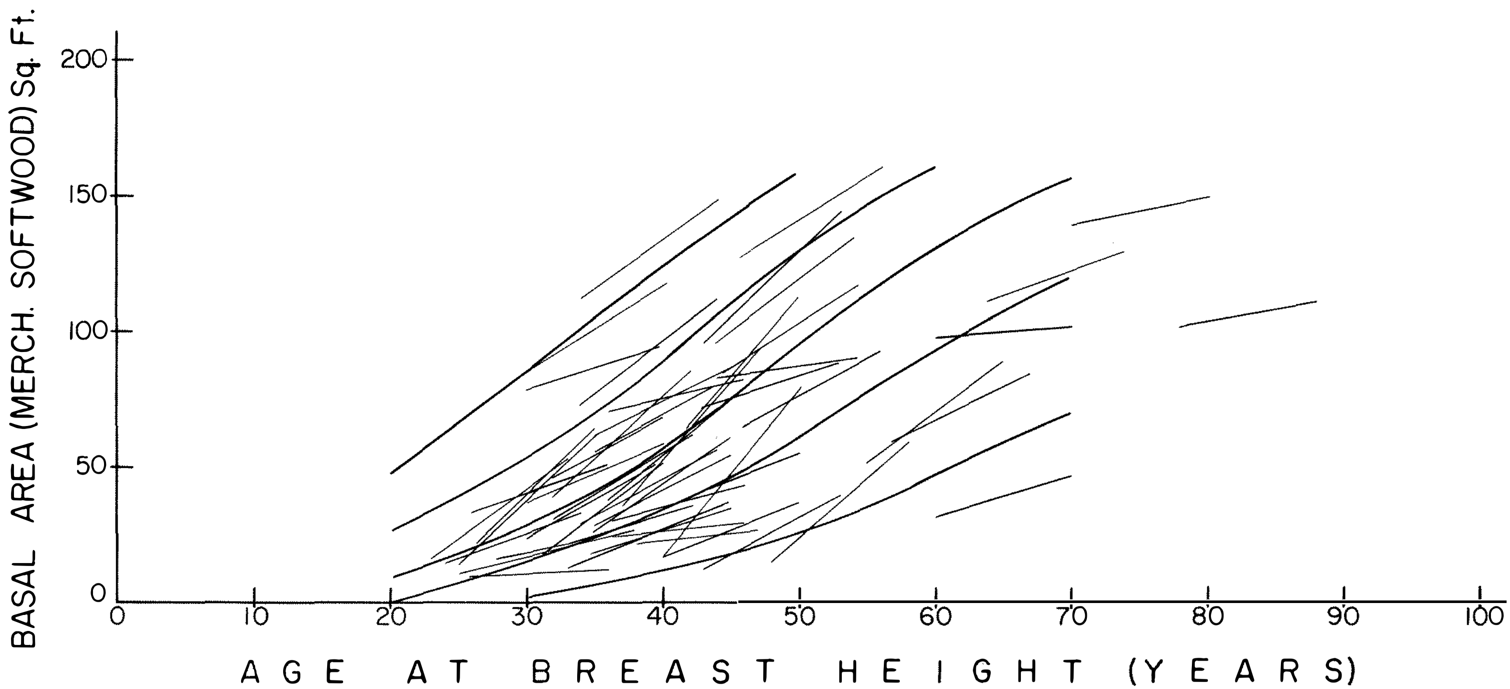

Figure 12. Basal area/age height indexes 36-45 black spruce

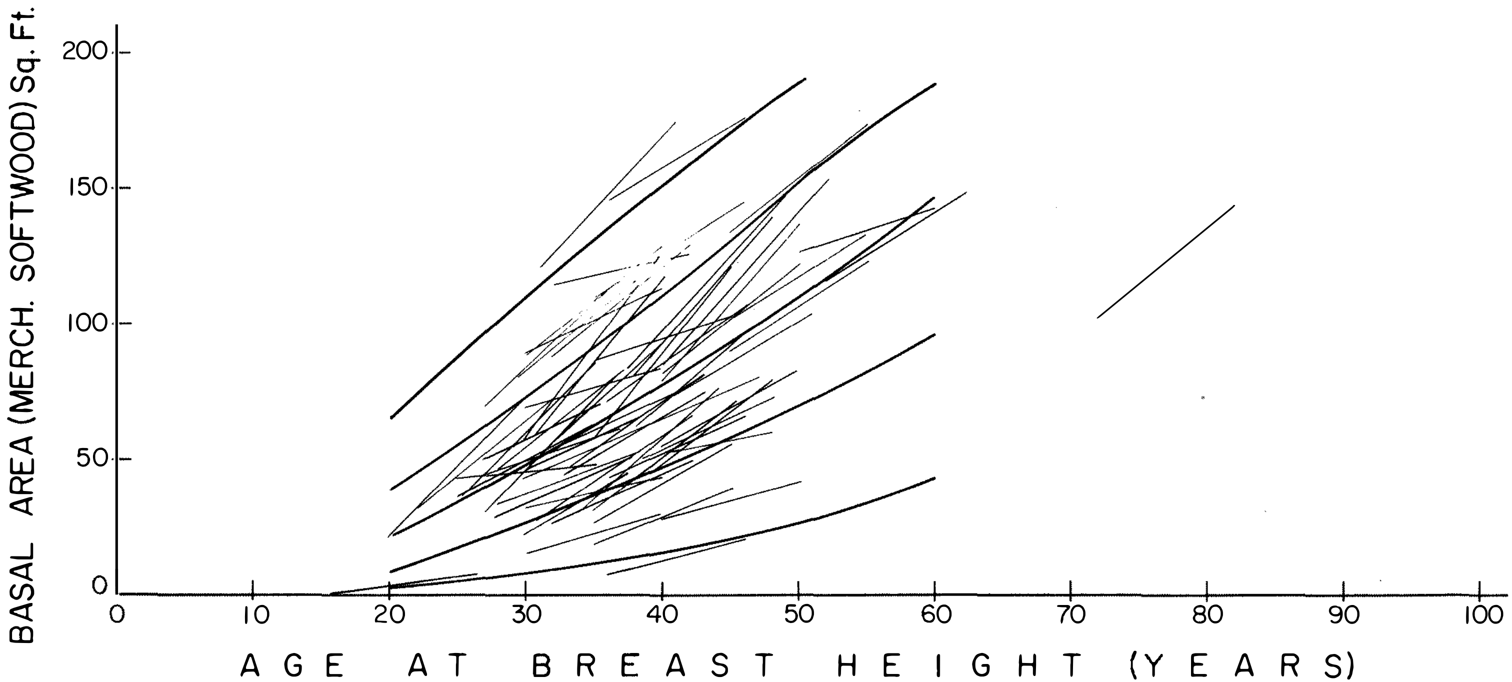

Figure 13. Basal area/age height indexes 46-55 black spruce

Figure 14. Basal area/age height indexes 56+ black spruce

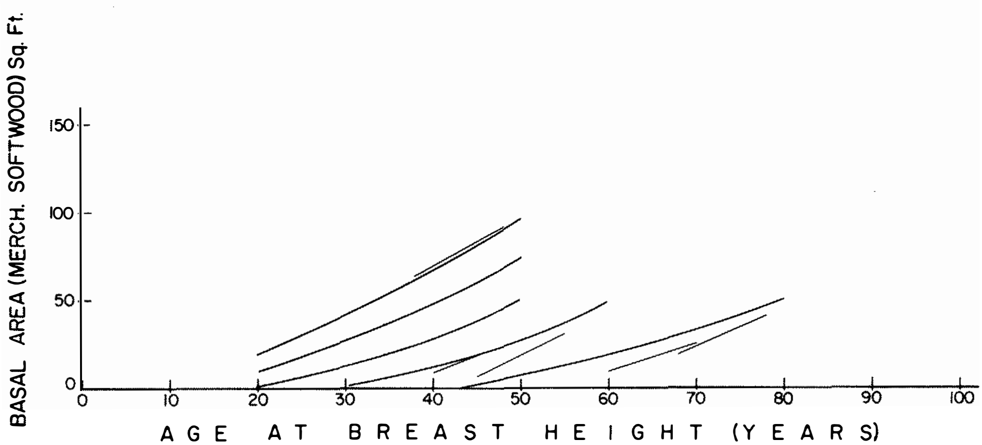

Figure 15. Basal area/age height indexes 26-35 balsam fir

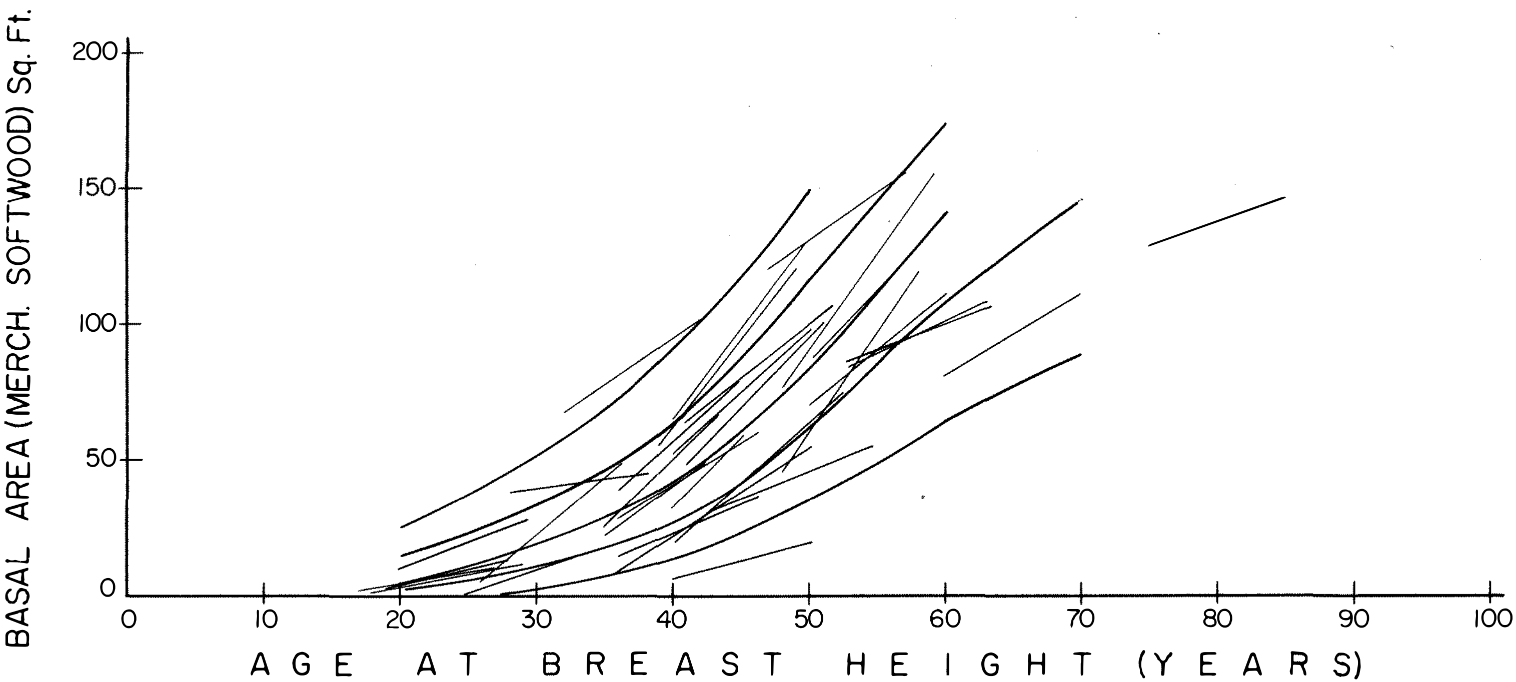

Figure 16. Basal area/age height indexes 36-45 balsam fir

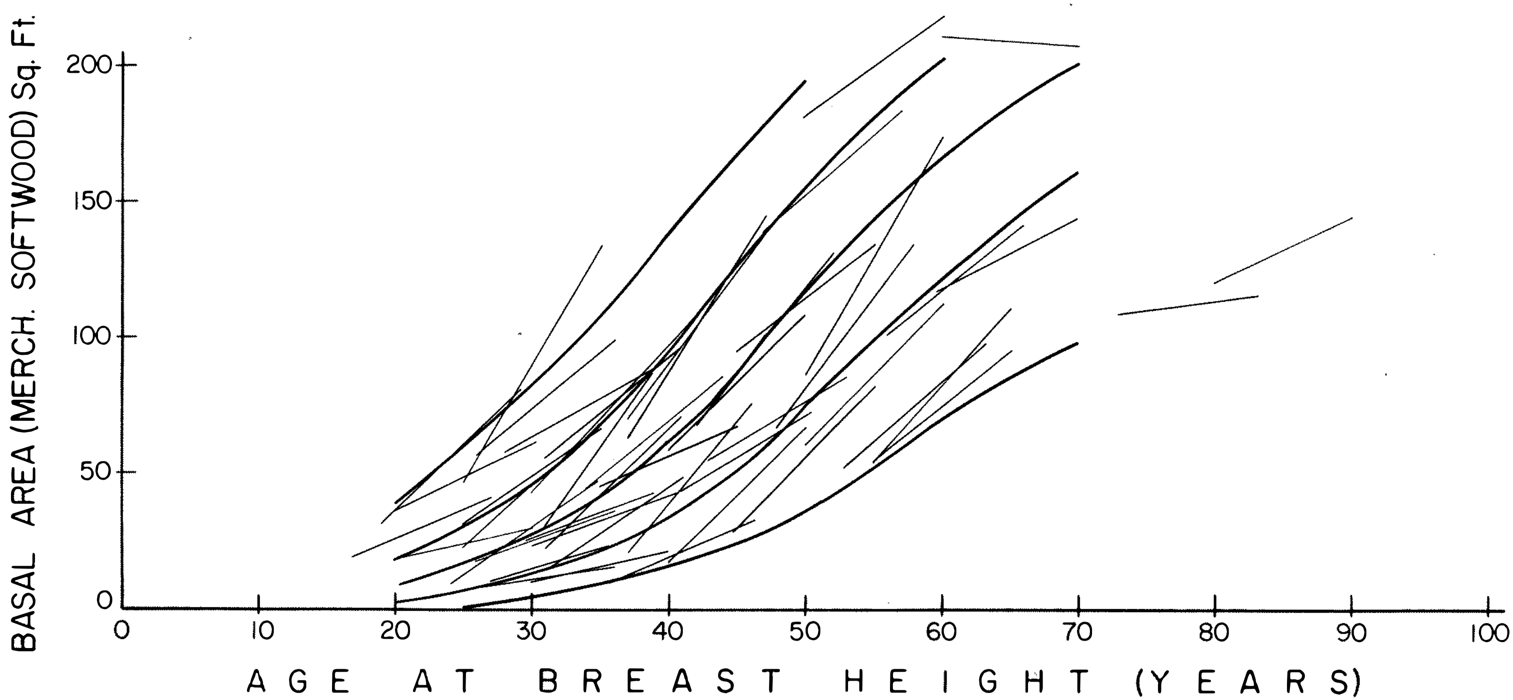

Figure 17. Basal area/age height indexes 46-55 balsam fir

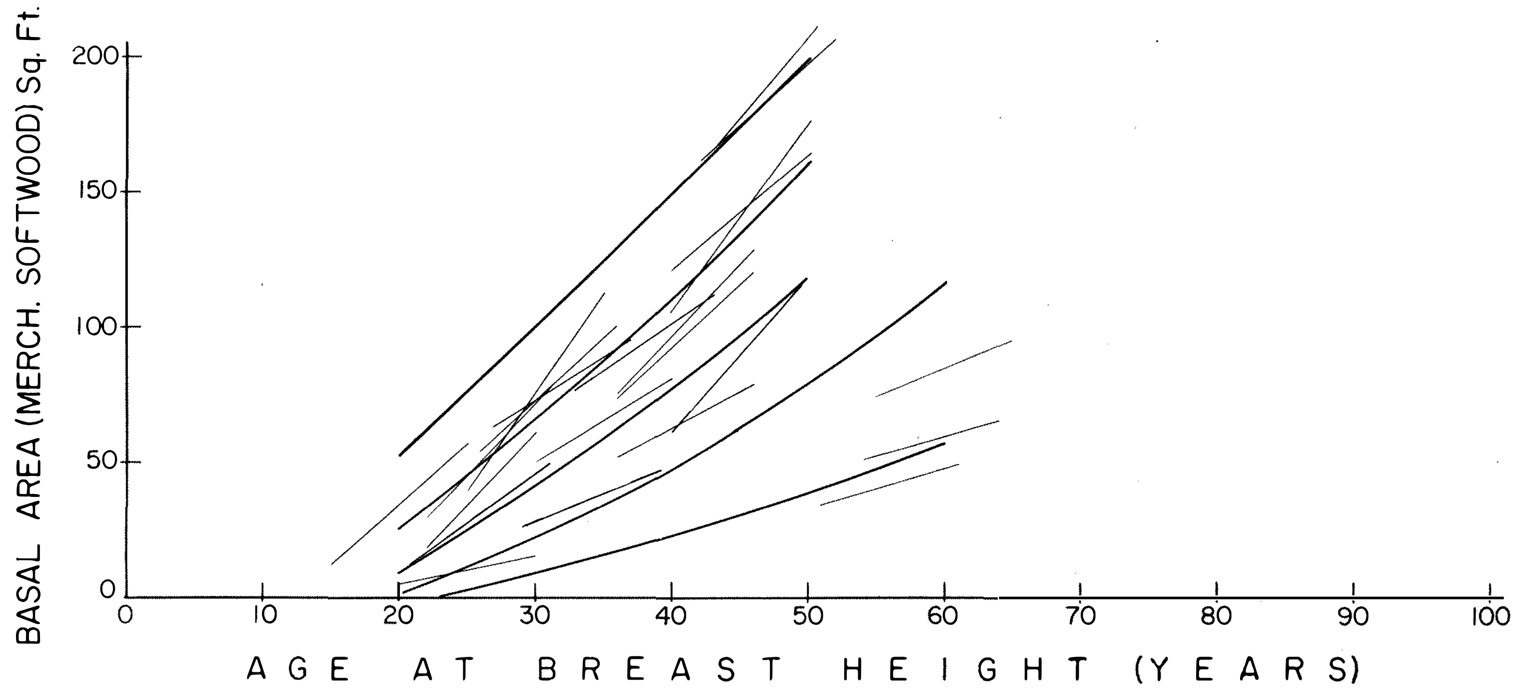

Figure 18. Basal area/age height indexes 56+ balsam fir

DISCUSSION

The tables in this report represent a preliminary attempt to show the growth of stands of varying densities. Although the methods used were largely graphical, statistical checks against the source data as well as checks against independent sample plot information indicate that these tables will give predictions within acceptable limits of accuracy. The absence of rotation ages at this time does not appreciably affect their usefulness, since their primary use will be to predict future volumes of relatively young stands over short periods; probably not more than twenty years. Following a second remeasurement in 1967-68 the new data will provide the basis for a revision. The new tables will be prepared by recognized multiple regression techniques, and it is hoped that rotation ages will be established for the various sites.

It was expected that the hardwood component would influence, to some extent, the increment of the softwoods in the same stand. However, tests showed that plots of a given height-index, age, and softwood volume, but having various proportions of hardwood, exhibit approximately the same ten year volume increment. For this reason the tables were made without regard to the hardwood component.

The surprisingly steep slope of some of the curves showing basal area change has resulted in volume increments in excess of one cord per acre per year. This, in part, is attributed to the fact that immature pulpwood stands in Newfoundland are characteristically very dense, and consequently the ingrowth of trees into the merchantable class is very high.

TABLE 8. AVERAGE HEIGHT AND VOLUME-DENSITY RATIOS BY SUBTYPE, HEIGHT INDEX CLASS, AND AGE

	HEIGHT INDEXES 26-35			HEIGHT INDEXES 36-45			HEIGHT INDEXES 46-55			HEIGHT INDEXES 56+		
Age at Breast Height	Average Height	Cubic Feet Per Square Foot of Basal Area	Cords Per Square Foot of Basal Area	Average Height	Cubic Feet Per Square Foot of Basal Area	Cords Per Square Foot of Basal Area	Average Height	Cubic Feet Per Square Foot of Basal Area	Cords Per Square Foot of Basal Area	Average Height	Cubic Feet Per Square Foot of Basal Area	Cords Per Square Foot of Basal Area
	BLACK SPRUCE											
20	13.8	6.4	.075	17.6	7.4	.087	22.1	8.7	.102	26.2	10.2	.120
30	17.2	7.3	.086	22.4	8.9	.105	29.0	11.0	.129	34.8	13.4	.158
40	20.6	8.3	.098	26.9	10.4	.122	34.8	13.3	.156	41.5	16.4	.193
50	23.5	9.2	.108	30.8	11.8	.139	39.3	15.3	.180	46.9	18.8	.221
60	25.8	9.8	.115	34.0	13.1	.154	43.0	16.9	.199	51.2	20.8	.245
70	27.4	10.4	.122	36.3	14.1	.166	45.7	18.2	.214	54.5	22.3	.262
80	28.6	10.8	.127	38.2	14.8	.174	47.7	19.2	.226	57.0	23.5	.276
90	29.5	11.2	.132	39.2	15.3	.180	49.0	19.8	.233	58.8	24.3	.286
100	30.0	11.4	.134	40.0	15.6	.184	50.0	20.2	.238	60.0	25.0	.294
	BALSAM FIR											
20	14.1	8.7	.102	18.7	10.1	.119	22.3	11.4	.134	26.8	12.8	.151
30	18.1	9.8	.115	23.6	11.7	.138	29.3	13.7	.161	35.0	15.8	.186
40	21.2	10.8	.127	27.7	13.1	.154	34.9	15.7	.185	41.4	18.2	.214
50	23.8	11.6	.136	31.2	14.4	.169	39.0	17.3	.204	46.7	20.1	.236
60	25.5	12.3	.145	34.0	15.4	.181	42.3	18.5	.218	50.5	21.5	.253
70	27.0	12.8	.151	36.1	16.2	.191	45.0	19.5	.229	53.8	22.7	.267
80	28.2	13.2	.155	37.8	16.8	.198	47.0	20.3	.239	56.2	23.6	.278
90	29.2	13.6	.160	39.2	17.3	.204	48.8	20.8	.245	58.2	24.3	.286
100	30.0	13.9	.164	40.0	17.6	.207	50.0	21.4	.252	60.0	25.0	.294

TABLE 9. STANDARD VOLUME TABLE

BLACK SPRUCE

MERCHANTABLE VOLUME IN CUBIC FEET
(Stump Height, 1.0 Feet: Top Diameter, 3 Inches)

TOTAL HEIGHT

D.B.H.	20	30	40	50	60
4	0.6	0.8	1.0	1.2	—
5	1.0	1.5	2.0	2.4	—
6	1.3	2.2	3.0	3.8	4.7
7	1.9	3.0	4.2	5.4	6.6
8	2.4	4.0	5.5	7.1	8.7
9		5.2	7.1	9.0	10.9
10		6.4	8.7	11.1	13.4
11			10.2	13.1	15.9
12			11.8	15.4	18.9
13			13.5	17.8	22.1
14			15.5	20.5	25.5
15			18.0	23.4	28.8
16			20.3	26.2	32.2
17			22.7	29.5	36.2
18			25.2	32.8	40.3
19				36.3	44.7
20				39.9	49.0

TABLE 10. STANDARD VOLUME TABLE

BALSAM FIR

MERCHANTABLE VOLUME IN CUBIC FEET
(Stump Height, 1.0 Feet: Top Diameter, 3 Inches)

TOTAL HEIGHT

D.B.H.	20	30	40	50	60
4	0.9	1.3	1.8	2.2	—
5	1.3	1.9	2.5	3.2	3.8
6	1.7	2.6	3.4	4.3	5.2
7	2.2	3.3	4.5	5.7	6.9
8		4.1	5.7	7.2	8.8
9		4.8	6.8	8.8	10.8
10		5.7	8.1	10.6	13.0
11			9.6	12.5	15.5
12			11.0	14.5	17.9
13			12.6	16.6	20.6
14			14.3	19.0	23.7
15			15.9	21.3	26.5
16				23.7	29.8
17				26.3	33.2
18				28.8	36.7
19				31.6	40.6
20				34.5	44.7

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