Forest Research Branch

COMPARISON OF TREE GROWTH ON TWO SITES IN THE RIDING MOUNTAIN FOREST EXPERIMENTAL AREA

by

J. S. JAMESON

Sommaire en français

DEPARTMENT OF FORESTRY PUBLICATION NO. 1019

1963

Published under the authority of
The Honourable John R. Nicholson, P.C., O.B.E., M.P.
Minister of Forestry
Ottawa, 1963

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1963

Catalogue No. Fo 47-1019

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ABSTRACT

Plot and tree measurements were made in uneven-aged white spruce-trembling aspen stands of common fire origin on the two predominant sites of the Riding Mountain Forest Experimental Area to compare stand and tree growth.

The number of merchantable trees, the rate of height growth and height of dominant trees at index ages and index diameters, and the merchantable and total volume were greater on the fresh Waitville site. Total number of trees per acre was greater on the moist Granville site.

The greater growth in volume and in height of dominant trees on the fresh site was attributed to more favourable soil texture, structure and moisture conditions than on the moist site.

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Comparison of Tree Growth on Two Sites in the Riding Mountain Forest Experimental Area

by
J. S. Jameson[2]

INTRODUCTION

Knowledge of the growth rates of trees on different kinds of forest land for the purpose of comparing levels of productivity is one of the requisites of silviculture, so that investment can be directed where it will yield the greatest return. One method of acquiring this knowledge is by the establishment and measurement of sample plots in mature stands. In the Riding Mountain Forest Experimental Area, sample plots were established in 1955 in mature trembling aspen[3] and white spruce stands to compare the growth of these two important tree species on the two most important sites or kinds of forest land. This paper reports on the results of that study.

DESCRIPTION OF AREA AND SITES

Location

The 25 square mile Riding Mountain Forest Experimental Area is located within Riding Mountain National Park about 140 miles northwest of Winnipeg, Manitoba and within the southeastern boundary of the B.18a Mixedwood Forest Section (Rowe 1959) (Figure 1).

Geology, Topography and Soil Parent Materials

The underlying geological materials are dark grey Cretaceous shales of the Riding Mountain formation, which are exposed on a steep east-facing escarpment about 15 miles east of the experimental area (Kirk 1930).

Surface deposits are largely glacial tills, although lacustrine materials, kames and terraces frequently occur near borders of existing small lakes and in former water channels (Johnston 1934). The topography over much of the area is moderately or strongly rolling, but near Clear Lake it is gently undulating or level. Elevations above sea level range from 2,016 feet at the lake to 2,300 feet.

The soil parent materials associated with the rolling topography are yellowish brown stony calcareous tills with a clay-loam texture; those associated with the level and undulating topography are dark greyish brown shaly tills with a clay-loam to clay texture. The kame, outwash and terrace materials are coarse gravel to medium sand; the lacustrine materials range from fine sand to clay.

Climate

Temperature and precipitation have been recorded at experimental area headquarters for the growing season (May to September) since 1951[4]. Annual summaries are available for Dauphin[5] where records have been maintained since

[1] Department of Forestry, Canada, Forest Research Branch Contribution No. 534.
[2] Forest Research Officer, Forest Research Branch, Department of Forestry, Winnipeg, Manitoba.
[3] For list of scientific names of plant species and abbreviations, see Appendix I.
[4] Waldron, R. M. 1961. Annual Meteorological Summaries for the Riding Mountain Forest Experimental Area. Canada Dept. of Forestry, For. Res. Br., Project MS-61, Unpub. Progress Report.
[5] Dauphin is located on a lacustrine plain, at 51.9° N. and 100.3° W, 970 feet above sea level and about 35 miles north of the experimental area which is at 2,250 feet above sea level. Dauphin is within the northern agricultural belt and its climate is typical of that region.

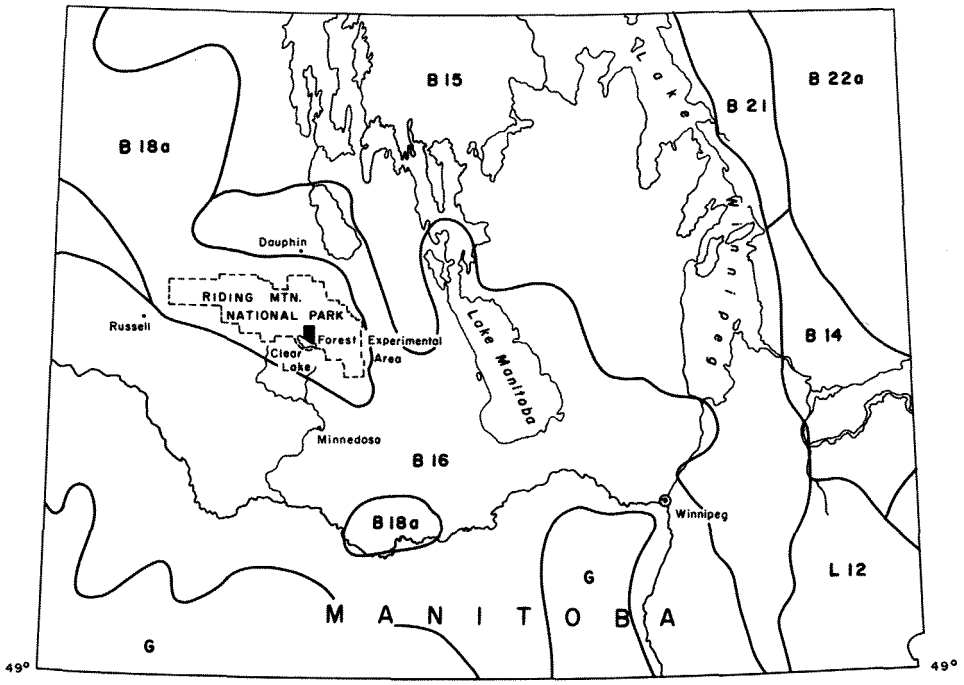

Figure 1. Location of experimental area and forest sections

1914. Mean January and mean annual temperatures, and mean annual precipitation for Dauphin, and a comparison of data for the growing season for the ten-year period 1951–59, for both stations are presented below:

Station	Mean Temperatures (°F)				Precipitation (inches)						
	May to Sept.	Jan.	July	Ann.	May	June	July	Aug.	Sept.	May to Sept.	Ann.
Dauphin (30 years)	60.0	2.5	67.8	36.7	1.84	3.17	2.51	2.12	1.70	11.34	17.79
(1951–59)	57.6	—	65.3	—	1.84	4.55	1.85	2.52	2.73	13.49	—
R. Mtn. (1951–59)	53.3	—	60.9	—	2.08	4.14	2.87	2.76	2.89	14.74	—

The experimental area is within a zone classed by Sanderson (1948) as dry subhumid, based on meteorological data obtained from Dauphin and other stations located outside the Riding Mountain area. However, the data presented above suggest that the Riding Mountain upland is moister and cooler than the dry subhumid zone within which it was mapped by Sanderson.

Forests

White spruce and trembling aspen predominate on fresh and moist sites, accompanied by white birch on the former and balsam poplar on the latter. Jack pine and balsam fir occur infrequently on the uplands and black spruce and tamarack occupy the wet depressions.

Merchantable stands were uneven-aged, with the oldest age class in white spruce and trembling aspen 100 to 120 years. Considerable aspen mortality had occurred and as a result most stands were semi-open. Average basal area in 1947 was 97 square feet per acre.

Sites—Soils and Lesser Vegetation

Fresh Waitville and moist Granville "sites" (syn. "habitats"—Nichols 1917) predominate and occupy more than fifty per cent of the experimental area (Rowe[1]). Soils of the fresh Waitville site have developed from yellowish brown stony calcareous clay-loam tills on moderately to strongly rolling topography; those of the moist Granville site from dark greyish brown shaly clay-loam to clay tills on smooth gently undulating topography. Table 1 presents generalized descriptions of typical soil profiles of these sites. The profile on the fresh Waitville site is characteristic of the Orthic Grey-Wooded subgroup (Figure 2); that on the moist Granville site of the Dark-Grey-Wooded subgroup (Figure 3). Both are representative of the Podzolic order of soils (Stobbe 1960).

TABLE 1—TYPICAL SOIL PROFILES ON FRESH WAITVILLE AND MOIST GRANVILLE SITES, RIDING MOUNTAIN FOREST EXPERIMENTAL AREA

Site	Fresh Waitville	Moist Granville
Moisture regime*	2—3	4—5
Organic horizons	2″ duff mull, Charcoal present	3″ mull, Charcoal present
A_h horizon depth	trace	3″
colour	10 YR 2/1**	10 YR 2/1
pH	—	5.9
texture	loam	loam to silt loam
A_e horizon depth	5″	2″
colour	10 YR 7/2 to 5/3	10 YR 8/1 to 6/2 outside 5Y 5/3 inside
pH	5.5	6.3
texture	sandy loam to loam	silty clay loam to clay loan
AB horizon depth	6″	3″
colour	10 YR 4/3 to 3/3	10 YR 4/1 to 10 YR 3/2
pH	5.6 to 6.1	6.3
texture	silty loam to clay loam	clay loam to heavy clay loam
B_t horizon depth	7″	6″
colour	10 YR 3/3 outside 10 YR 4/3 inside	10 YR 3/1 to 5 Y 3/2
pH	6.5	6.7
texture	clay loam to clay	clay
BC horizon depth	2″	4″
colour	10 YR 3/3 outside 10 YR 4/3 inside	2.5 Y 3/2 to 5/2
pH	7.0	7.1
texture	clay loam to heavy clay loam	heavy clay loam
C horizon depth	at 18 to 20″	at 18″
colour	10 YR 4/4 to 5/4	2.5 Y 4/2 to 5/2
pH	7.3+	7.3+
texture	clay loam	clay loam to heavy clay loam

* After Hills, G. A. (1950, 1952)
** Munsell Colour Chart.

[1] Rowe, J. S. 1954. Forest Sites—Riding Mountain Experimental Area 1953. Can. Dept. Northern Affairs and National Resources, For. Br., For. Res. Div., Unpub. Progress Report.

Figure 2. Soil profile on fresh Waitville site

Figure 3. Soil profile on moist Granville site

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Lesser vegetation on the fresh Waitville site consisted of vigorous tall shrubs and herbs dominated by hazelnut in the shrub layer and sarsaparilla, lungwort and bunchberry in the herb layer (Figure 4). These species were more abundant under pure aspen stands than under mixedwood and pure spruce stands.

Figure 4. Forest cover and lesser vegetation on fresh Waitville site

Lesser vegetation on the moist Granville site consisted of vigorous grasses and herbs dominated by marsh reed-grass, flat-topped white aster and goldenrod (Figure 5). These species occurred with similar abundance and frequency under all cover types.

Figure 5. Forest cover and lesser vegetation on moist Granville site

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METHODS

Many parameters have been studied to try to understand the relationship between the growth of stands and trees, and their environment. Those most commonly studied in comparing levels of productivity on different kinds of forest land are total wood volume and height of dominant trees in relation to age. Total wood volume is a direct measure of productivity that provides an estimate of the quantity of wood that a given area can produce. Height of dominant trees is an indirect measure that is widely accepted and, when correctly applied, is a useful *index* of productivity.

Irregular stand composition, uneven stand density, early suppression of dominant trees, and heterogeneity of site within the sample plot could confound results and invalidate the use of total wood volume and dominant height as indicators of total productivity for specific sites. To minimize these effects, plots were selected subjectively in fully stocked stands[1] of similar composition on homogeneous sites. Dominant trees chosen for height-age measurements and for stem analyses were also selected subjectively. To minimize any differences in growth which may have resulted from uneven stand density and irregular stand composition, only free-growing trees without any indication of past suppression were used. With these precautions it was assumed that age and history did not confound the results of the study.

Sampling areas were selected within fully stocked mature stands on homogeneous sites (fresh Waitville segments and moist Granville segments only) in four white spruce-aspen cover-type classes[2], a total of sixty one-fifth-acre plots being established. In addition, free-growing dominants of both species were selected off the plots.

The following measurements were made—

1. On one-fifth-acre plots:
   - (*a*) Diameter tally by species and one-tenth-inch classes of all living trees over 0.5 inch at breast height.
   - (*b*) Diameter, age and radial increment at breast height, and the total height of one tree in each one-inch diameter class of each species.
   - (*c*) Diameter, height and age of two free-growing dominant trembling aspen and white spruce.
   - (*d*) List of lesser vegetation species.
   - (*e*) Detailed soil description; topographic position.
   - (*f*) Remarks as to history, fire, damage by insects, etc.
2. On free-growing dominants selected off the plots:
   - (*a*) Stem analysis.
   - (*b*) Detailed soil description as in 1(*e*).
   - (*c*) Other remarks as in 1(*f*).

Sampling intensity for plots and stem-analysis trees was as follows:

Site	Cover type					Species	
	H	H-S	S-H	S	Total	tA	wS
	(Number of plots)					(Number of trees)	
Fresh Waitville	8	7	8	10	33	11	12
Moist Granville	7	6	7	7	27	10	11
Grand Total					60	21	23

[1] Fully stocked stands on both sites were defined as those having a basal area in excess of 172 square feet per acre with uniformly distributed stocking.

[2] Cover-type classes are based on content of softwood by basal area as follows: hardwood type (H) = 0–25 per cent softwood; hardwood-softwood type (H-S) = 26–50 per cent softwood; softwood-hardwood type (S H) = 51–75 per cent softwood; and softwood type (S) = 76–100 per cent softwood.

Height/diameter curves were prepared for trembling aspen and white spruce for each combination of cover type and site. From these curves and standard volume tables (Anon. 1948 and Johnson[1]), local total and merchantable volume tables were constructed according to methods described by Bedell (1948). Stand and stock tables were prepared for each cover type and site (Appendix III, Tables 1 to 4).

Free-hand dominant-height/age curves were prepared by site and species, and a curvilinear regression analysis was made of the white spruce data.

Measurements were made of total radius, inside the bark, and of radius ten years ago as it was in 1945. In calculating the diameters ten years previous, methods described by Smithers (1949) were used. Diameter at the time of measurement (1955) was plotted over diameter ten years ago (1945) by species and site. Free-hand curves were drawn and diameter increment for the ten-year period determined for each one-inch diameter class.

Data from stem-analysis trees were inspected for the purpose of discarding trees that had undergone early suppression. Stump height, breast height and height at each succeeding five-foot section above breast height were plotted over ages at those heights. Points were joined by straight lines, and height at each decade was read directly. Free-hand curves of height/age were then drawn for the two species by site. Radius was similarly plotted and free-hand curves of d.b.h./age were drawn, by species and site, from which dominant height/diameter curves were prepared. Statistical comparisons were made only for the height/age curves of the dominant white spruce (Figure 11) and for basal area by cover type for the two sites. The differences between the fresh site and the moist site in the hardwood-softwood cover type were found to be significant at the five per cent level. Differences for the other cover-types were not significant. Statistical comparisons for other stand factors were not made because basal area differences were not significant.

RESULTS

Table 2 presents a summary of the most important stand characteristics for the two sites, in which data for all cover types have been combined. Basal area, total volume and merchantable volume (14 inches d.b.h. and up) were greater (the latter was greater by an average of 1,000 cubic feet per acre) on the fresh Waitville site than on the moist Granville site. Height of dominant white spruce was considerably greater and of dominant aspen slightly greater on the former site.

Stand structure for the four cover types and two sites is shown in a series of phytographs in Figure 6. Number of trees was less, and basal area and volume were greater on the fresh Waitville site. Diameter of the largest tree was greater on the fresh Waitville site in two of the four cover types. Differences between the two sites were pronounced in the softwood and hardwood cover types; they were less in the hardwood-softwood and softwood-hardwood cover types.

Age Comparisons

The number of years required[2] to grow from stump height to breast height was greater for both species on the moist Granville site than on the fresh Waitville site. The mean and range for each group is shown below:

	Fresh Waitville	*Moist Granville*
	years	*years*
White spruce	5.6 (3 to 9)	7.2 (4 to 16)
Trembling aspen	5.8 (4 to 10)	6.0 (3 to 9)

[1] Johnson, H. J. 1955. Standard White Spruce Volume Tables. Can. Dept. Northern Affairs and National Resources, For. Br. Unpub. Report.

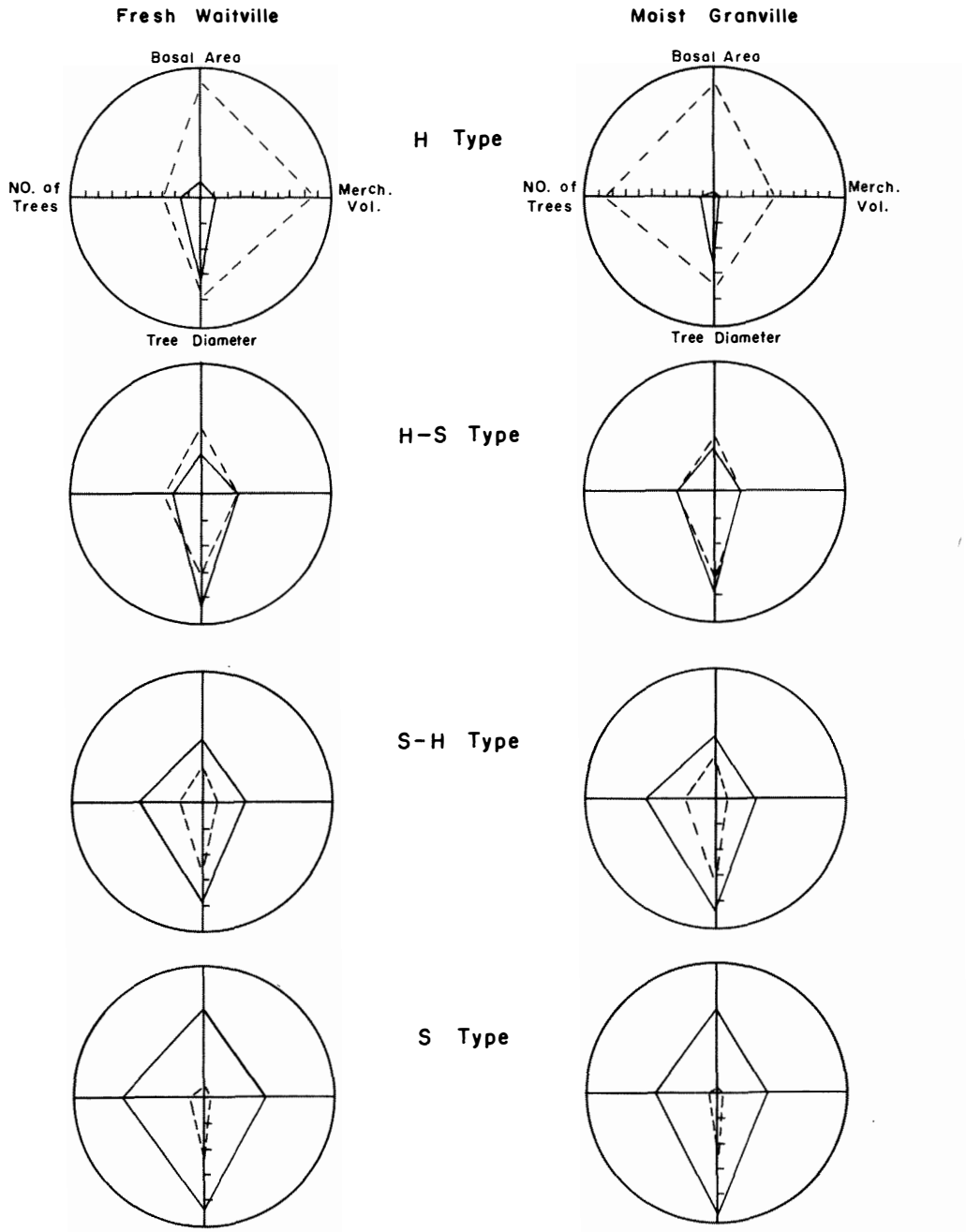
[2] Basis: Age counts at stump height (one foot) and breast height (4.5 feet) on 44 dominant stem analysis trees.

TABLE 2. SUMMARY OF STAND CHARACTERISTICS BY SITES

(All Cover Types Combined)

Riding Mountain Forest Experimental Area

Site	Number of Trees		Basal Area (sq ft.)		Total Volume (cu. ft.)		Merchantable Volume (cu. ft.)		Height of Free-Growing Dominants (feet)								
									Total Height Analysis		Stem Analysis						
	Per Acre								White Spruce		White Spruce				Trembling Aspen		
	Soft-wood	Total	Soft-wood	Total	Soft-wood	Total	Soft-wood	Total	120 yrs	18″ dbh	50 yrs	100 yrs	14″ dbh	18″ dbh	50 yrs	100 yrs	16″ dbh
Fresh Waitville.....	249	370	100	202	2,760	6,080	1,670	3,340	94	87	59	89	67	84	52	73	74
Moist Granville.....	227	468	90	194	2,360	5,390	1,320	2,360	89	81	51	82	59	74	49	70	72
Fresh/Moist—Percent	110	79	113	104	117	113	127	142	106	107	116	108	114	113	106	104	103



Phytographs show comparative number of trees, basal area, merchantable volume and diameter of largest tree (diameter expressed as a percentage of the greatest diameter in any type on either site) of White Spruce (—) and Trembling Aspen (--) in each cover type and site.

Figure 6. Stand structure for the four cover types and the two sites

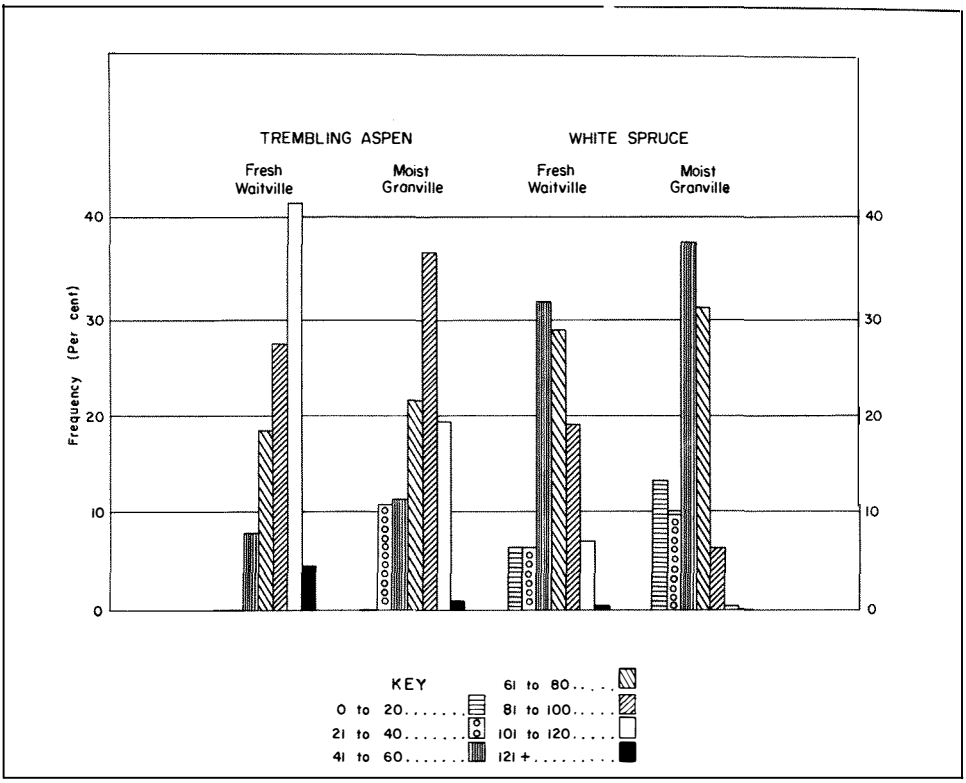


Figure 7. Distribution of breast-height age classes by species and sites

The frequency distribution (in per cent) of white spruce and trembling aspen by breast-height age classes and sites is shown in Figure 7. Trembling aspen is not represented in the youngest age class and predominates in age classes above 80 years. On the other hand, white spruce is more evenly distributed throughout all age classes on both sites.

Number of Trees

In three of the four cover-type classes there were more trees, considering all diameter classes, on the moist Granville site than on the fresh Waitville site (Figure 8). However, the number of merchantable trees (14 inches d.b.h. and up) was greater on the fresh Waitville site in all cover types (Figure 9).

Basal Area

Average basal area for all cover types was 194 square feet per acre on the moist Granville site compared with 202 square feet per acre on the fresh Waitville site. This difference was the result of a larger number of merchantable trees on the fresh site as compared to the moist site and was attributed to the effects of site.

Diameter Increment

The ten-year diameter increment plotted against diameter for each species on each site is shown in Figure 10. In the smaller diameter classes, diameter increment was greater on the moist site than on the fresh site. In the larger diameter classes, diameter increment was maintained on fresh sites, whereas it fell to a lower rate on moist sites.

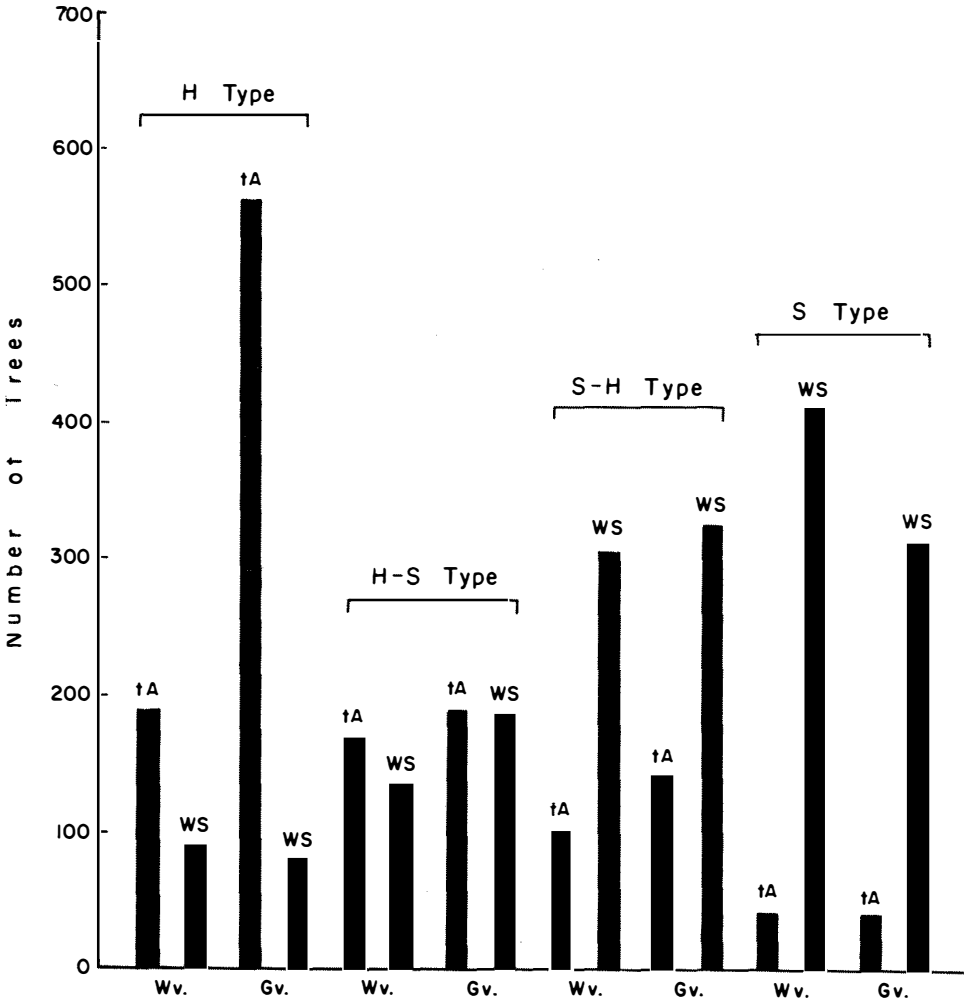


Figure 8. Number of trees per acre by site, cover type and species

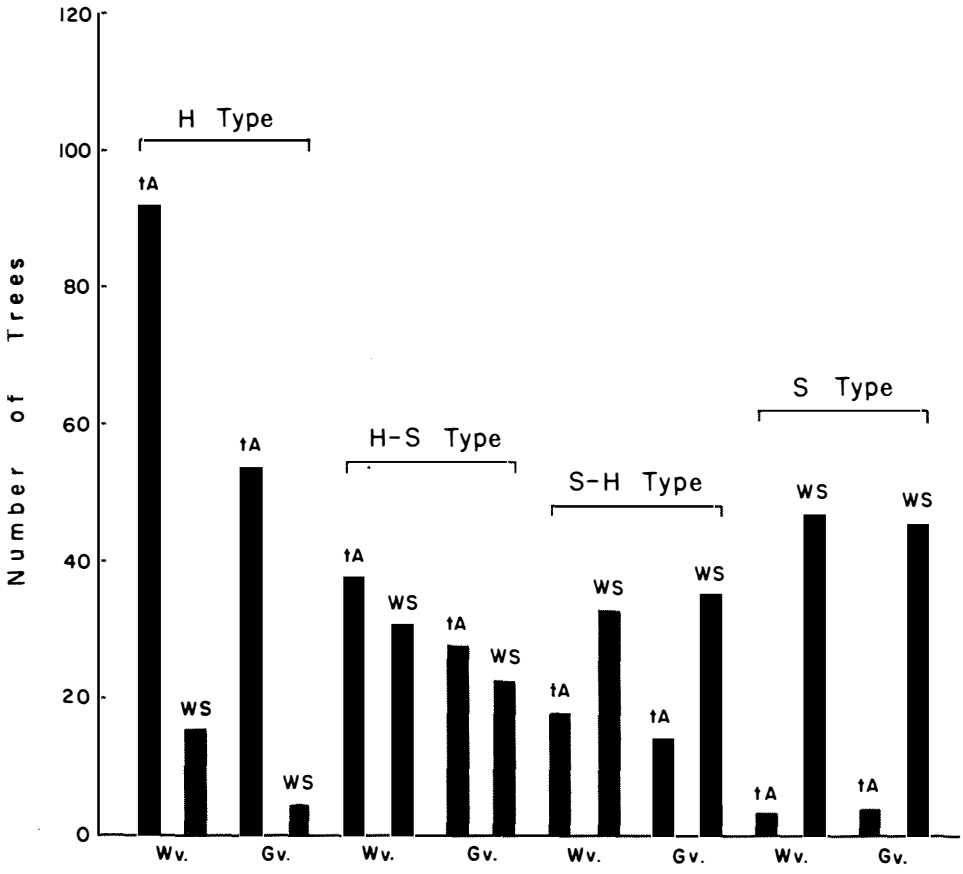


Figure 9. Number of merchantable trees (14" D.B.H. and up) per acre by site, cover type and species

Basal Area Increment

Periodic diameter increment for the preceding ten years (1945–1955) was converted to basal area and applied to the average stand table for each cover type and site to provide basal area increment in square feet per acre. For merchantable trees (14 inches d.b.h. and up) basal area increment was greater on the fresh site than on the moist site in all but the softwood-hardwood cover type. However, for all trees it was less on the fresh site than on the moist site in all but the softwood cover type. Basal area increment by cover type and site is as follows:

Site	H		H-S		S-H		S	
	1"+	14"+	1"+	14"+	1"+	14"+	1"+	14"+
	(square feet)							
Fresh Waitville	26.7	16.5	29.3	12.8	28.8	9.1	34.0	11.3
Moist Granville	38.3	9.5	36.5	10.9	37.7	10.8	31.6	9.7
Fresh/moist—per cent	70	174	80	117	76	86	108	116

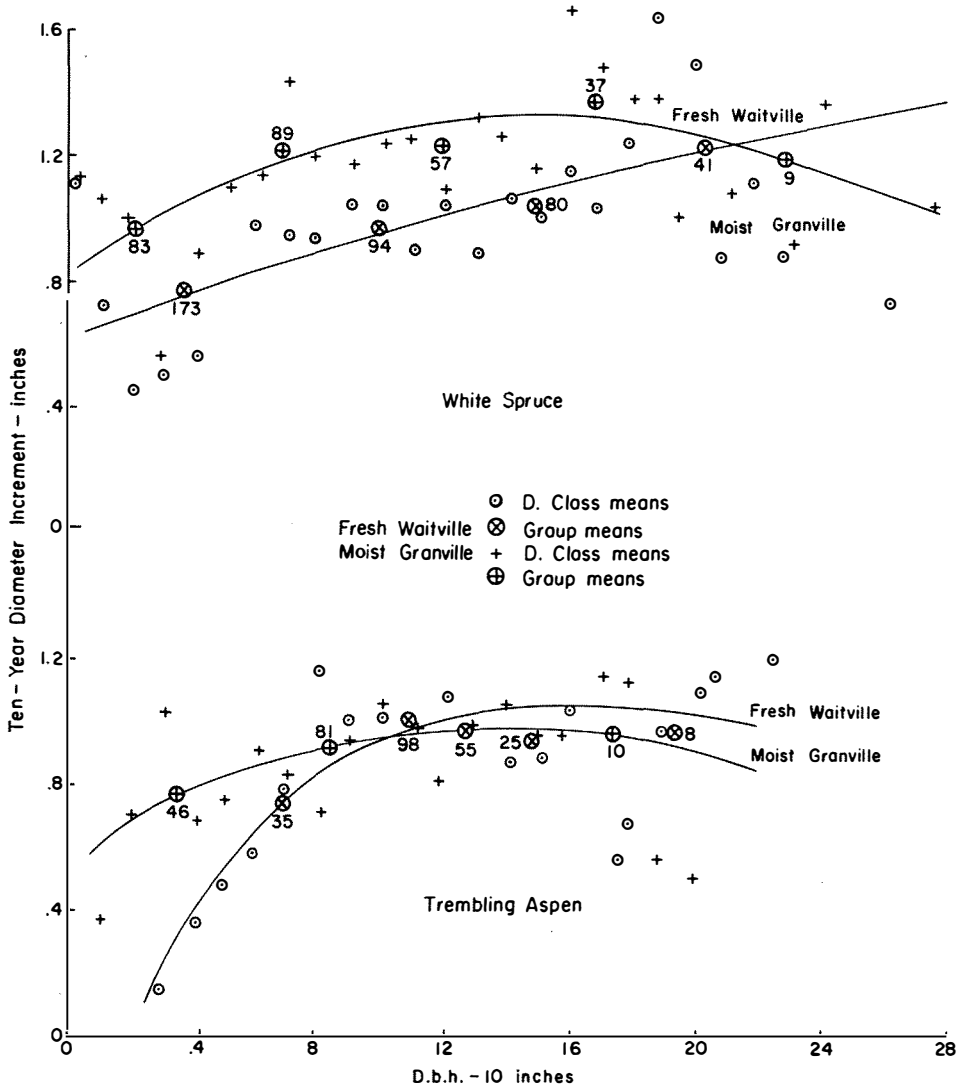


Figure 10. Influence of site on diameter increment to diameter relationship. (All cover types combined)

Height

Height in Relation to Age—Height of free-growing dominants of both species was greater (Figure 11), by an average difference of six feet, on the fresh Waitville site than on the moist Granville site. Differences between the white spruce curves were significant at the five per cent level. While the differences may be considered small, the statistical test indicated that they were largely due to effects of site and that within-site variation was low. Statistical tests were not made of the trembling aspen data.

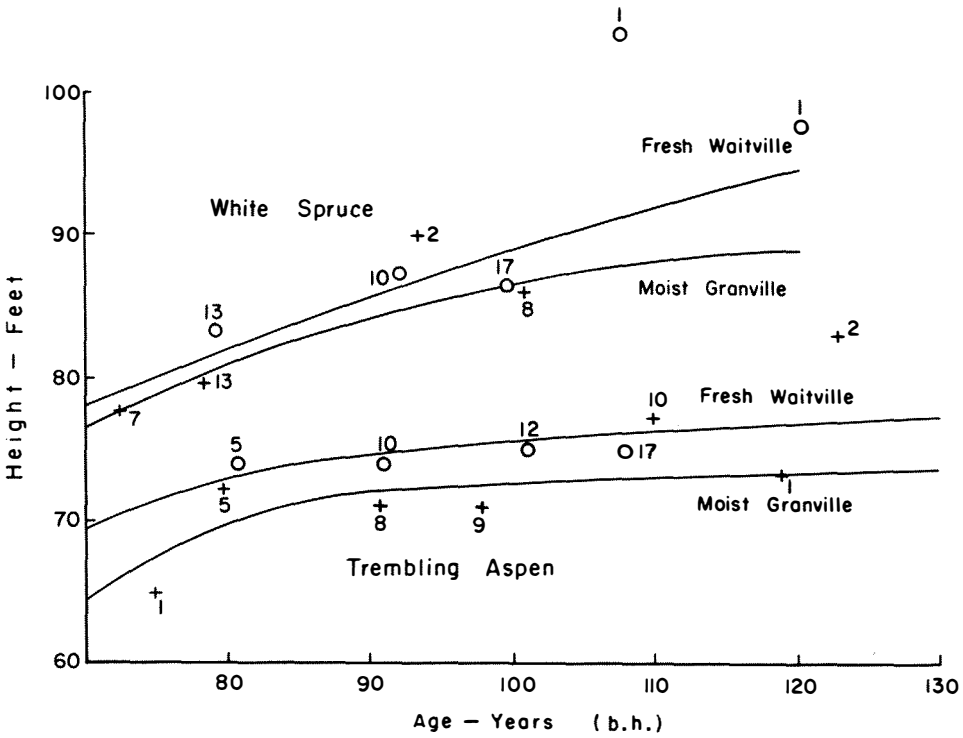


Figure 11. Influence of site on dominant height to age relationship. (All cover types combined)

Height in Relation to Diameter—Figure 12 shows height/diameter curves for trembling aspen and white spruce on the fresh Waitville and moist Granville sites, irrespective of cover type. Trembling aspen and white spruce were respectively ten and seven feet taller on the fresh site than on the moist site at maximum diameters of 24 and 28 inches. In the smaller diameter classes, height differences were less.

Stratification of the data by cover types did not change the relative positions of the curves, but it did make clearer height separations in some instances—notably for white spruce in the hardwood and softwood-hardwood cover types and for trembling aspen in all cover types.

Diameter was substituted for age as the independent variable for free-growing dominant white spruce (Figure 13). The relative positions of these two curves are the same as those of the height/age curves of Figure 11. However, height differences are greater and more consistent than provided by the height/age curves.

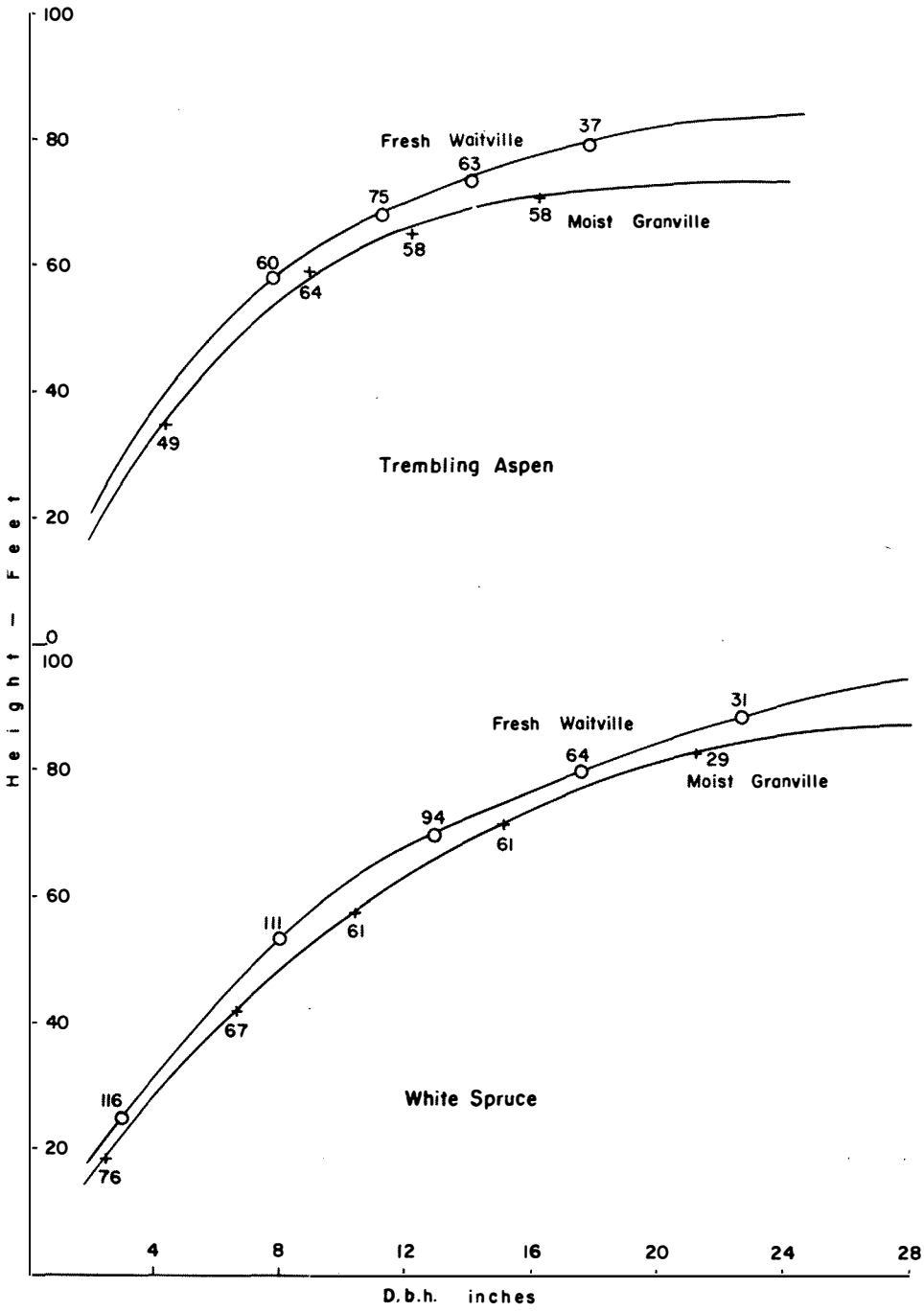


Figure 12. Influence of site on height to diameter relationship. (All cover types)

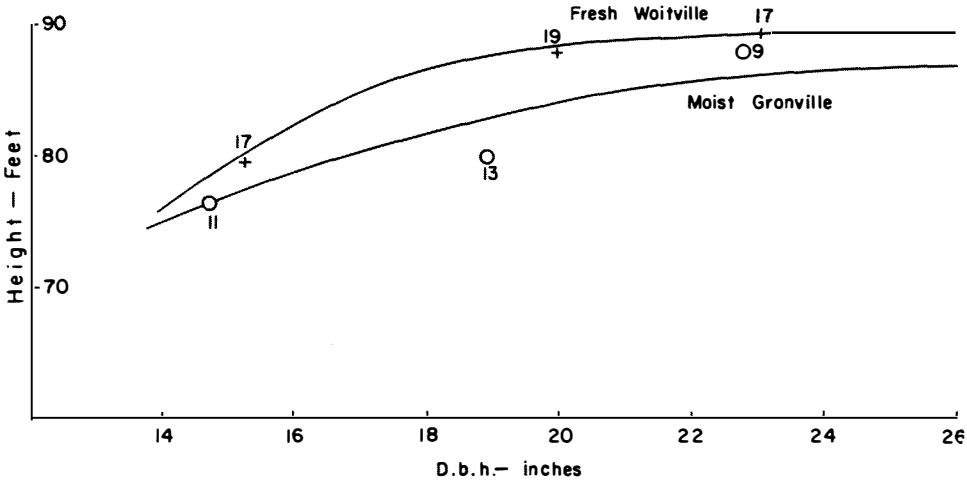


Figure 13. Influence of site on dominant height to diameter relationship—white spruce

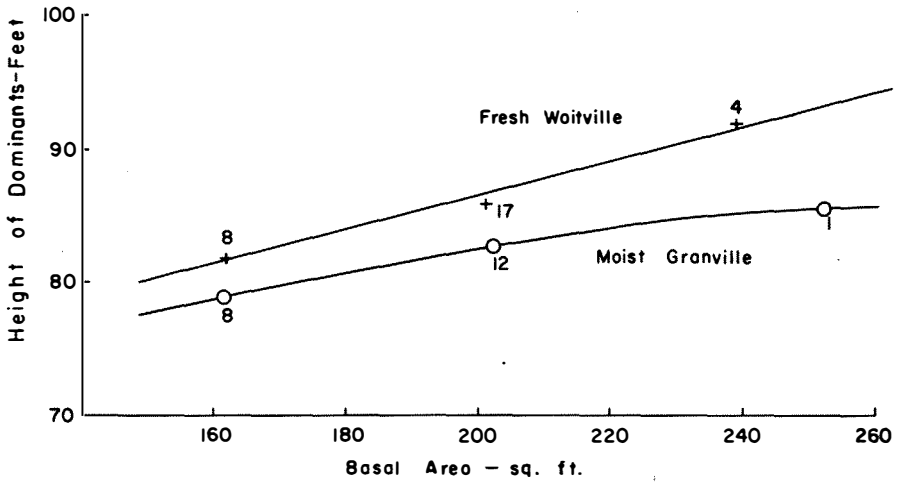


Figure 14. Relationship of dominant height of white spruce to basal area per acre by sites

Height in Relation to Basal Area—Basal area and dominant height have been shown to be greater on the fresh site than on the moist site. Figure 14 illustrates that for similar stand densities, dominant height of white spruce was greater on the fresh Waitville site than on the moist Granville site. Between-site differences are slightly greater at higher than at lower densities. One can only speculate as to whether this change in height difference with density is, in part, a result of density itself, or wholly the result of other influences.

Volume

Total volume for all cover types averaged 700 cubic feet greater on the fresh site than on the moist site (Table 2). Between-site differences ranged from a negligible volume in the softwood-hardwood cover type to 1,500 cubic feet in the hardwood cover type (Figure 15).

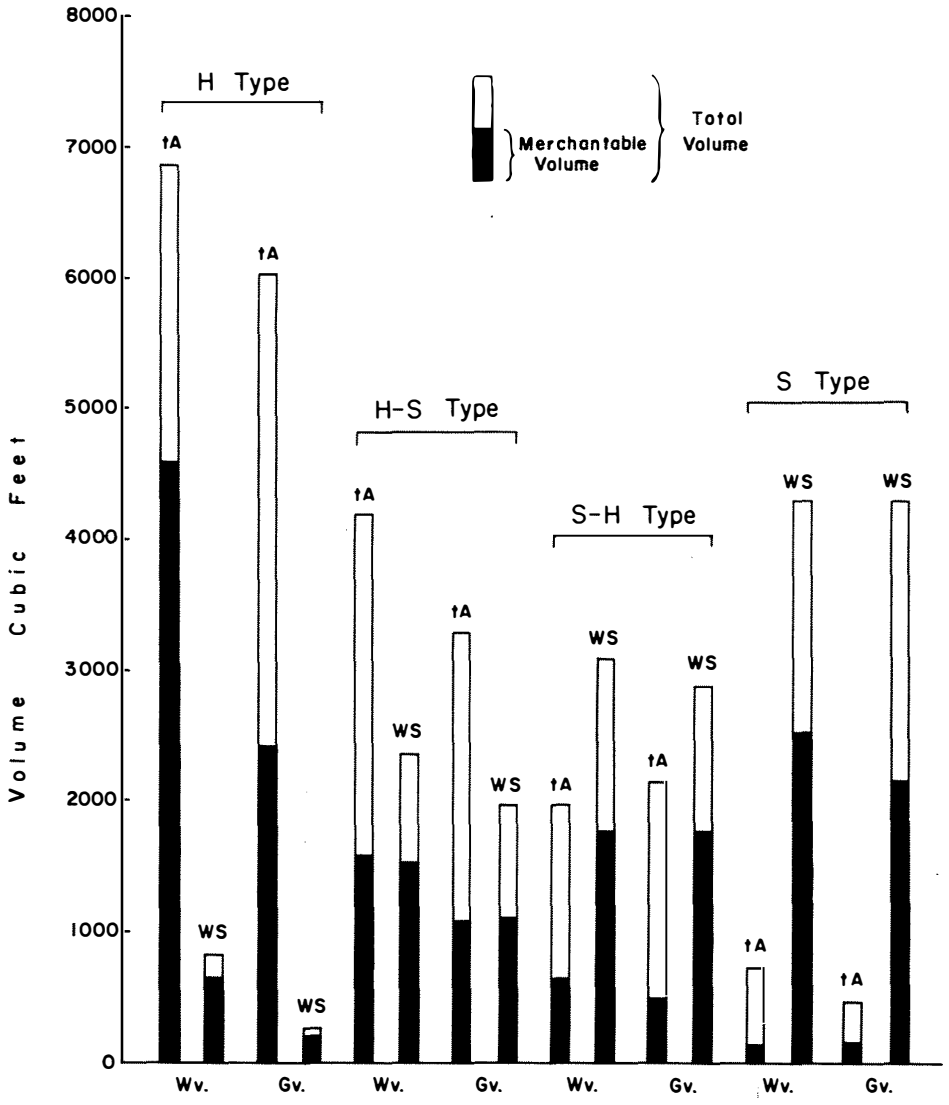


Figure 15. Total and merchantable volume by site, cover type and species

Merchantable volume (14 inches d.b.h. and up) on the fresh site exceeded that on the moist site by volumes ranging from 200 cubic feet in the softwood-hardwood cover type to 2,600 cubic feet in the hardwood cover type, and averaged 1,000 cubic feet per acre in all four cover types (Figure 15, Table 2). Sawlog volume in board feet, approximated by multiplying merchantable cubic feet by the factor 5, averaged 5,000 board feet greater on the fresh site than on the moist site.

Stem Analysis

Height/age curves from stem analysis of selected dominant white spruce trees on each site are shown in Figure 16. Heights at 50 years and 100 years (index ages) were 59 and 89 feet on the fresh Waitville site and 51 and 82 feet on the moist Granville site.

The curves in Figure 16 are not directly comparable with those of Figure 11 because breast height age rather than total age was used in the latter. Nevertheless it is clear that if adjustment was made to a common age, the curves would still not correspond in that age segment common to both. A number of factors might contribute to this situation, but sampling errors are considered to be mainly responsible.

Both sets of curves (Figures 11 and 16), nonetheless, depict differences in height attributable to site. The stem analysis curves are better defined, and probably more adequately describe the sites because they provide height not only at maturity but at all ages.

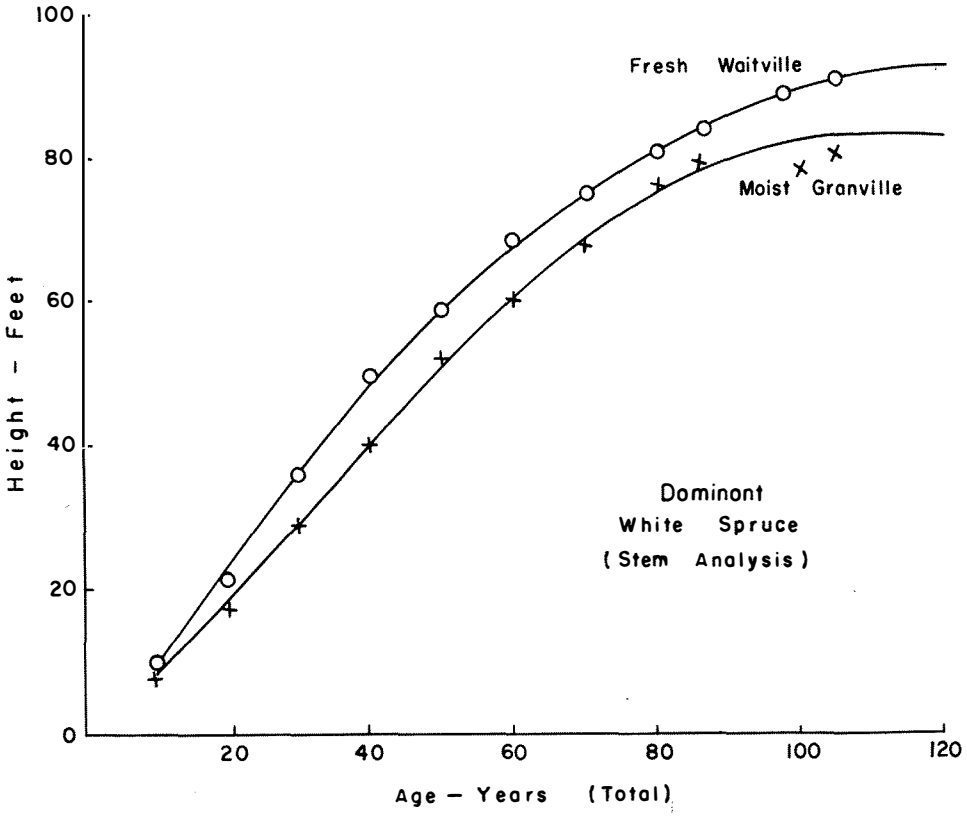


Figure 16. Influence of site on height to age relationship

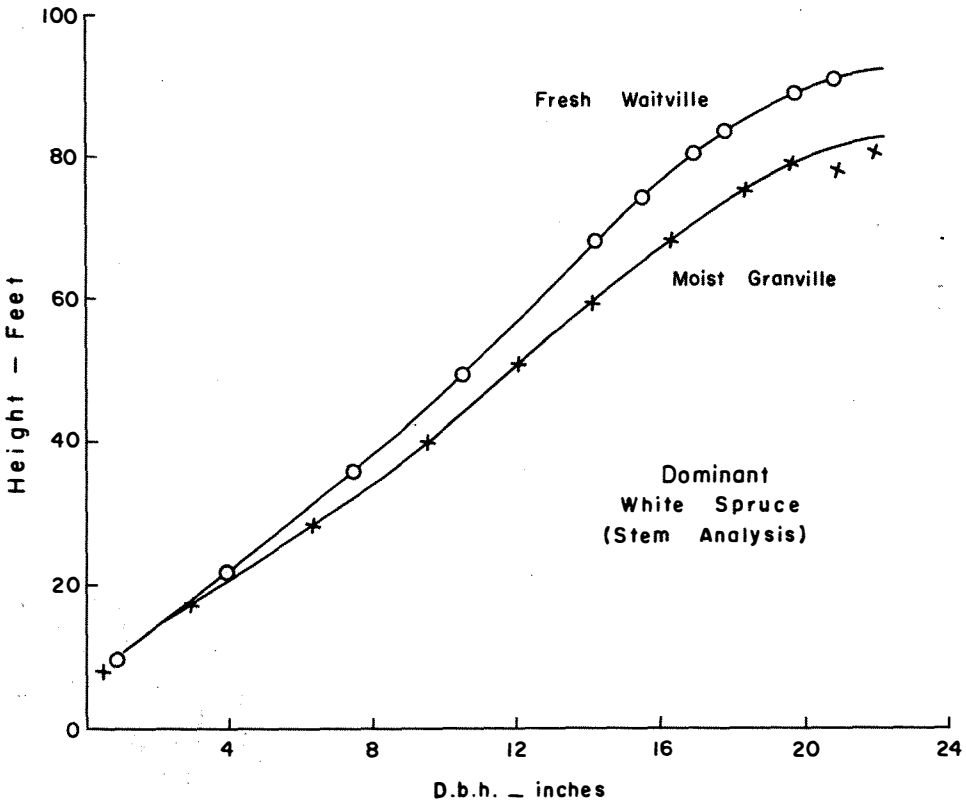


Figure 17. Influence of site on height to diameter relationship

Figure 17 shows height/diameter curves prepared by substituting diameter for age as the independent variable from stem analysis data. At index diameters of 14 inches and 18 inches, heights were 67 and 84 feet on the fresh site and 59 and 74 feet on the moist site.

Height/age curves for ten trembling aspen dominants indicated that height at index ages of 50 and 100 years was three feet greater on the fresh site than on the moist site. These differences are of little practical significance (Table 2).

DISCUSSION

This study has shown that there were significant differences between the stands on the two sites. Dissimilarities in topography, parent material, soil, soil moisture and vegetation were associated with substantial differences in the number of merchantable trees, rate of height growth, height of dominant trees and, consequently, in total and merchantable volume.

The fact that seedlings took longer to reach breast height, that dominant height was less at index ages and index diameters, and that total and merchantable volumes were lower on the moist Granville site than on the fresh Waitville site can be attributed primarily to differences in soil and in the associated vegetation.

On the fresh Waitville site, the soil has a slightly coarse but more favourable texture, and a sub-angular blocky but more favourable structure, than on the moist Granville site. On the latter site the soil is a very tenacious clay with a

structure that is massive when wet and columnar when dry. The soil on the fresh Waitville site is readily penetrated by tree roots; the soil on the moist site is penetrated by tree roots with some difficulty.

During the early part of the growing season there are excesses of soil moisture on the moist Granville site, partly due to topographic position and partly due to soil texture and structure, resulting in relatively poor soil aeration and low soil temperatures. On the fresh Waitville site soil moisture is seldom excessive, so that soil aeration and soil temperatures appear to be more satisfactory.

As the growing season progresses, soil moisture is reduced through transpiration and evaporation, resulting in the development of a columnar structure on the moist site. According to Wilde (1958), such structural formations may cause cracking at the soil surface and breakage of fine rootlets. On the fresh site no structural change occurs.

The moist growing conditions on the Granville site provide a suitable habitat for the development of the grass *Calamagrostis canadensis*. The less-moist growing conditions on the fresh Waitville site provide a suitable habitat for development of tall shrubs and herbs, such as *Corylus cornuta* and *Aralia nudicaulis*. As a longer period of time was required for seedlings to reach breast height on the moist site, it is concluded that the moister soil and more vigorous vegetation contributed to the slower seedling development. Waldron[1] also found that vegetation competed vigorously with artificial and natural regeneration on these two sites, but to a lesser degree on the fresh Waitville site.

The poorer growth in height of dominant trees on the moist site may be attributed to poorer growing conditions due to excessive soil moisture during the month of June when height growth was taking place. Waldron (1961) and Wheaton[2] have shown that more than 70 per cent of height growth in this area occurs in June, and it is concluded that the excessive soil moisture on the moist site had an adverse effect on height growth of dominants.

On the other hand, the better periodic diameter growth for all but the larger diameter classes on the moist site may be due to more favourable moisture conditions on this site during the latter part of the growing season. According to Wheaton, 70 per cent of diameter growth at the Riding Mountain Forest Experimental Area occurs after June 20—after the period of high rainfall—when soil moisture on the fresh site is being depleted.

Although the moist Granville site produced greater diameter growth during the last ten years, the fresh Waitville site appears to have a higher potentiality as confirmed by a greater rate of seedling development, rate of height growth, height of dominant trees, total volume and merchantable volume per acre. Thus it is concluded that more intensive silviculture for white spruce can be practised on the fresh Waitville site than on the moist Granville site as the investment should provide greater benefits in yield per acre.

[1] Waldron, R. M. 1961. The effect of site on survival of planted white spruce, Riding Mountain Forest Experimental Area. Canada Dept. of Forestry, For. Res. Br., Project MS–160–55A Unpublished Report.

[2] Wheaton, M. P. H. 1958. White spruce growth in relation to environment. Can. Dept. of Northern Affairs and National Resources, For. Br., For. Res. Div., Project MS–184, Unpub. Progress Report.

SUMMARY

An evaluation of two forest sites in the Riding Mountain Forest Experimental Area of the B.18a Forest Section was conducted in 1955 using Hills' (1950, 1952) physiographic approach. The sites had been previously recognized and briefly described, so that essentially this study consisted of gathering information on growth.

Sixty one-fifth-acre plots in well stocked uneven-aged white spruce-trembling aspen stands were established. Forty-four dominant free-growing mature trees were stem analysed. For each plot and stem analysis tree, soil, vegetation and topography were described.

From the studies it was clear that the dominant white spruce were significantly taller and the number of merchantable trees and the merchantable and total volumes per acre of white spruce and trembling aspen were substantially greater on the fresh site than on the moist site. Total number of trees per acre was greater on the moist Granville site. The greater growth in volume and in height of dominant trees on the fresh site was attributed to more favourable soil texture, structure and moisture than on the moist site.

Although there were similarities in some areas, it was concluded that the differences in growth, coupled with the significant differences in soil, topography, and vegetation, were sufficient to warrant separation of the sites for forest management purposes within the area.

SOMMAIRE

Une étude de deux stations dans l'aire d'expérimentation forestière du mont Riding, section forestière B.18a, a été exécutée en 1955 selon la méthode physiographique de Hills (1950, 1952). Les places avaient déjà été délimitées et décrites brièvement, de sorte que l'étude a consisté particulièrement à recueillir des données sur la croissance.

On a établi soixante places d'un cinquième d'acre bien pourvues de peuplements inéquiennes d'épinette blanche et de peuplier faux-tremble. L'auteur a analysé les fûts de quarante-quatre vigoureux arbres dominants d'âge mûr. Pour analyser chaque parcelle et chaque fût, il décrit l'arbre, le sol, la végétation et la topographie.

D'après les études exécutées, il est évident que les épinettes blanches dominantes étaient sensiblement plus hautes que les peupliers faux-trembles, et que le nombre d'arbres marchands et les volumes marchands globaux de l'épinette blanche et du peuplier faux-tremble à l'acre étaient sensiblement plus considérables dans la station fraîche que dans la station humide. Le nombre global d'arbres à l'acre était plus élevé dans la station humide de Granville. L'accroissement supérieur en volume et en hauteur des arbres dominants dans la station fraîche a été attribué à la texture, à la composition et à l'humidité du sol plus propices que dans la station humide.

Bien qu'il y ait certains facteurs analogues à certains endroits, l'auteur conclut que les différences de croissance associées aux différences importantes que présentent le sol, la topographie et la végétation basse, sont suffisantes pour justifier le classement des stations à des fins d'aménagement forestier dans la région.

APPENDIX I

Common and Scientific Names in Text

Aspen, trembling	tA	*Populus tremuloides* Michx.
Birch, white	wB	*Betula papyrifera* Marsh.
Fir, balsam	bF	*Abies balsamea* (L.) Mill.
Larch	tL	*Larix laricina* (Du Roi) K. Koch
Pine, jack	jP	*Pinus banksiana* Lamb.
Poplar, balsam	bP	*Populus balsamifera* L.
Spruce, black	bS	*Picea mariana* (Mill.) BSP.
Spruce, white	wS	*Picea glauca* (Moench) Voss
Aster, flat-topped white		*Aster umbellatus* Mill.
Bunchberry		*Cornus canadensis* L.
Goldenrod		*Solidago* spp.
Grass, marsh reed-		*Calamagrostis canadensis* (Michx.) Nutt.
Hazelnut		*Corylus cornuta* Marsh.
Lungwort		*Mertensia paniculata* (Ait.) G. Don.
Sarsaparilla		*Aralia nudicaulis* L.

APPENDIX II

Glossary of Terms

Regime, soil moisture (Hills, 1950)

Soil moisture regime refers to the fluctuation in levels of available moisture during a complete vegetation cycle (season).

Site (Syn. habitat)

Habitat, or site is defined by Nichols (1917) "as any unit area in which the combined influence of the various external factors which determine the ecological aspect of the vegetation is such as to produce an essentially uniform environment".

APPENDIX III

STAND AND STOCK TABLES

TABLE 1

STAND AND STOCK TABLE, PER ACRE HARDWOOD (H) COVER TYPE

	Granville—Moist						Waitville—Fresh					
	Number of Trees			Total Volume (cu. ft.)			Number of Trees			Total Volume (cu. ft.)		
D.b.h.	tA	wS	bP	tA	wS	bP	tA	wS	wB	tA	wS	wB
1	7.2	33.6	—	.3	.7	—	—	35.0	—	—	1.0	—
2	78.0	21.4	—	20.3	2.8	—	—	18.1	—	—	3.3	—
3	137.9	8.6	1.4	104.8	3.4	1.1	—	3.7	—	—	1.9	—
Total	223.1	63.6	1.4	125.4	6.9	1.1	—	56.8	—	—	6.2	—
4	63.6	1.4	—	102.4	1.2	—	—	1.9	0.6	—	2.1	1.2
5	17.9	2.1	0.7	52.1	3.4	2.0	—	1.2	—	—	2.4	—
6	12.9	—	0.7	59.3	—	3.2	—	1.2	—	—	4.0	—
7	15.0	—	0.7	103.5	—	4.8	—	0.6	0.6	—	3.1	4.6
8	28.6	3.6	—	274.6	21.1	—	5.0	1.2	0.6	52.5	8.8	6.3
9	34.3	4.3	—	442.5	34.8	—	8.6	1.9	0.6	118.7	19.4	8.3
10	49.3	—	—	823.3	—	—	21.3	3.1	1.9	379.1	42.2	33.8
11	27.1	0.7	—	561.0	10.0	—	21.3	—	—	468.6	—	—
12	20.0	—	—	500.0	—	—	19.4	1.9	—	519.9	42.2	—
13	18.6	—	—	554.3	—	—	23.1	2.5	—	741.5	68.2	—
Total	287.3	12.1	2.1	3,473.0	70.5	10.0	98.7	15.5	4.3	2,280.3	192.4	54.2
14	12.9	0.7	—	447.6	18.8	—	24.4	6.3	—	915.0	190.9	—
15	11.4	0.7	—	452.6	22.3	—	21.9	3.1	—	946.1	120.3	—
16	13.6	0.7	—	614.7	25.9	—	11.2	3.1	—	554.4	138.9	—
17	5.0	—	—	254.0	—	—	13.8	1.2	—	779.7	61.8	—
18	5.7	1.4	—	323.8	68.0	—	11.2	0.6	—	700.0	34.8	—
19	2.1	—	—	132.3	—	—	5.6	—	—	392.0	—	—
20	2.1	0.7	—	146.0	42.4	—	1.9	0.6	—	147.2	42.0	—
21	0.7	—	—	53.6	—	—	0.6	0.6	—	51.3	46.2	—
22							0.6	—	—	56.1	—	—
23							—	—	—	—	—	—
24							0.6	—	—	66.6	—	—
25												
26												
27												
28												
29												
30												
Total	53.5	4.2	—	2,424.6	177.4	—	91.8	15.5	—	4.608.4	634.9	—
Grand Total	563.9	79.9	3.5	6,023.0	254.8	11.1	190.6	87.8	4.3	6,888.7	833.5	54.2

TABLE 2

STAND AND STOCK TABLE, PER ACRE HARDWOOD-SOFTWOOD (H-S) COVER TYPE

	Granville—Moist						Waitville—Fresh					
	Number of Trees			Total Volume (cu. ft.)			Number of Trees			Total Volume (cu. ft.)		
D.b.h.	tA	wS	bP	tA	wS	bP	tA	wS	wB	tA	wS	wB
1	3.3	32.5	—	0.2	1.0	—	—	12.1	—	—	0.4	—
2	5.8	14.2	—	1.7	2.6	—	—	7.1	—	—	1.3	—
3	3.3	14.2	—	2.7	7.7	—	—	7.1	—	—	4.0	—
Total	12.4	60.9	—	4.6	11.3	—	—	26.3	—	—	5.7	—
4	3.3	10.0	0.8	5.4	11.3	1.3	0.7	7.8	0.7	1.2	9.8	1.2
5	9.2	11.7	—	26.5	24.0	—	—	8.6	—	—	19.4	—
6	7.5	17.5	1.7	33.8	57.8	7.6	3.6	9.3	—	17.2	34.3	—
7	15.0	15.8	—	99.3	78.2	—	5.0	11.4	0.7	35.2	63.8	4.9
8	15.8	11.7	—	143.8	82.5	—	5.7	10.0	0.7	56.7	80.0	7.0
9	20.0	6.7	0.8	244.0	65.0	9.3	20.0	5.0	—	268.0	55.0	—
10	23.3	8.3	—	365.8	106.2	—	19.3	7.1	0.7	332.0	103.0	12.0
11	23.3	6.7	—	456.7	111.2	—	22.8	4.3	—	483.4	79.6	—
12	20.0	5.0	—	478.0	103.0	—	29.3	5.0	0.7	753.0	114.5	18.0
13	12.5	8.3	—	351.2	211.6	—	22.1	9.3	—	674.0	259.5	—
Total	149.9	101.7	3.3	2,204.5	850.8	18.2	128.5	77.8	3.5	2,620.7	818.9	43.1
14	9.2	7.5	0.8	301.8	232.5	26.2	10.7	7.1	1.4	379.8	233.6	49.7
15	9.2	2.5	—	342.2	92.0	—	11.4	7.1	—	458.3	274.1	—
16	5.0	2.5	—	212.5	108.0	—	10.7	4.3	—	486.9	191.4	—
17	2.5	2.5	—	118.8	125.2	—	0.7	2.9	—	36.0	145.0	—
18	0.8	—	—	42.0	—	—	2.8	2.1	—	159.6	119.7	—
19	—	3.3	—	—	209.6	—	—	2.9	—	—	187.0	—
20	—	1.7	—	—	119.8	—	0.7	0.7	—	48.6	50.0	—
21	0.8	—	—	54.4	—	—	—	1.4	—	—	109.2	—
22	—	0.8	—	—	68.4	—	—	—	—	—	—	—
23	—	0.8	—	—	74.4	—	—	0.7	—	—	64.4	—
24	—	0.8	—	—	79.6	—	—	0.7	—	—	69.6	—
25							—	—	—	—	—	—
26							—	—	—	—	—	—
27							—	0.7	—	—	84.0	—
28												
Total	27.5	22.4	0.8	1,071.7	1,109.5	26.2	37.0	30.6	1.4	1,569.5	1,528.0	49.7
Grand Total	189.8	185.0	4.1	3,280.8	1,971.6	44.4	165.5	134.7	4.9	4,190.2	2,352.6	92.8

TABLE 3

STAND AND STOCK TABLE, PER ACRE SOFTWOOD-HARDWOOD (S-H) COVER TYPE

	Granville—Moist						Waitville—Fresh							
	Number of Trees			Total Volume (cu. ft.)			Number of Trees				Total Volume (cu. ft.)			
D.b.h.	tA	wS	bP	tA	wS	bP	tA	wS	bP	jP	tA	wS	bP	jP
1	—	69.3	—	—	2.1	—	—	24.4			—	0.7	—	—
2	7.1	38.6	—	1.9	7.3	—	—	35.6			—	7.1	—	
3	14.3	32.1	—	10.7	17.7	—	—	30.0			—	17.7	—	
Total	21.4	140.0	—	12.6	27.1	—	—	90.0	—	—	—	25.5	—	—
4	7.9	20.7	—	12.5	24.4	—	0.6	35.6			1.3	45.2	—	
5	5.7	24.3	1.4	16.0	51.0	3.9	1.9	35.0			6.5	81.9	—	
6	5.0	25.0	0.7	22.8	85.8	3.2	3.1	33.1			16.0	126.8	—	
7	2.9	20.7	1.4	19.4	105.6	9.4	8.1	18.7	0.6		59.1	109.4	4.4	
8	10.7	15.7	1.4	98.2	115.4	12.9	8.1	16.8			80.2	141	—	
9	10.0	12.9	0.7	118.0	128.1	8.3	12.5	15.0			161.2	172.5	—	
10	12.8	8.6	—	190.7	111.8	—	17.5	8.7			280.0	132.2	—	
11	20.0	9.3	0.7	368.0	155.3	12.9	8.1	5.0			160.4	95.5	—	
12	17.1	8.6	1.4	379.6	177.2	31.1	11.9	8.1			282.0	188.7	—	
13	15.7	5.0	—	408.2	124.5	—	10.6	8.1			296.8	226.0	—	
Total	107.8	150.8	7.7	1,633.4	1,079.1	81.7	82.4	184.1	0.6	—	1,343.5	1,319.2	4.4	—
14	5.0	5.7	—	150.5	167.6	—	9.4	5.6			306.4	183.7	—	
15	3.6	5.7	—	123.8	196.1	—	5.0	3.1		0.6	187.5	117.2		22.7
16	1.4	4.3	—	54.6	169.8	—	2.5	4.4			106.2	189.6	—	
17	2.1	2.1	—	92.4	94.5	—	0.6	5.0			28.6	245.0	—	
18	0.7	2.9	—	34.3	146.4	—	—	3.8			—	209.0	—	
19	—	3.6	—	—	202.7	—	—	2.5			—	153.8	—	
20	0.7	3.6	—	41.4	225.0	—	—	—			—	—	—	
21	—	2.1	—	—	142.8	—	—	3.1			—	231.0	—	
22	—	1.4	—	—	103.6	—	—	3.1			—	251.1	—	
23	—	0.7	—	—	56.0	—	—	1.2			—	107.4	—	
24	—	1.4	—	—	121.1	—	—	0.6			—	57.9	—	
25	—	—	—	—	—	—								
26	—	1.4	—	—	138.6	—								
27														
28														
Total	13.5	34.9	—	497.0	1,764.2	—	17.5	32.4	—	0.6	628.7	1,745.7	—	22.7
Grand Total	142.7	325.7	7.7	2,143.0	2,870.4	81.7	99.9	306.5	0.6	0.6	1,972.2	3,090.4	4.4	22.7

TABLE 4

STAND AND STOCK TABLE, PER ACRE SOFTWOOD (S) TYPE

	Granville—Moist								Waitville—Fresh									
	Number of Trees				Total Volume (cu. ft.)				Number of Trees					Total Volume (cu. ft.)				
D.b.h	tA	wS	bP	bS	tA	wS	bP	bS	tA	wS	bP	jP	bF	tA	wS	bP	jP	bF
1	—	10.7	—	—	—	0.3	—	—	—	20.5	—	—	—	—	0.6	—	—	—
2	0.7	15.7	—	—	0.3	2.8	—	—	—	49.5	—	—	—	—	9.9	—	—	—
3	2.1	24.3	—	—	2.2	13.6	—	—	—	45.5	—	—	—	—	26.8	—	—	—
Total	2.8	50.7	—	—	2.5	16.7	—	—	—	115.5	—	—	—	—	37.3	—	—	—
4	4.3	24.3	—	—	8.3	28.9	—	—	—	47.5	—	—	—	—	62.2	—	—	—
5	5.0	20.7	—	—	15.8	44.9	—	—	0.5	44.5	—	—	—	1.4	105.9	—	—	—
6	3.6	30.0	—	—	16.9	107.1	—	—	1.0	40.0	—	—	—	4.5	152.8	—	—	—
7	0.7	22.8	—	—	4.7	126.3	—	—	5.5	33.0	—	—	—	36.8	194.7	—	—	—
8	3.6	26.4	1.4	—	32.2	213.8	12.5	—	2.5	27.0	—	—	—	24.0	226.8	—	—	—
9	7.1	25.0	0.7	0.7	83.8	282.5	8.3	7.9	7.0	18.5	0.5	—	—	89.6	209.0	6.4	—	—
10	0.7	28.6	0.7	—	10.5	426.1	10.5	—	8.5	15.0	—	—	—	137.7	222.0	—	—	—
11	5.7	15.0	—	—	106.6	283.5	—	—	6.0	7.0	—	0.5	—	118.8	130.2	—	9.3	—
12	0.7	12.1	0.7	0.7	16.0	278.3	16.0	16.1	4.0	9.5	0.5	—	—	94.0	217.6	11.8	—	—
13	1.4	11.4	—	—	38.6	315.8	—	—	3.5	8.0	—	—	—	96.6	221.6	—	—	—
Total	32.8	216.3	3.5	1.4	333.4	2,107.2	47.3	24.0	38.5	250.0	1.0	0.5	—	603.4	1,742.8	18.2	9.3	—
14	2.1	12.8	—	—	69.5	418.6	—	—	1.5	8.0	—	0.5	0.5	47.8	260.0	—	16.2	16.2
15	0.7	6.4	—	—	27.4	241.9	—	—	0.5	7.5		—	—	18.0	282.0		—	—
16	—	5.0	—	—	—	216.5	—	—	1.0	4.5	—	—	—	40.8	195.8	—	—	—
17	—	7.1	—	—	—	347.2	—	—	—	4.5	—	—	—	—	222.8	—	—	—
18	0.7	4.3	—	—	43.4	233.1	—	—	—	5.0	—	—	—	—	277.5	—	—	—
19	—	3.6	—	—		216.0	—	—	—	4.5	—	—	—	—	274.5	—	—	—
20	—	2.1	—	—		137.6	—	—	—	4.0	—	—	—	—	270.0	—	—	—
21	—	2.1	—	—		149.1	—	—	—	2.0	—	—	—	—	146.0	—	—	—
22	—	0.7	—	—		53.6	—	—	—	2.0	—	—	—	—	159.0	—	—	—
23	—		—	—			—	—	—	2.0	—	—	—	—	171.0	—	—	—
24	—		—	—			—	—	—	—	—	—	—	—	—	—	—	—
25	—	0.7	—	—		65.8	—	—	—	1.0	—	—	—	—	97.5	—	—	—
26	—		—	—			—	—	—	1.0	—	—	—	—	103.0	—	—	—
27	—		—	—			—	—	—	0.5	—	—	—	—	65.0	—	—	—
28	—		—	—			—	—										
29	—		—	—			—	—										
30	—	0.7	—	—		86.8	—	—										
Total	3.5	45.5	—	—	140.3	2,166.2	—	—	3.0	46.5	—	0.5	0.5	106.6	2,514.1	—	16.2	16.2
Grand Total	39.1	312.5	3.5	1.4	476.2	4,290.1	47.3	24.0	41.5	412.0	1.0	1.0	0.5	710.0	4,294.2	18.2	25.5	16.2

REFERENCES

ANON. 1948. Form Class Volume Tables (Second Edition). Canada, Dept. Mines and Resources, Mines, Forests and Scientific Services Branch, Dominion Forest Service.

BEDELL, G. H. D. 1948. Form-class of white pine and jack pine as affected by diameter, height and age. Canada, Dept. Mines and Resources, Dominion Forest Service, Silv. Res. Note No. 89.

HILLS, G. A. 1950. The use of aerial photography in mapping soil sites. For. Chron. 26:4–37.

——— 1952. The classification and evaluation of site for forestry. Ontario, Dept. Lands and Forests, Div. of Res., Res. Rept. No. 24.

JOHNSTON, W. A. 1934. Surface deposits and ground-water supply of Winnipeg map-area, Manitoba. Canada, Dept. of Mines, Bureau of Economic Geology, Geol. Survey, Memoir 174.

KIRK, S. R. 1930. Cretaceous stratigraphy of the Manitoba Escarpment. Geol. Surv., Canada, Summ. Rept. 1929, Pt. B. pp. 112–135.

NICHOLS, G. E. 1917. The interpretation and application of certain terms and concepts in the ecological classification of plant communities. Plant World 20:305–319, 34–353. Quoted by J. W. TOUMEY and C. F. KORSTIAN, 1947. Foundations of silviculture upon an ecological basis. 468 pp. John Wiley and Sons, New York.

ROWE, J. S. 1959. Forest regions of Canada. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, Bull. No. 123.

SANDERSON, Marie. 1948. The climates of Canada according to the new Thornthwaite classification. Scientific Agriculture 28:501–517.

SMITHERS, L. A. 1949. The Dwight co-frequency principle in diameter growth analysis. Canada, Dept. Mines and Resources, Mines, Forests and Scientific Services Branch, Dominion Forest Service, Silv. Res. Note No. 91.

STOBBE, P. D. 1960. Report on the classification of podzolic soils. In Proceedings of the Fourth National Meeting of the National Soil Survey Committee of Canada, Ontario Agricultural College, Guelph, February 22 to 27, 1960.

WALDRON, R. M. 1961. The effects of certain climatic factors on the terminal growth of white spruce at the Riding Mountain Forest Experimental Area in Manitoba. M. Sc. F. Thesis, University of Toronto.

WILDE, S. A. 1958. Forest soils, their properties and relation to silviculture. 537 pp. The Ronald Press Company, New York.