Forest Research Branch

THE EFFECTS OF SITE ON JACK PINE GROWTH IN NORTHERN ONTARIO

by
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Sommaire en français

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ABSTRACT

Effects of soil moisture regime, soil texture, soil petrography and regional macroclimate on height growth and diameter growth of dominant jack pine trees were studied on various sites in northern Ontario. Sampling was confined to pure or almost pure, fully stocked jack pine stands growing on deep uniformly-sorted acid podsolized sandy soils. Height and diameter growth of dominant jack pine trees varied with the individual site factors and their combinations. With a few exceptions, the pattern of this variation was similar in both height and diameter growth.

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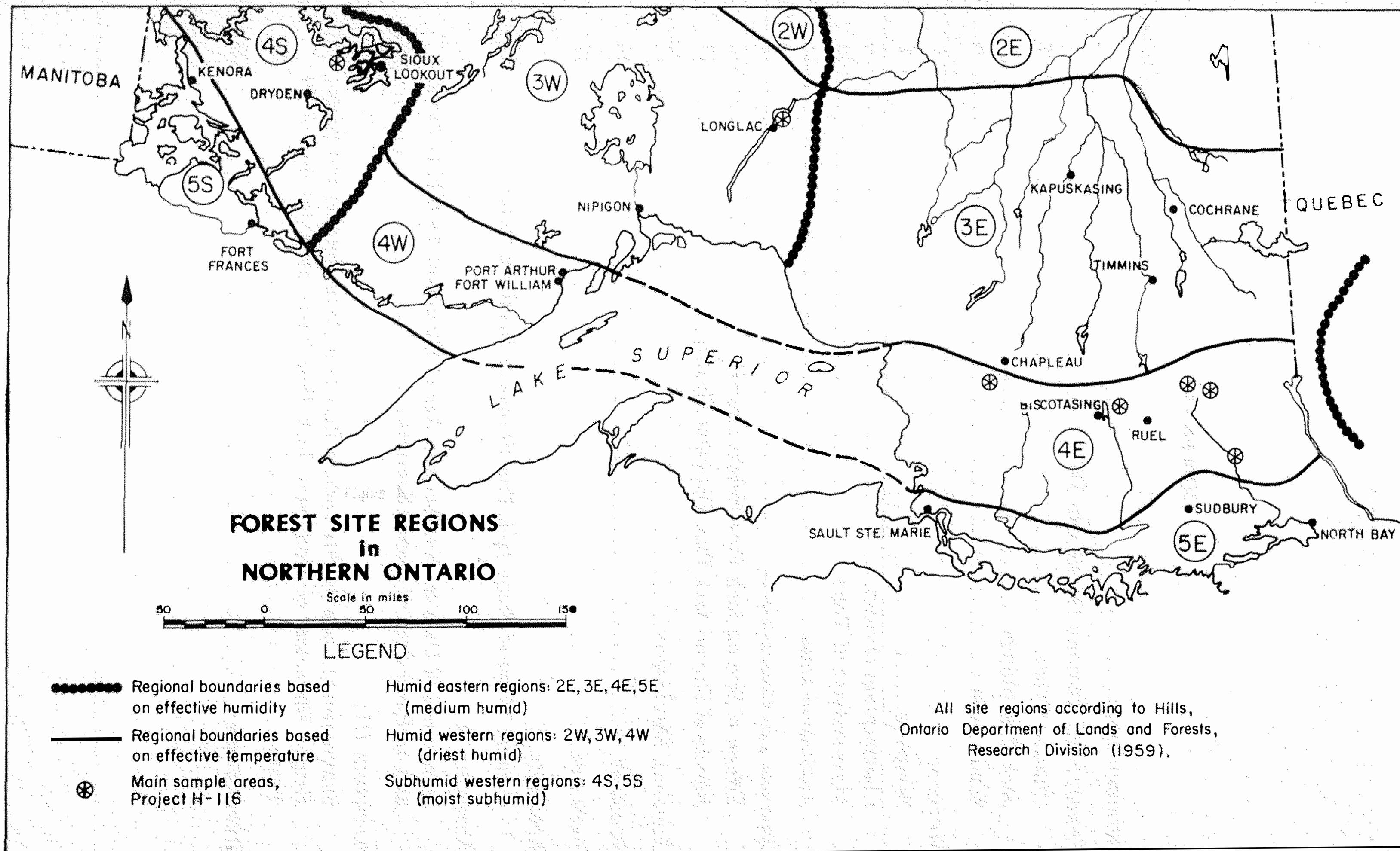

Frontispiece—Forest site regions in northern Ontario

The Effects of Site on Jack Pine Growth in Northern Ontario[1]

by

Z. Chrosciewicz[2]

INTRODUCTION

There are several sources of information concerning jack pine (*Pinus banksiana* Lamb.) growth in northern Ontario. The information was presented either by groups of sites based on certain physiographic features of soil materials (Bedell and MacLean, 1952; Wilde, et al, 1954; Morawski, et al, 1958), or by classes of sites based on certain relationships between tree height and tree age (Plonski, 1956). However, none of these sources provided information on the actual correlation of jack pine growth with the various site factors.

For this reason, the Department of Forestry established a research project to secure additional data of a more fundamental nature. The objective of this project was to determine the effects of soil moisture regime, soil texture, soil petrography, and regional macroclimate on height growth and diameter growth of dominant jack pine trees as represented by site indices at age 50 years. The growth on sandy sites in Forest Site Regions 4E, 4S and 3W (Hills, 1959), was sampled in 1958–59 (Frontispiece), and results are presented in this report.

FOREST SITE REGIONS 4E, 4S and 3W

Climate Types

Using the succession of vegetation under specific landform conditions as indicators of the effective climate, Hills (1959) delineated and subsequently defined the forest site regions in Ontario as macroclimatic regions. Thus, the forest climate types ascribed to the various regions were actually based on combined differences in effective humidity and effective temperature. According to Hills (1959), the forest climate types of the three regions in question are:

Mid-humid warm-boreal in Site Region 4E;
Moist-subhumid warm-boreal in Site Region 4S
Dry-humid mid-boreal in Site Region 3W.

The characteristic differences between these climate types are evident from the terms used. The climate in Site Region 4E is warmer and more humid than the climate in Site Region 3W. In contrast, the climate in Site Region 4S is just as warm as the climate in Site Region 4E, but it is generally less humid than the climates in the other two regions. For further details of the individual climate types see Hills (1959).

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Jack Pine Stands

In all three site regions, pure or almost pure even-aged jack pine stands were found on thin soils overlying rock outcrops, on glacio-fluvial plains, eskers and kames with sandy and gravelly soils, on fluvial sand terraces along the rivers, on sand dunes, on upland sandy and loamy tills, and occasionally on lowlands w th soils ranging from sand to clay. On better sites with silty sands, loamy sands and loams, sometimes on flats but mostly on gentle to moderate slopes, jack pine was often intermixed in varying proportions with trembling aspen (*Populus tremuloides* Michx.) and white birch (*Betula papyrifera* Marsh.). A black spruce (*Picea mariana* (Mill.) BSP.) understorey was frequently present in otherwise pure jack pine stands on rocky upland tills, in depressions, on low-lying flats, and wherever the soils were fresh or moister than fresh. Balsam fir (*Abies balsamea* (L.) Mill.) in all three regions, and white spruce (*Picea glauca* (Moench) Voss) predominantly in Site Regions 4E and 3W, were the common admixtures in the understorey of jack pine stands regardless of soil material. Scattered red pine (*Pinus resinosa* Ait.) and white pine (*Pinus strobus* L.) were often found in jack pine stands growing on some of the better sites, but white pine was generally absent from the northern and the eastern portions of Site Region 3W. Some of the jack pine stands are shown in Appendix I.

Sandy Soils

Deep siliceous very fine sands, fine sands and medium sands, all within a definite range of soil moisture regimes (0 to 4), and some with varied content of basic rock particles (less than 10 per cent, and 30 to 40 per cent)[1], were the soil materials covered by this project. The predominantly siliceous sandy soils were found in all three site regions, but those with the higher content of basic rock particles occurred mainly in Site Region 4E. Apart from variations in soil moisture regime, soil texture and soil petrography, the sandy soil materials examined had many common featu es. In each of the three site regions, their usual topographic positions were on tops and slopes of dunes, on tops and slopes of elevated terraces, on outwash plains, in depressions between these landforms, and on some of the lowlands along the rivers or bordering the black spruce swamps.

Invariably the soils exhibited acid reactions and other typical characteristics of podsolization. The humus was a predominantly dark brown 2 to 4 inch matted mor (pH 3.6 to 4.1) overlying directly the light grey, strongly leached, 1 to 5 inch A_2 horizon (pH 4.0 to 4.5), which in turn overlaid the more or less reddish brown, enriched by nutrients, 1 to 6 inch B_2 horizon (pH 4.1 to 5.2) and the somewhat lighter coloured, 2 to 11 inch B_3 horizon (pH 4.4 to 5.7). Immediately below were the more or less yellow to light greyish yellow parent soil materials of the 3 to 14 inch C_1 horizon (pH 4.7 to 6.1) and the deep C_2 horizon (pH 5.0 to 6.4). The very fine sands in the C_1 and C_2 horizons were invariably overlaid by loamy very fine sand in the B_2 and B_3 horizons, and by silty very fine sands in the A_2 horizon. In contrast, the fine sands and the medium sands were uniformly sorted throughout the soil profiles.

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[1] Some of the basic rocks are often referred to as "green stones" (Hills, 1954; Rowe, 1959).

In all three site regions, the depth of humus varied directly with stand age and soil moisture regime. The A_2, B_2 and B_3 horizons were generally deeper, and the B_2 and B_3 horizons somewhat darker, in moister soils. The B_2 horizon was usually deeper in very fine and fine sands than in medium sands, whereas the B_3 and C_1 horizons were definitely deeper in fine and medium sands than in very fine sands. Because of many variations in the colour and depth of soil horizons that occur, the foregoing relationships indicate only general trends which are subject to considerable variation.

Regardless of the content of basic rock particles in otherwise siliceous sandy materials, the pH values of individual soil h rizons were quite similar in Site Regions 4E and 4S, but were invariably lower in Site Region 3W. The generally acid reactions, extending downward for about 4 feet and including the upper portions of the C_2 horizon, indicated that the soils examined in all three site regions were low in lime co itent insofar as free carbonates are concerned. Even in those areas where other soils seemed to contain appreciable amounts of lime, most of the uniformly sorted sands w re predominantly siliceous materials.

The positions of ground water were generally comparable in all three regions. In the dry to moderately fresh (soil moisture regimes 0 and 1) very fine sands, fine sands and medium sands, and also in the fresh (soil moisture regime 2) very fine sands and f ne sands, the ground water was invariably deeper than 7 feet, or beyond the effective reach of tree roots. However, in all other fresh and moister than fresh (soil moisture regimes 2 to 4) sandy soil materials examined, the depth to ground water ranged from 3 to 6 feet and was always near the rooting zone (Table 1).

METHODS

Sampling

Sampling was restricted to pure or almost pure, fully stocked, undisturbed jack pine stands growing on deep uniformly-sorted, acid podsolized sandy soils of aëolian, fluvial and glacio-fluvial origin. It covered five soil moisture regime classes (0 to 4), three soil texture classes (very fine sand, fine sand, and medium sand) and two soil petrography classes (siliceous soil material with less than 10 per cent basic intrusive and effusive rock particles, and siliceous soil material with 30 to 40 per cent basic intrusive and effusive rock particles). With the exception of one petrography class, the sampling of all conditions was repeated in each of the three site regions 4E, 4S and 3W.

The sampling included excavation of soil pits, classification of individual site factors, stem analyses of dominant jack pine trees for height growth and diameter growth, and estimates of stand basal area. The procedure was identical in all three regions. Although the classification of site factors usually followed the selection of suitable stands and sample trees, it preceded, but never followed, the actual measurement of trees. In most stands three dominant jack pines constituted a sample unit; these trees were situated close to the soil pits used for the classification of site factors. To ensure that soil conditio is were the same throughout the sample unit, the materials under each tree were probed with a soil auger and compared with materials in the soil pit. Under certain site conditions, however, single dominant jack pines selected in different portions of a given stand, or in different stands, were the sample units. This was necessary when there was considerable variation in any of the site factors within a limited area such as tops of dunes, lower positions on slopes, depressions, etc. In such cases, a soil pit was excavated close to each tree. As shown in Appendix II, Tables 1, 2 and 3, the number of dominant jack pine trees analyzed for height growth and diameter growth by the various combinations of site factors was either 3 or 6, the average ages of those trees ranged from 43 to 97 years, and the average basal areas per acre of the stands sampled varied from 110 to 150 sq. feet.

Classification of Sites

All soil pits were excavated to a depth of 4 feet and their profiles described in detail. The bottom of each pit was probed with a soil auger for an additional 3 feet to determine whether there were traces of the ground water table. Soil profile descriptions included data on texture, compactness, colour, petrography and depth of each individual horizon. Notes on the topographic position and on the position of ground water were taken. Soil reactions were determined with a Hellige-Truog tester from a few profiles in each sample area to check the lime content of the soils. Where the pH values of horizons within the upper 4-foot stratum were all on the acid side, the soils were considered low in lime content.

The various site factors were classified directly in the field. Soil moisture regime was determined from the characteristics of soil profile, the topographic position and the position of ground water, using a system developed by Hills (1952; 1954). Table 1 shows the classification of soil moisture regimes in all three site regions. Soil texture was determined from the estimated relative proportion of mineral soil particles of various sizes, according to a classification

TABLE 1.—CLASSIFICATION OF SOIL MOISTURE REGIMES IN FOREST SITE REGIONS 4E, 4S and 3W

Soil Moisture Regime	Topographic Position	Depth of Horizons $A_2+B_2+B_3$	Depth to Compacted Sand	Depth to Ground Water
	Descriptions	Inches		Feet
	Deep Very Fine Sand* (Silty Sand in A_2; Loamy Sand in B_2 and B_3)			
0	Tops of dunes with steep slopes	5–10	—	>7
1	Middle slopes of dunes and gently sloping upper terraces	4–11	—	>7
2	Lower slopes of dunes and gently sloping lower terraces	8–14	18–24	>7
3	Gently sloping bases of dunes, lower terraces and depressions	9–12	18–24	5–6
4	Flat to gently sloping lower terraces and depressions	9–11	24–36	3–4
	Deep Fine Sand* (Uniformly Sorted Sand Throughout Soil Profile)			
1	Middle slopes of dunes and gently sloping upper terraces	6–9	—	>7
2	Lower slopes of dunes and gently sloping lower terraces	9–17	18–24	>7
3	Gently sloping bases of dunes, lower terraces and depressions	11–18	24–36	4–5
	Deep Medium Sand* (Uniformly Sorted Sand Throughout Soil Profile)			
1	Flat to gently sloping upper terraces and outwash plains**	7–10	18–24	>7
2	Flat to gently sloping lower terraces and outwash plains	8–12	24–36	5–6
3	Flat to gently sloping lower terraces and depressions	8–16	24–36	3–4

*Texture of parent mineral soil material, horizons C_1 and C_2.
**Soil moisture regime 1 due to compacted lower sand strata.

of the U.S. Department of Agriculture (Anon., 1951) as adopted and modified by Hills (1954). The feel and moist cast tests described by Hills (1954) were employed in separating sands from other soil textures. Soil petrography was determined from the relative proportion of basic rock particles (colours mostly green with some black, specific lustre, and specific texture) as estimated by examination with a lens. Other evidences such as the presence of certain types of rock outcrops, boulders, gravels and coarse sands within each of the sample areas were usually of assistance in making estimates of soil petrography.

Measurement of Trees

All sample trees were felled, cut into sections, and analyzed for height growth and diameter growth. Trees were cut at 1-foot stump height, and their total heights measured to the nearest 0.01 foot. The stems were sectioned at 4.5-foot breast height measured from the ground, and at 8-foot intervals above the stump. Data obtained from each of the stem cross sections included current average diameter outside bark, current average double bark thickness, and average diameters inside bark both current and at successive decades in the past plus for the odd annual rings near the pith, all measured to the nearest 0.01 inch. The total age of each tree was determined by a ring count on a section cut flush with the ground. Readings with a Panama angle-gauge for basal area estimates were taken at points directly above the stumps of felled trees.

Analysis of Data

The data collected from the sample trees were grouped and analyzed in relation to various combinations of site factors (soil moisture regime, soil texture and soil petrography) within each site region. The average age of the dominant trees and the average basal area per acre of the stands sampled were computed on this basis. The data on height growth and diameter growth were then compiled.

The stages in compilation of height growth data were:

1. Plotting the height/age curves for the individual trees directly from the stem-analysis data;
2. Reading the heights from these curves at 5-year total age intervals and averaging the values obtained by the respective combinations of site factors within each region;
3. Plotting the average height/age curves in composite sets showing comparisons by the different variables of the individual site factors within each region and between regions[1];
4. Comparison of site indices read from the average height/age curves at the total age of 50 years.

The stages in compilation of diameter growth data were:

1. Computation of the breast height diameters outside bark at decades directly from the stem-analysis data, using the formula:—

$$\text{D.B.H.o.b. at decade} = \frac{(\text{D.B.H.i.b. at decade}) \times (\text{D.B.H.o.b. now})}{(\text{D.B.H.i.b. now})}$$

[1] Although not presented in this report, the curves are available for short-term loans from the Director, Forest Research Branch, Dept. of Forestry, Ottawa, Ontario.

2. Plotting the diameter/age curves for the individual trees from the computed data;
3. Reading the diameters from these curves at 5-year total age intervals and averaging the values obtained by the respective combinations of site factors within each region;
4. Plotting the average diameter/age curves in composite sets showing comparisons by the different variables of the individual site factors within each region and between regions[1];
5. Comparison of site indices read from the average diameter/age curves at the total age of 50 years.

RESULTS AND CONCLUSIONS

Effects of Site on Jack Pine Height Growth

Figure 1 shows the comparison of site indices based on average total heights of dominant jack pine trees at an index age of 50 years by various combinations of soil moisture regime, soil texture, and soil petrography in Site Regions 4E, 4S and 3W. The supporting data for this comparison are summarized in Appendix III, Table 1. Since dominant heights, or site indices at a specific age are usually sufficiently representative of the cumulative effects of site on tree growth, any variation between the indices can be considered as expressing variations in total growth related to site differences. It is thus evident from Figure 1 that the site indices vary in relation to changes in the individual site factors and their combinations within each of the three regions and between the regions.

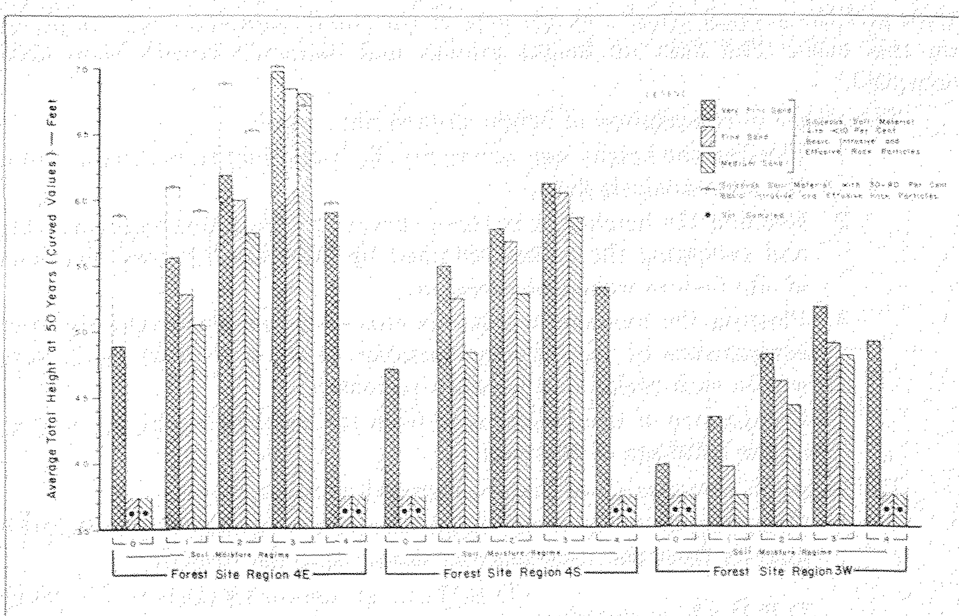

Figure 1.—Site indices based on average total heights of dominant jack pine trees

[1] Although not presented in this report, the curves are available for short-term loans from the Dir ctor, Forest Research Branch, Dept. of Forestry, Ottawa, Ontario.

Effects of Soil Moisture Regime

By soil textures and soil petrography classes, the highest site indices in each of the three regions are associated with soil moisture regime 3. As the moisture regime in each region decreases from 3 to 0, the site indices gradually diminish. A similar reduction of the site indices in each region occu s when the moisture regime increases beyond the optimum from 3 to 4. This variation in site indices attributed to changes in the soil moisture regime is generally greater on soils with a lower content of basic rock particles than on soils in which such content is higher.

Effects of Soil Texture

By soil moisture regimes and soil petrography classes, the highest site indices in each of the three regions are associated with very fine sand in which the upper soil horizons are silty or loamy. As the texture in each region changes from very fine sand to fine sand, and then to medium sand, the site indices gradually diminish. This variation in site indices, attributed to changes in the soil texture, is generally greater on drier soils than on moister soils.

Effects of Soil Petrography

By soil moisture regimes and soil texture classes, the highest site indices (except for one value) in Site Region 4E are associated with siliceous soil materials containing 30 to 40 per cent basic intrusive and effusive rock particles. As the content of such particles decreases to less than 10 per cent, the site indices diminish. This variation in site indices, attributed to changes in the soil petrography, is generally greater on drier soils than on moister soils.

Effects of Regional Macroclimate

By soil moisture regimes and soil textures within the same soil petrography class, the highest site indices are associated with mid-humid warm-boreal climate in Site Region 4E. As the climate changes from mid-humid warm-boreal in this region to moist-subhumid warm-boreal in Site Region 4S, and then to dry-humid mid-boreal in Site Region 3W the site indices gradually diminish. This variation in site indices, attributed to changes in the regional climate, is generally greater between Site Regions 4S and 3W than between Site Regions 4E and 4S.

Effects of Site on Jack Pine Diameter Growth

Figure 2 shows the comparison of site indices based on average breast-height diameters of dominant jack pine trees at an index age of 50 years by various combinations of soil moisture regime, soil texture and soil petrography in Site Regions 4E, 4S and 3W. The supporting data for this comparison are summarized in Appendix III, Table 2. Although values of this kind are seldom, if ever, used as site indices, a comparison of their variation with the variation of normal site indices based on dominant heights brings forward a few interesting points. It is evident from Figure 2 that, with very few exceptions, the site indices based on breast height diameters vary in a similar way to those based on total heights of the same trees. In fact, the effects of the individual site factors and their combinations are quite similar in each region as far as the diameter growth and the height growth are concerned. However, this is not entirely the case when the effects of regional macroclimate are considered. Although the site indices based on breast height diameters are, by the various combinations of site factors, generally lower in Site Region 3W than in Site Region 4E, most of them are somewhat higher in Site Region 4S than in Site Region 4E. In the first case, the pattern of variation established by the site indices based on total heights is maintained, whereas in the second case the pattern is different. The data available do not provide any reason for this rather unusual deviation from the general pattern of variation in site indices between the regions. All samples were taken from fully stocked stands, but it is possible that the stands sampled in Site Region 4S might have been understocked at some earlier age. Since the rate of diameter growth is inversely related to stand density, such conditions would have a decisive effect on tree diameters even after the stands became fully stocked.

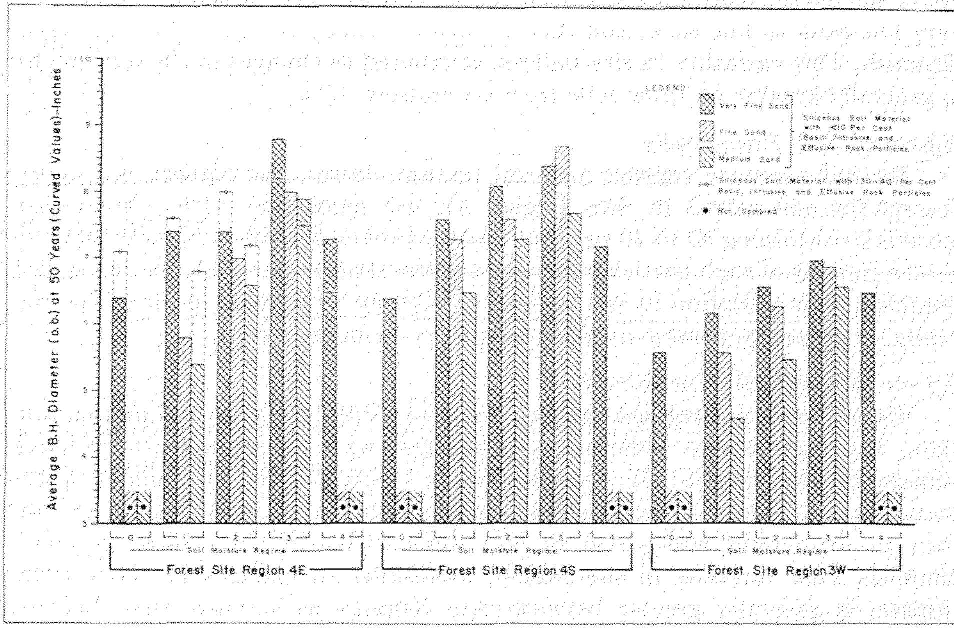

Figure 2.—Site indices based on average b. h. diameters of dominant jack pine trees

GENERAL DISCUSSION

Proper evaluation of the productive capacity of forest sites on any given tract of land is a fundamental requirement in rational forest management. Recognizing the importance of this fact, more and more research work has been carried out in recent years with the aim of developing suitable methods of site evaluation. Included in the methods used in Ontario are classification and evaluation of sites by the Hills' system (Hills, 1952; Hills and Pierpoint, 1960), and direct determination of site classes with the aid of average heights of dominant and codominant trees at specific ages (Plonski, 1956).

In this project, the main emphasis was placed on correlating the growth of dominant jack pine trees with soil moisture regime, soil texture, soil petrography and regional macroclimate. Despite several shortcomings such as the relatively small number of trees sampled on each of the sites, the generally narrow range of sites covered by the sampling, the rather limited distribution of samples in relation to the regional expanse of site conditions, and the almost complete reliance on field estimates employed in the classification of sites, the project has fulfilled its purpose. Specifically, it provided a sufficient proof that both the height growth and the diameter growth of dominant jack pine trees vary with each of the factors and their combinations. Perhaps the most significant point raised by this project is the fact that none of the site factors under consideration can be regarded as "unimportant" in classifying the physiographic sites, because all the factors, whether independently, or in interaction, are capable of influencing jack pine growth.

Sampling in this project was restricted to fully stocked jack pine stands with the aim of eliminating that portion of variation in tree growth which is normally attributed to variation in stand density. For want of historical data, it was necessary to assume that the stands sampled were fully stocked throughout their development. However, this might not have been so if the stands had different past densities, and attained full stocking only by the time of sampling. Although such early variation in stand density would have practically no effect on the height growth of dominant jack pine trees, it would have a significant effect on their diameter growth. In most cases, the patterns of variation by the individual site factors and their combinations were similar in both the height growth and the diameter growth of such trees, and this indicated that most of the stands sampled developed under uniform conditions of full stocking.

Since the growth of dominant jack pine was affected by the various site components, so the growth of other classes of trees in the fully stocked stands must have been similarly affected by the same components though in different degrees, depending on their relative positions in the forest canopy. Thus, it was reasonable to expect that the basal area per acre of the fully stocked stands would vary with the individual site factors and their combinations. This, however, was not substantiated by the data obtained. Although the apparent absence of correlation in terms of basal area per acre may be partially attributed to a combination of the possible past variation in the stand density and the wide range in the stand age classes sampled, perhaps much of it resulted form the use of a Panama angle-gauge in making the appropriate estimates. When tested against conventional plot tallies, the maximum error for this time-saving device was ± 9 per cent. But since only general stand descriptions were sought, and the project made no provisions for studying the actual variations in the basal area per acre, increased accuracy of such estimates was not required.

Moreover, it must be understood that the site conditions covered by this project are not necessarily the most important ones in Ontario as far as their frequency is concerned. Depending on area, some of the sites were found easier than others, and some of those not sampled occurred more often than those sampled. In short, the main objective of this project was to study the growth of dominant jack pine trees within a selected range of conditions and not necessarily on the most representative si es.

It is evident that the project described in this report should be considered an initial venture into the complex relationships between jack pine growth and site. Thus, there is a definite need for extending the growth study over a much wider range of site conditions. Both the effects of site and the effects of stand density on jack pine growth should be incorporated in such a study. In addition, the existing variations in the basal area per acre, and also in the volume per acre, should be studied on comparable sites and between different sites to determine the actual ranges in their productive capacity. Further research along these lines is recommended.

SUMMARY

In 1958-59, the Department of Forestry carried out a research project in northern Ontario to determine the effects of soil moisture regime, soil texture, soil petrography, and regional macroclimate on height growth and diameter growth of dominant jack pine trees. Sampling was restricted to pure or almost pure, fully stocked 43- to 97-year-old jack pine stands growing on deep uniformly-sorted acid podsolized sandy soils. It included five soil moisture regime classes, three soil texture classes and two soil petrography classes. Within one of the petrography classes the entire sampling was replicated in three regions, each with a different macroclimate. Three to six dominant jack pine trees per combination of the above site factors were felled and analyzed for height growth and diameter growth. The analysis of data included plotting the average growth curves by the various combinations of site factors, and comparing the site indices read from these curves at points corresponding to the total age of 50 years. Briefly, results revealed that:

1. The height and diameter growth of dominant jack pine trees varied with the individual site factors and their combinations in each of the regions and between the regions;
2. Except for a few irregularities, the pattern of this variation was similar in both the height growth and the diameter growth.

SOMMAIRE

En 1958-1959, le ministère des Forêts faisait exécuter des recherches dans le nord de l'Ontario, afin de déterminer l'influence du régime d'humidité des sols, de leur texture et de leur composition minérale, ainsi que du macroclimat sur la croissance en hauteur et en diamètre des pins gris dominants. L'échantillonnage a été limité à des peuplements complets de pins gris, purs ou presque purs, de 43 à 97 ans, établis sur des sols profonds, uniformément mélangés, acides, podsolisés et sableux. Ces échantillons comprenaient cinq catégories de sols possédant divers régimes d'humidité, trois catégories de sols à texture variée et deux catégories de sols pétrographiques. Quant à l'une des catégories de sols pétrographiques, l'échantillonnage entier a été répété dans trois régions jouissant d'un macroclimat différent. De trois à six pins gris dominants de chaque station possédant une combinaison des facteurs précités ont été abattus et leur croissance en hauteur et en diamètre a été analysée. L'analyse des données comprenait le tracé des courbes moyennes de croissance à l'égard des diverses combinaisons de facteurs et une comparaison des indices de fertilité relevés sur ces courbes à des points correspondant à un âge global de 50 ans. En somme, les résultats de cette étude ont révélé que:

1° La croissance en hauteur et en diamètre des pins gris dominants variait en fonction des facteurs individuels et de leur combinaison dans chacune des régions et d'une région à l'autre;

2° Sauf quelques irrégularités, les variations de croissance en hauteur et en diamètre étaient analogues.

APPENDIX I

General Views of Some Jack Pine Stands
in Northern Ontario

Plate 1.—Jack pine on thin sandy soil overlying rock outcrop. Soil moisture regime 0

Plate 2.—Jack pine on outwash plain with somewhat sorted gravelly sand. Soil moisture regime 0 to 1

Plate 3.—Jack pine on river terrace with uniformly sorted sand. Soil moisture regime 1 to 2

Plate 4.— Jack pine on dune with uniformly sorted sand. Soil moisture regime 0 to 1

Plate 5.—Jack pine on a wet site with uniformly sorted sand overlying clay. Soil moisture regime 6 to 8

Plate 6.—Jack pine with some trembling aspen and white birch on uniformly stratified loamy sand. Soil moisture regime 2 to 3

Plate 7.—Jack pine with black spruce understorey in depression between sand dunes. Soil moisture regime 1 to 3

Plate 8.—Jack pine with black spruce understorey on extremely rocky, washed, sandy upland till. Soil moisture regime 1 to 3

Plate 9.—Jack pine with black spruce understorey on loamy upland till. Soil moisture regime 2 to 3

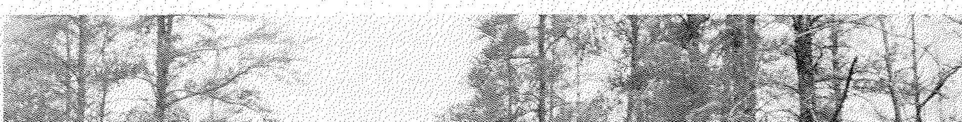

Plate 10.—Jack pine with black spruce, white spruce and balsam fir understorey on loamy upland till. Soil moisture regime 3

APPENDIX II

Summaries of Data on Number and Age of Dominant Jack Pine Trees, and on Basal Area of Stands Sampled

TABLE 1.—NUMBER OF DOMINANT JACK PINE TREES ANALYZED FOR HEIGHT GROWTH AND DIAMETER GROWTH

Texture of Parent Mineral Soil Material Horizons C_1 and C_2	Number of Trees														
	S.M.R.0*			S.M.R.1*			S.M.R.2*			S.M.R.3*			S.M.R.4*		
	4E	4S	3W	4E	4S	3W	4E	4S	3W	4E	4S	3W	4E	4S	3W
	n														
	Siliceous Soil Material with <10 Per Cent Basic Intrusive and Effusive Rock Particles														
Very Fine Sand**...	3	3	3	6	3	3	6	3	3	6	3	3	3	3	3
Fine Sand..........	—	—	—	6	3	3	6	3	3	6	3	3	—	—	—
Medium Sand.......	—	—	—	3	3	3	3	3	3	3	3	3	—	—	—
	Siliceous Soil Material with 30–40 Per Cent Basic Intrusive and Effusive Rock Particles														
Very Fine Sand**...	3	—	—	3	—	—	3	—	—	3	—	—	3	—	—
Medium Sand.......	—	—	—	3	—	—	3	—	—	3	—	—	—	—	—

* S.M.R.—Soil moisture regime. 4E, 4S and 3W—Forest site regions.
** Silty sand in the A_2 horizon and loamy sand in the B_2 and B_3 horizons.

TABLE 2.—AVERAGE AGE OF DOMINANT JACK PINE TREES ANALYZED FOR HEIGHT GROWTH AND DIAMETER GROWTH

Texture of Parent Mineral Soil Material Horizons C_1 and C_2	Average Total Age														
	S.M.R.0*			S.M.R.1*			S.M.R.2*			S.M.R.3*			S.M.R.4*		
	4E	4S	3W	4E	4S	3W	4E	4S	3W	4E	4S	3W	4E	4S	3W
	Years														
	Siliceous Soil Material with <10 Per Cent Basic Intrusive and Effusive Rock Particles														
Very Fine Sand**...	59	49	94	61	75	93	63	71	95	61	67	96	63	67	92
Fine Sand..........	—	—	—	67	49	95	65	49	97	65	67	94	—	—	—
Medium Sand.......	—	—	—	66	77	95	65	77	95	66	49	94	—	—	—
	Siliceous Soil Material with 30–40 Per Cent Basic Intrusive and Effusive Rock Particles														
Very Fine Sand**...	44	—	—	44	—	—	44	—	—	44	—	—	43	—	—
Medium Sand.......	—	—	—	48	—	—	43	—	—	43	—	—	—	—	—

* S.M.R.—Soil moisture regime. 4E, 4S and 3W—Forest site regions.
** Silty sand in the A_2 horizon and loamy sand in the B_2 and B_3 horizons.

TABLE 3.—AVERAGE BASAL AREA PER ACRE OF JACK PINE STANDS SAMPLED

Texture of Parent	Average Total Basal Area														
Mineral Soil Material	S.M.R.0*			S.M.R.1*			S.M.R.2*			S.M.R.3*			S.M.R.4*		
Horizons C_1 and C_2	4E	4S	3W	4E	4S	3W	4E	4S	3W	4E	4S	3W	4E	4S	3W
	Sq. Feet Per Acre														
	Siliceous Soil Material with <10 Per Cent Basic Intrusive and Effusive Rock Particles														
Very Fine Sand**	127	110	113	137	117	123	128	133	120	140	130	120	127	150	147
Fine Sand	—	—	—	118	130	117	120	123	133	125	127	146	—	—	—
Medium Sand	—	—	—	113	123	130	110	123	123	117	127	150	—	—	—
	Siliceous Soil Material with 30-40 Per Cent Basic Intrusive and Effusive Rock Particles														
Very Fine Sand**	117	—	—	117	—	—	130	—	—	130	—	—	137	—	—
Medium Sand	—	—	—	130	—	—	127	—	—	133	—	—	—	—	—

* S.M.R.—Soil moisture regime. 4E, 4S and 3W—Forest site regions.
** Silty sand in the A_2 horizon and loamy sand in the B_2 and B_3 horizons.

APPENDIX III

Summaries of Data on Site Indices Based on Total Heights and Breast Height Diameters of Dominant Jack Pine Trees at Total Age of 50 Years

TABLE 1.—SITE INDICES BASED ON AVERAGE TOTAL HEIGHTS OF DOMINANT JACK PINE TREES

Texture of Parent	Average Total Height at 50 Years (Curved Values)														
Mineral Soil Material	S.M.R.0*			S.M.R.1*			S.M.R.2*			S.M.R.3*			S.M.R.4*		
Horizons C_1 and C_2	4E	4S	3W	4E	4S	3W	4E	4S	3W	4E	4S	3W	4E	4S	3W
	Feet														
	Siliceous Soil Material with <10 Per Cent Basic Intrusive and Effusive Rock Particles														
Very Fine Sand**...	48.9	47.1	39.8	55.6	55.0	43.4	61.9	57.8	48.2	69.8	61.2	51.8	59.1	53.3	49.2
Fine Sand..........	—	—	—	52.8	52.5	39.6	60.0	56.8	46.1	68.5	60.5	49.0	—	—	—
Medium Sand.......	—	—	—	50.5	48.4	37.4	57.5	52.8	44.3	68.1	58.6	48.1	—	—	—
	Siliceous Soil Material with 30-40 Per Cent Basic Intrusive and Effusive Rock Particles														
Very Fine Sand**...	58.8	—	—	61.0	—	—	68.9	—	—	70.2	—	—	59.8	—	—
Medium Sand.......	—	—	—	59.2	—	—	65.3	—	—	67.2	—	—	—	—	—

* S.M.R.—Soil moisture regime. 4E, 4S and 3W—Forest site regions.
** Silty sand in the A_2 horizon and loamy sand in the B_2 and B_3 horizons.

TABLE 2.—SITE INDICES BASED ON AVERAGE B.H. DIAMETERS OF DOMINANT JACK PINE TREES

Texture of Parent	Average B.H. Diameter (o.b.) at 50 Years (Curved Values)														
Mineral Soil Material	S.M.R.0*			S.M.R.1*			S.M.R.2*			S.M.R.3*			S.M.R.4*		
Horizons C_1 and C_2	4E	4S	3W	4E	4S	3W	4E	4S	3W	4E	4S	3W	4E	4S	3W
	Inches														
	Siliceous Soil Material with <10 Per Cent Basic Intrusive and Effusive Rock Particles														
Very Fine Sand**...	6.4	6.4	5.6	7.4	7.6	6.2	7.4	8.1	6.6	8.8	8.4	7.0	7.3	7.2	6.5
Fine Sand..........	—	—	—	5.8	7.3	5.6	7.0	7.6	6.3	8.0	8.7	6.9	—	—	—
Medium Sand.......	—	—	—	5.4	6.5	4.6	6.6	7.3	5.5	7.9	7.7	6.6	—	—	—
	Siliceous Soil Material with 30-40 Per Cent Basic Intrusive and Effusive Rock Particles														
Very Fine Sand**...	7.1	—	—	7.6	—	—	8.0	—	—	8.2	—	—	6.5	—	—
Medium Sand.......	—	—	—	6.8	—	—	7.2	—	—	7.5	—	—	—	—	—

* S.M.R.—Soil moisture regime. 4E, 4S and 3W—Forest site regions.
** Silty sand in the A_2 horizon and loamy sand in the B_2 and B_3 horizons.

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