THE NICAUBA RESEARCH FOREST
A RESEARCH AREA FOR BLACK SPRUCE IN QUEBEC
Part I: Forest Land Survey

by

M. Jurdant and G. J. Frisque

FOREST RESEARCH LABORATORY
QUEBEC REGION, QUEBEC
INFORMATION REPORT Q-X-18

CANADIAN FORESTRY SERVICE
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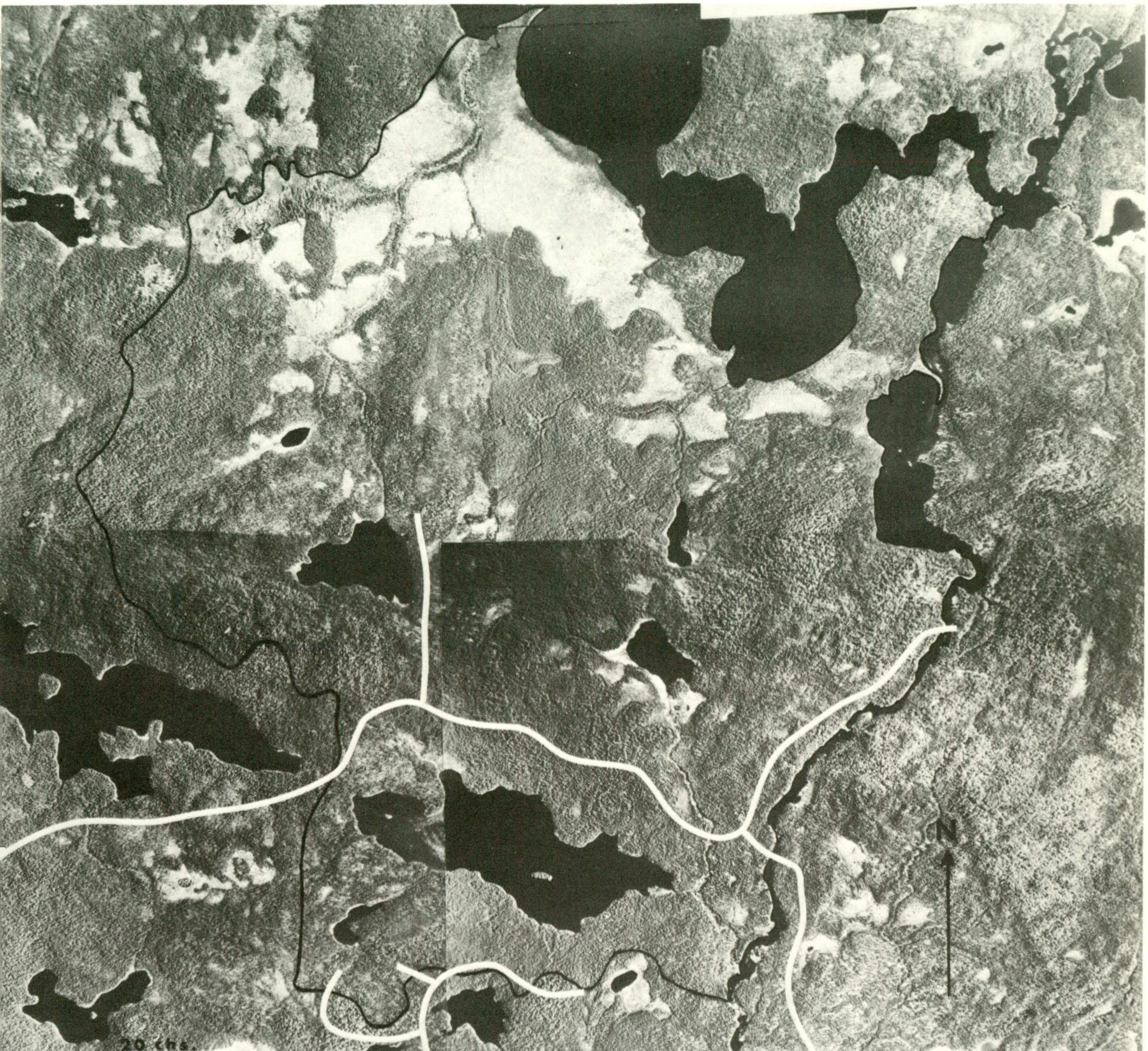


NICAUBA RESEARCH FOREST

STEREOPAIR ILLUSTRATING THE

BLACK SPRUCE—BALSAM FIR TYPE

ACKNOWLEDGMENTS

The authors are indebted to Mr. R.J. Hatcher who in 1964 established the Nicauba Research Forest, directed the forest survey and initiated the research on black spruce in the boreal forest of Quebec. Mr. J.T. Arnott succeeded him and continued to develop and direct the work from 1967 to 1969. Since the creation of the Research Forest, Mr. J.B. Breton has been responsible for the technical work performed. The soil analyses were done by Mr. A. Jean.

Special thanks are due to Consolidated-Bathurst Ltd., and to The Laurentian Forest Protective Association Ltd. for their full cooperation. Consolidated-Bathurst terminated cutting in the Research Forest area and provided manpower and equipment when requested. The Laurentian Forest Protective Association provided camp and kitchen facilities.

INTRODUCTION

Black spruce (Picea mariana) is by far the most important tree species of the Boreal Region in Quebec. The need for undertaking research in the black spruce forests is urged if one wants to discover, develop, and promote methods for growing, protecting, and harvesting trees at competitive costs in a manner compatible with concern for the environment.

To fill that purpose, agreement was reached with Consolidated-Bathurst Ltd. in March 1964, to establish a research forest in their Nicauba Management Unit for the study of black spruce ecology, silvics and silviculture.

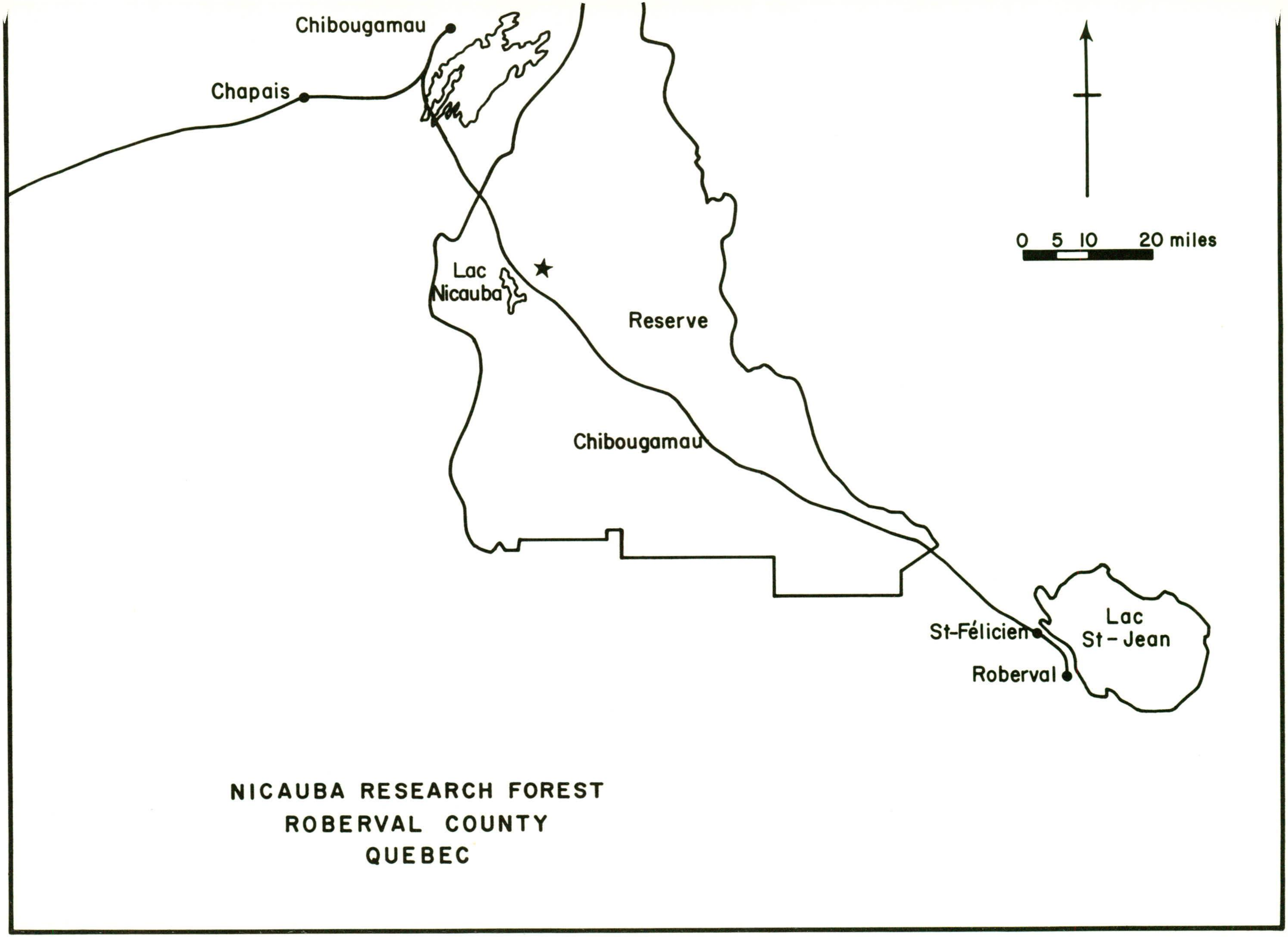
The Nicauba Research Forest includes 2,600 acres in the southwest part of the Forest Section B-1b (Rowe, 1959). It is located in the Chibougamau Provincial Park, 310 road miles northwest from Quebec City and adjacent to the Petite Chaudière River (figures 1 and 2). The coordonates are: Lat. 49° 27' N, Long. 74° 01' W, elevation: 1,300 ft.

This report deals with the forest land survey of the research forest. It includes the ecological survey of the area which aims at providing the forest scientist and the forest manager with ecologically significant geographic units which are relatively homogeneous with respect to landform, soil and vegetation. It also deals with the forest survey which provides forestry information and timber potential production estimates within the framework given by the ecological survey.

It is believed that the information brought by this forest land survey provides the geographic framework from which the results of research can be subsequently extended over adjacent areas.

M. Jurdant was responsible for the ecological survey and G.J. Frisque was responsible for the forest survey.

A second report (Frisque and Arnott, 1970) deals with the black spruce research program which was developed in the Research Forest following the completion of the forest land survey.


Chibougamau
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Reserve
Chibougamau
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St - Jean
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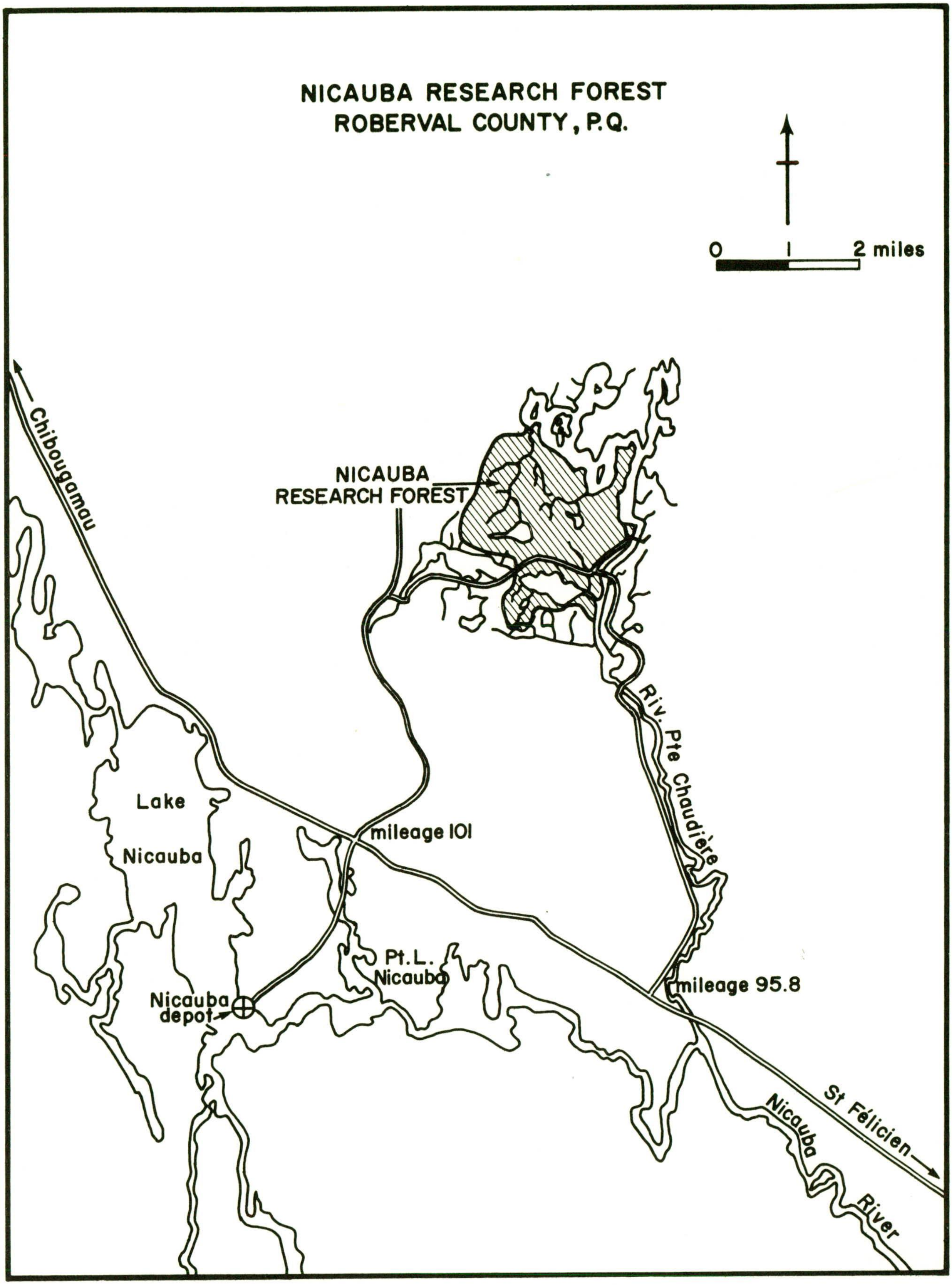
Roberval
0 5 10 20 miles
NICAUBA RESEARCH FOREST
ROBERVAL COUNTY
QUEBEC

FIGURE 1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RESEARCH FOREST
Riv. Pte Chaudière
Lake
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Pt. L.
Nicauba
Nicauba
depot
mileage 95.8
St Félicien
Nicauba
River

FIGURE 2

A. ECOLOGICAL SURVEY

1. GENERAL DESCRIPTION OF THE AREA

The Nicauba Research Forest is representative of the environmental conditions prevailing throughout the Chibougamau-Natashquan Section B-1b of Rowe(1959), an area of approximately 120,000 square miles. The region is the northernmost part of Quebec which can still be called a productive forest zone. It is characterized by black spruce and lies between the sub-arctic lichen woodland to the north and the more productive fir-spruce forests to the south.

Climatic summaries based on the meteorological station located at Chibougamau (latitude: 49°54'N, elevation: 1234 feet) about 40 miles north-west of the Research Forest, are provided by Rowe (1959), Ferland et Gagnon (1967) and Chapman and Brown (1966). The following climatic data provide a summarized picture of the climatic conditions of the area:

Mean annual temperature:	31°F.
July mean temperature :	58 to 60°F.
January mean temperature:	-5 to 0°F
Start of the growing season: (above 42°F mean temperature):	May 10 to 15
End of the growing season (above 42°F mean temperature):	Oct. 6 to 11
Degree-days above 42°F :	1750 to 2000
Mean "frost-free" period:	80 to 90 days
Average annual precipitation:	39.7 inches
Average May to September pre-cipitation:	19 inches
Potential evapotranspiration:	18.5 inches
Average annual actual evapo-transpiration (4 inches storage):	18 to 19 inches

In short, the climate of the Research Forest is cold and wet. On June 16, 1964, 8 inches of heavy snow fell and remained on the ground for about 20 hours.

The region belongs to the Grenville Ecological Sub-Province (Laurin, 1955). The bedrock is dominated by biotite and hornblend gneisses of precambrian age.

The study area is located in the Canadian Shield near the height of land between the rivers flowing southeastward towards the St. Lawrence River and the rivers flowing northwestward towards the Hudson Bay. It belongs to the Ashuapmuchuan River basin which flows into the Lake Saint-Jean and the Saguenay River.

The topography is undulating and typical of the western portion of the Blb Forest Section. The region could be broadly described as a bed-rock-controlled fluted till plain. Bedrock outcrops are relatively rare as the Pleistocene glaciations deposited a drift mantle of variable thickness. Glacial till covers more than 50% of the area; it may occur as shallow deposits on the higher hills, as deep basal till sometimes with a drumlin appearance at the lower elevations, or as recessional moraines in various locations. Peat bogs cover about 10-20% of the area and numerous lakes another 10-20%. Fluvio-glacial deposits, kames, eskers, and sandy glacio-lacustrine deposits are also common throughout the region. All these landforms are represented in the Research Area.

2. ECOLOGICAL SURVEY METHOD

The purpose of the ecological survey is to provide the forest manager and the forest scientist with a geographical framework suitable for extending the information obtained through management practices and research experiments to other areas within the region, i.e. the western part of the Blb Forest Section, an area of about 40,000 square miles. The assumption is that whenever similar ecological conditions of a site will be present the reaction of the forest stand to a given treatment will also be similar.

The aim of the ecological survey is therefore to delineate ecologically uniform areas or, within a given climatic region, to delineate areas uniform in terms of landform, soil and vegetation (Jurdant, 1968).

(a) Analyses

The landforms of the study area were first pre-typed on air photos before the field season began. This preliminary map was used as a framework to stratify the field sampling along transects representative of the major ecological conditions present in the area. Thirty-nine 1/10-acre plots were established, 29 of which were at the same location as forest inventory plots. The description of these plots consists in an analysis of the physiography, the landform, the soil by means of the description of a soil profile (N.S.S.C., 1968), and a vegetation analysis by means of the Zurich-Montpellier method (Becking, 1957). In addition, 152 soil and humus samples were taken for analysis in the laboratory. All laboratory determinations were carried out on less than 2 mm fractions, and results are reported on an oven dry (110°C) weight basis. The laboratory methods were as follows:

pH: Glass electrode using 1:1 ratio (Peech, Alexander et al, 1947).

Organic carbon: Mineral horizons: wet combustion as modified by the Walkley-Black method (Peech, Alexander et al, 1947). Organic horizons: loss on ignition ÷ 1.8 (Lunt, 1931).

Loss on ignition (in organic horizons): difference between oven dry and ignited samples.

Organic matter: Mineral horizon: organic carbon x 1.8 (Lunt, 1931). Organic horizons: loss on ignition.

Total Nitrogen: Kjeldahl method (Wilde and Voigt, 1955).

Free iron: Modification of Deb's method (Asami and Kumada, 1959).

Cation exchange capacity: NH_4 saturation and direct distillation of NH_3 (Peech, Alexander et al, 1947).

Extractable cations; Method of Bray and Willhite (1929).

Particle size distribution analysis: Hydrometer method (Day, 1956).

(b) Classification

The landforms are classified on the basis of form, mode of origin, texture and petrography of the geological surface materials.

The soils are classified in Order, Great Group, Sub-group and Series according to the regular soil survey methods (N.S.S.C., 1968). The basic soil classification unit used in this survey is the Series. A Soil Series consists of soils essentially uniform in differentiating characteristics and in arrangement of horizons, that are developed on similar parent materials and under similar environmental conditions, particularly drainage. In the present study, the criteria for separation of Series were:

- Kind, thickness and arrangement of horizons
- Texture of the sub-soil
- Depth to bedrock
- Kind of surface organic horizon

In classifying vegetation, all plots that appeared to have similar distribution of major tree dominants and similar parent materials under similar topographic conditions were assembled together in vegetation synthesis tables. In these tables, all species are listed on the left side, and the plots are listed vertically along the top so that each species can be checked for its presence, abundance, and dominance in all plots simultaneously. Successive vertical rearrangements of plots and horizontal rearrangements of species lead to the determination of vegetation units characterized by the relative abundance and/or absence of species or groups of species.

In order to allow comparisons of the relative importance of a given species among groups of plots and comparisons of the relative importance of a given group of species among plots or groups of plots, a suitable index has been used which is derived from both the presence and the abundance of each species in a plot. The index is called "Importance Value" (Jurdant, 1968).

From the study of the vegetation synthesis tables, it appears that groups of species can be formed which behave similarly with respect to environmental features. These groups are called "ecological groups of species". They are the basis on which the final vegetation synthesis table is established.

The vegetation is classified in Association, Sub-Association and Variant according to the Zurich-Montpellier nomenclature (Braun-Blanquet, 1932). The practical basic vegetation unit used in this survey is the Forest Type. The Forest Type is the lowest unit within an Association, usually a

Sub-Association. but in some cases corresponding to either an Association or a Variant.

Once the vegetation and the soils are classified with a geomorphic framework of landform, the classification of forest ecosystems in the Nicauba Research Forest is based on the concept of "Ecological Type" developed by Jurdant (1968). The Ecological Type is a Forest Type growing on a particular Soil Series.

(c) Mapping

The Ecological Types were mapped on aerial photographs at the scale of 1:7920. These forest land units were refined in the field as the survey progressed and a final Ecological Map was then proposed (map in appendix).

Each mapping unit contains a symbol that identifies the landform, the Forest Type, and the Soil Series found within the unit. The symbol comprises small letters representing the landform, followed by a fractional expression where the forest type (or complex of types) is the numerator, and the soil series (or complex of series) is the denominator. Where complexes are mapped, the forest types and soil series are listed in descending order of area occupation within the unit. Landforms and Ecological Types (Forest Type/Soil Series) are separated with solid and broken lines respectively.

In summary, the mapping units are relatively small, ecologically homogeneous segments of the landscape which are characterized by the following land properties:

- topographic form
- texture, stoniness, sorting and depth of the surficial geological materials
- soil drainage and soil moisture regime
- physical and chemical properties of the soil
- physiognomy, structure, and composition of the vegetation.

3. LANDFORMS

A summarized description of the landforms present in the Nicauba Research Forest is provided in table 1. Ground moraine (bt) occupies most of the area (38%); the material is a compact, sometimes cemented glacial till whose texture indicates a well graded fine sandy loam (Appendix 1). The depressions within the ground moraine areas are often covered by water-worked drift (wd) whose texture is similar to the basal till; it is however better sorted and the material is loose indicating a reworking of the till by water; this landform occupies 15% of the research forest. Here and there in the ground moraine areas are also some bedrock outcrops (gn). Some areas of till are also covered with shallow glacio-lacustrine materials (ld) composed of loose and very well sorted fine sand. Bogs (bg) occupy a large portion of the northern part of the forest around lake Bonhomme as well as the deepest depressions within the ground moraine area; 18% of the research forest is covered by bogs. A relatively small area (0.7%) is occupied by knobs of ice-contact stratified drift (cd) whose material consists in irregularly interbedded sorted sand and gravel. Along the Petite Chaudière river at the southeastern extremity of the forest, there is a small area of outwash (2.2%) which consists in regularly stratified sorted sand and gravel. The eastern portion of the forest has a knob and kettle topography; the material is loose and poorly sorted, although better sorted than in the till areas; it is a stony gravelly loamy medium sand; the landform has been classified as a kame moraine (km). It covers 9% of the Research Forest. Several isolated areas totalling 9% of the research forest consist in bedrock hills covered with 2 to 3 feet of superglacial till and colluvium (landform: tg); the material is a loose, unsorted, stony fine sandy loam.

Table 1 Summarized description of the landforms of the Nicauba Research Forest

Symbol[1)]	Landform	Form	Mode of origin	Characteristics of the surficial materials
bt	Ground moraine.	Smooth relief, slightly controlled by bedrock topography.	Drift accumulation by the glacier.	Basal till. Fine sandy loam. Unsorted. Compact (sometimes cemente
tg	Shallow till over bedrock.	Irregular relief, controlled by bedrock topography.	Drift accumulation by the glacier, solifluction, and mass-wasting.	Superglacial till and colluvium. Stony fine sandy loam. Unsorted. Loose.
wd	Water-worked drift complex.	Lower concave slopes and smooth depressions.	Postglacial or periglacial erosion in ground moraine areas.	Till with much of the fines removed by water. Fine sandy loam. Poorly sorted or sorted. Loose.
km	Kame moraine.	Ridgelike, hummocky topography.	Drift accumulation along the margin of a glacier lobe.	Superglacial till. Stony gravelly loamy medium sand. Poorly sorted. Loose.
sd	Stratified drift.	Level topped terraces bounded by steep slopes.	Drift accumulation in proglacial streams.	Outwash. Gravelly very coarse sand. Well sorted. Loose.
cd	Ice-contact stratified drift.	Knob and kettle topography.	Drift accumulation in immediate contact with wasting ice.	Irregularly stratified drift. Gravelly very coarse sand. Well sorted. Loose.
ld	Glacio-lacustrine deposit.	Smooth, nearly level areas.	Drift accumulation in proglacial lakes.	Stratified drift. Fine sand. Very well sorted. Loose.
gn	Gneissic bedrock outcrop.	Convex knobs in the ground moraine areas.	Glacial erosion.	Gneissic rock.
bg	Bog.	Flat, low-lying areas.	Post-glacial organic accumulation.	Organic matter.

1) These symbols are those of the ecological map (in appendix)

The mechanical analyses shown in appendix 1 give the major textural characteristics of the surficial materials from the landforms present in the Nicauba Research Forest. The landforms bt (ground moraine), tg (shallow till over bedrock), and wd (water-worked drift complex) are all well graded fine sandy loams although the textural curve of the landform wd is steeper, indicating a better sorted material. The surficial material from the landform km (kame moraine) is coarser and better sorted than the first three materials. With a slope at inflexion point of the textural curve of 69 degrees, the material from the landforms sd (stratified drift) and cd (ice-contact stratified-drift) is well sorted, and the texture is a gravelly very coarse sand. Finally, the material from the landform ld (glacio-lacustrine deposit) is a very well sorted fine sand.

By colouring the ecological map (in appendix) according to the symbols for landform, one can easily obtain the geographical distribution of each of them.

4. SOILS

The morphogenetic classification of the soils of the Nicauba Research Forest is given in appendix 2. The soils are also classed by landform and drainage class in appendix 3. Pertinent data relative to the chemical and textural properties of the soils are also provided in appendices 4, 5 and 6.

The cold and humid climate prevailing throughout the region where the Nicauba Research Forest is located, is the major environmental factor which, together with the presence of a coniferous forest vegetation, originates a series of pedogenetic processes leading to the formation of Orthic Humo-Ferric Podzols on the well drained sites. These soils are characterized in the study area by a thick (4 to 12 inches), poorly decomposed, surface organic horizon of the type fibrimor, and by a relatively shallow soil profile development, exceeding rarely 18 inches. Typically, these Orthic Humo-Ferric Podzols have a profile development of the type: FH-Ae-Bfh-Bf-C. Three Series belong to the Orthic Humo-Ferric subgroup; they are the Chibougamau (A) on basal till, the Aigremont (B) on kame moraine and the Mignault (C) on outwash materials.

On gentle slopes, the soil drainage is moderately good, which is reflected in the soil profile by a slightly darker Ae and by the presence of mottling in the B and C horizons;it is the Nicauba (E) Soil Series which belongs to the Gleyed Humo-Ferric Podzol subgroup.

On concave relief, and flat topped areas, the imperfectly and the poorly drained soils are characterized by a dark grey Ae and a dark reddish brown Bh more than 4 inches thick in which organic matter is the main accumulation product. They belong to the Gleyed Humic Podzol subgroup.

The imperfectly drained Ducharme (G) and Rohault (H) Series and the poorly drained Jourdain (I) and Bouteroue (J) Series belong to this subgroup.

On flat depressed lowlands, the soil is permanently water-logged. The organic matter accumulates on the surface, and bogs are developed. Depending on the aeration status of the ground water, either a Sphagnic Fibrisol or a Typic Mesisol is formed. The corresponding Series are respectively the Epave (K) and the Argenson (L).

The well drained soils that have formed on the shallow till-covered hills do not differ markedly from the Orthic Humo-Ferric Podzol except for a lithic contact within 3 feet from the surface. They belong to the Lithic Humo-Ferric Podzol subgroup. They form the Chaudière (D) Series.

On bedrock exposures, there is no profile development except for an accumulation of organic matter. It forms the Gabriel (F) Series which belongs to the Lithic Regosol subgroup.

In the following pages, the Soil Series of the Nicauba Research Forest are described by alphabetic order of their symbols. The description embodies the environmental factors leading to their formation, the morphology of the soils, their major physical and chemical properties and their geography within the Research Forest.

Soil Series A: CHIBOUGAMAU

(1) Factors of soil formation:

Topography and landform:middle and upper convex slopes within the ground moraine area (bt).

Drainage: good and excessive.

Parent material: well graded fine to medium sandy loam, usually stony and bouldery, deep and very compact.

Associated vegetation: black spruce-Kalmia-Cladonia type; KP.td

(2) Morphology: The solum is shallow, 10 to 18 inches. The surface organic horizon is a typical fibrimor of variable thickness but commonly ranging from 4 to 10 inches. The Ae horizon is thin but with a very high Munsell value. The B horizons are reddish brown to yellowish red and friable but they include very often important patches of ortstein, especially in the upper part. The subsoil is firm. They belong to the Humo-Ferric Podzol subgroup.

The following is a description of a representative profile developed on the upper convex part of a gently undulating area, on compact basal till, under a virgin black spruce-Kalmia-Cladonia forest (plot no. 5038):

FH: 4 to 0 inches; fibrous matted dry mor; abundant fine and medium roots; abrupt smooth boundary; 3 to 5 inches thick.

Ae: 0 to 3 inches; white (5 YR 8/1); well graded fine sandy loam; single grain; loose; few fine and medium roots; abrupt, smooth boundary; 2 to 4 inches thick.

Bfh(c): 3 to 5 inches; dark reddish brown (5YR 3/2); well graded gravelly loamy medium sand; medium strong platy structure; very firm when moist and very hard when dry (ortstein); few fine roots; abrupt smooth boundary; 1 to 3 inches thick.

Bf(c): 5 to 10 inches; yellowish red (5YR 5/6); well graded gravelly loamy medium sand; weak fine granular structure; friable; some areas of medium strong platy structure, very firm when moist and very hard when dry (ortstein) particularly in the upper part; few roots; clear smooth boundary; 4 to 6 inches thick.

C: 10 inches +; pale olive-olive (5YR 6/3-5/3); well graded gravelly loamy fine sand; medium moderate platy structure; firm; no roots.

(3) Soil properties: In spite of relatively favourable textural properties (Appendix 6) the soils belonging to the Chibougamau Series have structural properties, such as the compactness of the subsoil and the occurrence of ortstein in the upper B, which adversely affect the nutrient cycle and the water movements in these soils. The evidence of strong illuviation of both organic matter and free iron is shown in appendix 5. The very high C/N ratio and low base saturation of the surface organic horizon (Appendices 4 and 5) reflect the poor nutrient status of these soils. In summary, these soils are nutrient poor and water deficient after relatively short periods without rainfall.

(4) Geography: The Chibougamau soils occur mostly on the middle and upper convex slopes in the undulating till plain of the central, western, and southern part of the area, where they are commonly associated with the moderately well drained Nicauba (E) soils. They occupy 10.6% of the research area.

Soil Series B: AIGREMONT

(1) Factors of soil formation:

- Topography and landform: middle and upper convex slopes within the kame moraine area (km and cd).

- Drainage: good and excessive.
- Parent material: poorly graded gravelly loamy fine to medium sand; stony and bouldery; loose ablation or superglacial till; sometimes ice-contact stratified drift.
- Associated vegetation: black spruce-Hypnum type; HP.k

(2) Morphology: This soil is similar to the Chibougamau soil except for the absence of ortstein, a much less compact subsoil, and a greater rockiness. The Aigremont Series also belongs to the Humo-Ferric Podzol subgroup.

The following is a description of a representative profile developed on the upper convex slope of a small hill consisting of stony and bouldery superglacial till, under a virgin black spruce - Hypnum forest (plot no. 5004):

FH: 7 to 0 inches; fibrous mor; abundant fine and medium roots; abrupt wavy boundary; 5 to 15 inches thick.

Ae: 0 to 3 inches; pinkish grey (7.5YR 7/2), well graded fine sandy loam; single grain structure; loose; common fine and medium roots; abrupt wavy boundary; 2 to 5 inches thick.

Bfh: 3 to 3.5 inches; dark reddish brown (5YR 3/4); well graded fine sandy loam; stony and bouldery; moderate medium blocky structure; friable; common large and medium roots; clear wavy boundary; 0 to 1 inch thick.

Bfl: 3.5 to 6 inches; yellowish red (5YR 4/6) well graded gravelly fine sandy loam; stony and bouldery; moderate medium blocky structure; very friable, few large and medium roots; gradual wavy boundary; 2 to 5 inches thick.

Bf2: 6 to 12 inches; strong brown (7.5YR 5/6); well graded gravelly fine sandy loam; stony and bouldery; structureless; loose; few large roots; gradual wavy boundary; 5 to 10 inches thick.

C: 12 inches +; olive (5Y 5/3); poorly graded gravelly loamy fine sand; stony and bouldery; structureless; loose; no roots.

(3) Soil properties: Although texturally similar to the Chibougamau soils (Appendix 6), these soils provide a better edaphic environment for forest growth since both the solum and the subsoil are much less compact. The chemical data of appendices 4 and 5 show the strong illuviation of both organic matter and iron and a relatively poor nutrient status. In summary these soils can be regarded as deep, well aerated, with a good water holding capacity, but nutrient poor.

(4) Geography: The Aigremont soils cover 4.9% of the Nicauba Research forest. They occupy the middle and upper convex slopes of the kames and kame moraine area located in the eastern part of the area.

Soil Series C: MIGNAULT

(1) Factors of soil formation:

- Topography and landform: slightly convex or level areas on stratified drift (sd).
- Drainage: good and excessive.
- Parent material: very well sorted, gravelly and cobbly, coarse and very coarse sand; stratified outwash material.
- Associated vegetation: black spruce-Kalmia-Cladonia type; KP.td.

(2) Morphology: The surface organic horizon of this Humo-Ferric Podzol is relatively thinner than in the Chibougamau and Aigremont soils. The Ae is thin but well defined, and patches of cemented Bfh (ortstein) form in some places. In most profiles however, the Bfh is not cemented.

The following is a description of a representative profile developed on an outwash terrace under an open virgin forest of the type: Black spruce-Kalmia-Cladonia (plot no. 5022):

FH: 1 to 0 inch; matted fibrous mor; somewhat greasy; abundant fine and medium roots; abrupt smooth boundary; 1 to 2 inches thick.

Ae: 0 to 2 inches; pinkish grey (7.5YR 7/2); well graded gravelly loamy fine sand; single grain structure; loose; few medium roots; abrupt smooth boundary; 1 to 3 inches thick.

Bfh(c): 2 to 8 inches; dark red (2.5YR 3/6); very well sorted, very gravelly, very coarse sand; structureless and loose except for patches with medium strong platy structure, very firm when moist and very hard when dry (ortstein); no roots; clear smooth boundary; 3 to 8 inches thick.

C: 8 inches +; light olive brown (2.5YR 5/4); very well sorted, very coarse sandy gravel; abundant cobbles; structureless; loose; no roots.

(3) Soil properties: Due to their coarse texture (Appendix 6), the Mignault soils are rapidly permeable to water. Illuviation of organic matter and iron is important (Appendix 5). These soils are low in plant nutrients, droughty and have a very poor water holding capacity.

(4) Geography: The Mignault soils occur on the flat-lying glacial terraces along the Chaudière river in the southeastern part of the Nicauba Research Forest. They occupy 1.3% of the research area.

Soil Series D: CHAUDIERE

(1) Factors of soil formation:

- Topography and landform: middle and upper convex slopes on shallow till-covered precambrian hills (tg).

- Drainage: good and excessive.

- Parent material: shallow granitic till; well graded, stony and bouldery, fine to medium sandy loam.

- Associated vegetation: black spruce-balsam fir type; AP

(2) Morphology: The Chaudière soils have a relatively thin surface organic horizon which, most generally is of the type humo-fibric. The mineral soil resembles the Aigremont profile except for a lithic contact within 3 feet from the surface. They belong to the lithic humo-ferric podzol subgroup.

The following is a description of a representative profile developed on the upper convex slope of a shallow bouldery till-covered granitic hill, under a balsam fir-black spruce-white birch forest (plot no. 5006):

FH: 3 to 0 inches; humo-fibric mor, somewhat granular in some places; abundant fine and medium roots; abrupt smooth boundary; 2 to 5 inches thick.

Ae: 0 to 3 inches; light brownish grey (10YR 6/2); well graded fine sandy loam; stony and bouldery; single grain structure, loose; many fine, medium, and large roots; abrupt wavy boundary; 2 to 5 inches thick.

Bfh: 3 to 6 inches; yellowish red (5YR 4/6); well graded medium sandy loam; stony and bouldery; weak medium blocky structure; friable; many fine, medium, and large roots; gradual wavy boundary; 2 to 4 inches thick.

Bf: 6 to 13 inches; yellowish red (5YR 4/8); well graded loamy medium sand; stony and bouldery; weak medium blocky structure; friable; some large and medium roots; gradual wavy boundary; 5 to 12 inches thick.

C: 13 to 25 inches; light olive brown (2.5 YR 5/4); well graded loamy coarse sand; stony and bouldery; structureless; loose; no roots.

R: 25 inches +; gneissic precambrian bedrock.

(3) Soil properties: Texturally similar to the Chibougamau and Aigremont soils (Appendix 6), the Chaudière soils are shallower and have a more favourable structure, which produce soils that are well aerated and with a good water holding capacity. Both organic matter and iron are strongly illuviated (Appendix 5), but the relatively narrower C/N ratio of the surface organic horizon (Appendices 4 and 5) indicates a relatively more favourable nutrient status than in any other soil of the Research Forest, except the Bouteroue (J) Series. The shallowness of these soils together with their physiographic position in the landscape make these soils warmer than the others.

(4) Geography: The Chaudière soils occur on large isolated areas on all the precambrian hills of the Nicauba Research Forest. They occupy 8.9% of the research area.

Soil Series E: NICAUBA

(1) Factors of soil formation:

- Topography and landform: gentle slopes.
- Drainage: moderately good.
- Parent material: variable.
- Associated vegetation: black spruce-Kalmia type; KP.ts.

(2) Morphology: Under a thick (4 to 15 inches) fibrous surface organic horizon, there is generally a well developed greyish brown Ae horizon which is darker than the Ae of the better drained Chibougamau, Aigremont, Mignault, and Chaudière soils. The Bfh is commonly dark reddish brown. The lower B and the C horizons are mottled or marbled. The Nicauba soils belong to the Gleyed Humo-Ferric Podzol subgroup.

The following is a description of a profile located on a lower concave slope, and developed in stony and bouldery compact basal till, under a virgin Kalmia-black spruce forest (plot no. 5016):

FH: 9 to 0 inches; fibrous mor; abundant fine, medium, and large roots; abrupt smooth boundary; 4 to 12 inches thick.

Ae: 0 to 3 inches; dark reddish grey (5YR 4/2); well graded very fine sandy loam; single grain structure; loose; common fine and medium roots; abrupt, smooth boundary; 2 to 4 inches thick.

Bfh: 3 to 5 inches; dark reddish brown (2.5YR 2/4); well graded fine sandy loam; stony; medium weak blocky structure; friable, a few areas of medium strong platy structure (ortstein); few fine and medium roots; clear smooth boundary; 0 to 2 inches thick.

Bfg: 5 to 12 inches; reddish brown (5YR 4/4); well graded fine sandy loam; stony; common medium distinct strong brown(7.5YR 5/6) mottles; fine, weak, blocky structure; very friable; few fine and medium roots; clear wavy boundary; 4 to 10 inches thick.

Cg: 12 inches +; olive (5YR 5/3); well graded loamy fine sand; stony and bouldery; common medium distinct strong brown (7.5YR 5/6) mottles; medium moderate platy structure; friable; no roots.

(3) Soil properties: Chemically, the Nicauba soils closely resemble the Chibougamau soils (Appendices 4 and 5). Their topographic position provides however more water for tree growth.

(4) Geography: The Nicauba soils cover 19% of the Nicauba Research Forest. They extend on all the gentle till covered slopes of the area in close association with the better drained Chibougamau and the imperfectly drained Ducharme.

Soil Series F: GABRIEL

(1) Factors of soil formation:

- Topography and landform: gently convex gneissic bedrock outcrops.
- Drainage: excessive to good.
- Parent material: gneissic bedrock.
- Associated vegetation: black spruce-Cladonia-Kalmia type; KP.c

(2) Morphology: The Gabriel soils consist in a fibrous surface organic horizon 2 to 8 inches thick, somewhat greasy in some places, lying directly on bare rock. In several places a light grey Ae and a dark reddish brown Bfh can be present but they rarely exceed 3 to 5 inches in thickness, except along fracture lines. They belong to the Lithic Regosol subgroup.

(3) Soil properties: These soils are very low in plant nutrients and very droughty.

(4) Geography: The Gabriel soils do not cover large areas in the Nicauba research forest, 1.3% only. They occupy however significant areas in the higher convex parts of the till plain area.

Soil Series G: DUCHARME

(1) Factors of soil formation:

- Topography and landform: very gentle slope and depressions.
- Drainage: imperfect.
- Parent material: variable.
- Associated vegetation: black spruce-Kalmia-Sphagnum type; KP.s.

(2) Morphology: The surface organic horizon is a fibric peaty mor 4 to 15 inches thick. The dark grey Ae horizon is frequently much darker than in all better drained soils. The B horizons are dark reddish brown and the C is mottled or marbled olive and grey. They belong to the Gleyed Humic Podzol subgroup.

The following is a description of a profile located on a very gentle slope and developed in a stony and bouldery compact basal till, under a virgin black spruce forest of the type Black spruce-Kalmia-Sphagnum (plot no. 5039):

FH: 12 to 0 inches; fibrous and slightly greasy mor; abundant fine, medium, and large roots; abrupt smooth boundary; 6 to 18 inches thick.

Ae: 0 to 2 inches; dark grey (5YR 4/1), well graded loamy medium sand; stony; single grain structure; loose; common medium roots; clear smooth boundary; 1 to 3 inches thick.

Bh1: 2 to 6 inches; dark reddish brown (5YR 2/2); well graded gravelly loamy fine sand; stony; coarse weak granular structure; very friable; few medium roots; gradual smooth boundary; 3 to 5 inches thick.

Bh2: 6 to 12 inches; dark reddish brown (5YR 3/4); poorly graded loamy fine sand; stony and bouldery; structureless; loose; no roots; clear smooth boundary; 5 to 10 inches thick.

Cg: 12 inches +; olive (5YR 5/4); well graded loamy fine sand; stony and bouldery; abundant medium distinct mottles; medium moderate platy structure; firm; no roots.

(3) Soil properties: The chemical data of Appendix 5 show the low nutrient status of these soils, the strong illuviation of organic matter and the weak accumulation of free iron in the B horizons, which is typical of the soils belonging to the Humic Podzol great-group. Being waterlogged for long periods during the growing season, these soils are too wet for forest growth.

(4) Geography: The Ducharme soils occur through the research forest everywhere there are very gentle slope, in close association with the moderately well drained Nicauba soils. They cover 18.5% of the total area.

Soil Series H: ROHAULT

(1) Factors of soil formation:

- Topography and landform: very gentle slopes along streams.
- Drainage: imperfect (with lateral movement of water: seepage).
- Parent material: variable.
- Associated vegetation: black spruce-Sphagnum-Alnus type; SP.a

(2) Morphology: The soils of the Rohault Series closely resemble those of the Ducharme Series except for the surface organic horizon which is more greasy, and sometimes granular. They also belong to the Gleyed Humic Podzol subgroup.

The following is a description of a profile located in a gentle depression and developed in water-worked drift, under a virgin black spruce forest of the type: black spruce-Sphagnum-Alnus (plot no. 5034):

FH: 15 to 0 inches; humo-fibric peaty mor with a thick Sphagnum mat; abundant fine and medium roots; abrupt smooth boundary; 10 to 20 inches thick.

Ae: 0 to 2 inches; dark grey (5YR 4/1); well graded loamy fine sand; single grain structure; loose; few fine and medium roots; gradual smooth boundary; 0 to 3 inches thick.

Bh1: 2 to 6 inches; dark reddish brown (5YR 2/2); well graded loamy fine sand; stony; structureless; loose; few fine and medium roots; gradual smooth boundary; 3 to 4 inches thick.

Bh2: 6 to 16 inches; dark reddish brown (5YR 3/4); well sorted loamy fine sand; stony; structureless; loose; no roots; clear smooth boundary; water table at 7 inches (July 20); 5 to 12 inches thick.

Cg: 16 inches +; olive (5YR 4/3); well sorted loamy fine sand, stony and bouldery; many medium, distinct mottles; structureless; loose; no roots.

(3) Soil properties: The analyses of these soils (Appendices 4 and 5) indicate the great resemblance between the Rohault and the Ducharme soils. It is suspected however that the telluric water circulating laterally through the Rohault soils does provide a relatively better nutritional status.

(4) Geography: Only 4.4% of the Nicauba Research Forest is covered by the Rohault soils. They occur mainly in the vicinity of streams.

Soil Series I: JOURDAIN

(1) Factors of soil formation:

- Topography and landform: closed depressions and in border of large peat bogs.
- Drainage: poor.
- Parent material: variable.
- Associated vegetation: black spruce-Sphagnum-Chamaedaphne type; SP.c.

(2) Morphology: The Jourdain soils are similar to the Ducharme soils except for a thicker surface organic horizon (10 to 20 inches thick) and darker B horizon which are black to dark reddish brown or dark brown. They belong to the Gleyed Humic Podzol Subgroup.

The following is a description of a profile located near the margin of a peat bog and developed in a compact basal till, under an open black spruce-Sphagnum-Chamaedaphne forest (plot no. 5019):

FH: 20 to 0 inches; fibrous peaty mor; the lower part is somewhat mucky and better decomposed; abundant fine, medium, and large roots; abrupt smooth boundary; 15 to 24 inches thick.

Ae: 0 to 2 inches; dark grey (10YR 4/1); well graded fine sandy loam; stony and bouldery; single grain structure; loose; few medium and fine roots; clear smooth boundary; 1 to 3 inches thick.

Bh1: 2 to 5 inches; black (10YR 2/1); well graded fine sandy loam; stony and bouldery; structureless; loose; no roots; gradual smooth boundary; 2 to 5 inches thick.

Bh2: 5 to 9 inches; dark brown (10YR 3/3); poorly graded loamy fine sand; stony and bouldery; structureless; loose; no roots; gradual smooth boundary; 2 to 10 inches thick.

Bh3: 9 inches +; dark yellowish brown (10 YR 4/3); poorly graded loamy fine sand; stony and bouldery; structureless; loose; no roots; water table at 10 inches (July 1).

(3) Soil properties: The analyses of appendix 5 show the large accumulation of organic matter in the B horizons of these soils, while there is practically no iron accumulation. They also indicate that these soils are nutrient-poor. Added to nearly permanent and

stagnant water-logging conditions, this makes these soils very unfavourable to forest growth.

(4) Geography: These soils occupy relatively small isolated areas in close association with the very poorly drained Epave soils and the imperfectly drained Ducharme soils. They cover 6.4% of the Research Forest.

Soil Series J: BOUTEROUE

(1) Factors of soil formation:

- Topography and landform: level areas along streams.
- Drainage: poor (with lateral movement of water: seepage).
- Parent material: variable.
- Associated vegetation: black spruce-Sphagnum-Alnus type SP.a

(2) Morphology: These soils are at the limit between the mineral and the organic soils. At the time of the survey, the water table was at five inches from the top of the surface organic horizon. The soil profile is however very similar to the Jourdain soils except for the surface organic horizon which is more greasy and better decomposed.

(3) Soil properties: The chemical data for the surface organic horizon (Appendices 4 and 5) show that these soils are richer in plant nutrients than most of the soils of the Research Forest except those belonging to the Chaudière Series.

(4) Geography: The Bouteroue soils cover only 2.1% of the total area. They are limited to narrow bands along streams.

Soil Series K: EPAVE

(1) Factors of soil formation:

- Topography and landform: bogs.
- Drainage: very poor.
- Parent material: organic materials.
- Associated vegetation: Sphagnum-Chamaedaphne type; SC

(2) Morphology: These soils consist of deep, uniform fibrous organic matter, derived dominantly from Sphagnum mosses and ericaceous shrubs.

(3) Soil properties: The Epave soils are very poor in nutrients (Appendix 5) and they have a very high stagnant water table. They are therefore unsuitable for forest growth.

(4) Geography: These soils cover extensive areas in the northern part of the Nicauba Research Forest and minor areas in the vicinity of lakes and low depressed areas. They cover 7% of the total area.

Soil Series L: ARGENSON

(1) Factors of soil formation:

- Topography and landform: level areas along streams.
- Drainage: very poor (with lateral movement of water: seepage).
- Parent material: organic materials.
- Associated vegetation: Alder-black spruce type; PAl

(2) Morphology: These soils consist of deep, moderately fibrous, but partly decomposed black organic matter derived from deciduous and coniferous trees.

(3) Soil properties: The Argenson soils are nutrient rich, but they have a very high water table. They are unsuitable for forest growth unless artificially drained.

(4) Geography: The Argenson soils occur in narrow bands along streams. They cover only 0.5% of the Research Forest.

5. VEGETATION

The phytosociological method used for classifying the vegetation of the Nicauba Research Forest led to the production of a vegetation synthesis table (Vegetation table in appendix) which subdivides the vegetation into 7 associations and 11 forest types. The silvicultural significance of the forest type derives from the fact that it indicates a group of forests which are physiognomically, floristically and ecologically similar. Appendix 7 gives the Latin, English and French nomenclature of the vegetation units.

(a) The ecological groups of species

The vegetation synthesis table (in appendix) shows that 58 of the 74 species found in the Nicauba Research Forest have a differential value in at least one vegetation unit. All species with similar differential values were considered to behave similarly in regard to environmental conditions. On this empirical basis, 17 ecological groups of species were formed. Their composition is indicated in table 2.

In an attempt to objectively assess the behavior of these ecological groups in relation with soil wetness and humus nutrient status, the relationships between the importance value of each group and the parameters of soil moisture regime and C/N ratio of the surface organic horizon have been studied. The method used is the one used by Jurdant (1968) in the Montmorency River area.

Table 2. The ecological groups of species (The species after which the group is named is underlined).

Group Number	Species
1	Sorbus americana
	Amelanchier bartramiana
	Aralia nudicaulis
	Lycopodium obscurum
	Pyrola secunda
	Acer spicatum
	Bazzania trilobata
	Dryopteris spinulosa
	Pteridium latiusculum
2	Hylocomium splendens
	Abies balsamea
	Listera cordata
	Trientalis borealis
	Clintonia borealis
	Linnaea borealis
3	Maianthemum canadense
	Betula papyrifera
	Alnus crispa
	Dicranum fuscescens
4	Pinus banksiana
5	Hypnum crista-castrensis
6	Dicranum undulatum
7	Calliergon schreberi
	Vaccinium myrtilloides
	Gaultheria hispidula
	Cornus canadensis
8	Kalmia angustifolia
	Picea mariana
	Vaccinium pensylvanicum
9	Coptis groenlandica
	Lycopodium annotinum
10	Ledum groenlandicum
11	Cladonia alpestris
	Cladonia rangiferina
12	Sphagnum spp.
13	Carex trisperma
	Rubus chamaemorus
	Smilacina trifolia
14	Chamaedaphne calyculata
	Kalmia polifolia
	Andromeda glaucophylla
	Vaccinium oxycoccos
	Betula pumila
15	Eriophorum virginicum
	Sarracenia purpurea
16	Alnus rugosa
	Equisetum sylvaticum
	Oxalis montana
	Carex canescens
	Viburnum trilobum
17	Mnium punctatum
	Rubus pubescens
	Athyrium filix femina
	Viola incognita
	Dryopteris disjuncta
	Ribes glandulosum
	Ribes lacustre

All plots were grouped into 6 classes of soil moisture regime and 3 classes of C/N ratio of the surface organic horizon. The distribution of these classes is shown in table 3. The average importance value of each ecological group was determined in each soil moisture regime and C/N classes. Then, the relative importance value of each ecological group was expressed as a percentage of the maximum importance value of that particular group in all classes.

Table 3 Classes of soil moisture regime and C/N ratio of the surface organic horizon

Class	Soil Moisture Regime	Number of plots
1	very dry	2
2	dry	13
3	fresh	6
4	moderately wet	7
5	wet	6
6	very wet	4

Class	C/N ratio of surface organic horizon	Number of plots
1	smaller than 37	11
2	37 to 54	10
3	larger than 54	13

The average importance values and the relative importance values of the ecological groups along the gradients of soil moisture and C/N ratio of the surface organic horizon are shown in appendices 8 and 9.

These tables were critically examined to determine whether significant patterns of occurrence were recognizable. Several ecological groups showed similar patterns, indicating a similar ecological response to the environmental gradients studied. As an aid to interpreting these patterns, a series of graphs were prepared. Figures 3 and 4 reveal the relationships between relative importance value of ecological groups on the one hand, and soil moisture regime of C/N ratio of the surface organic horizon on the other. Similar patterns are grouped on the same graph and named accordingly. Seven types of soil moisture pattern and four types of nutrient patterns have been so obtained.

The relationships revealed by these diagrams allow local and empirical but objective classification of ecological groups of species according to the environmental situations where their requirements for soil moisture and nutrients are met most effectively. The classification is presented in appendix 10.

FIGURE: 3 ; THE PATTERNS OF ECOLOGICAL GROUPS OF SPECIES IN RELATION TO THE GRADIENT OF SOIL MOISTURE .

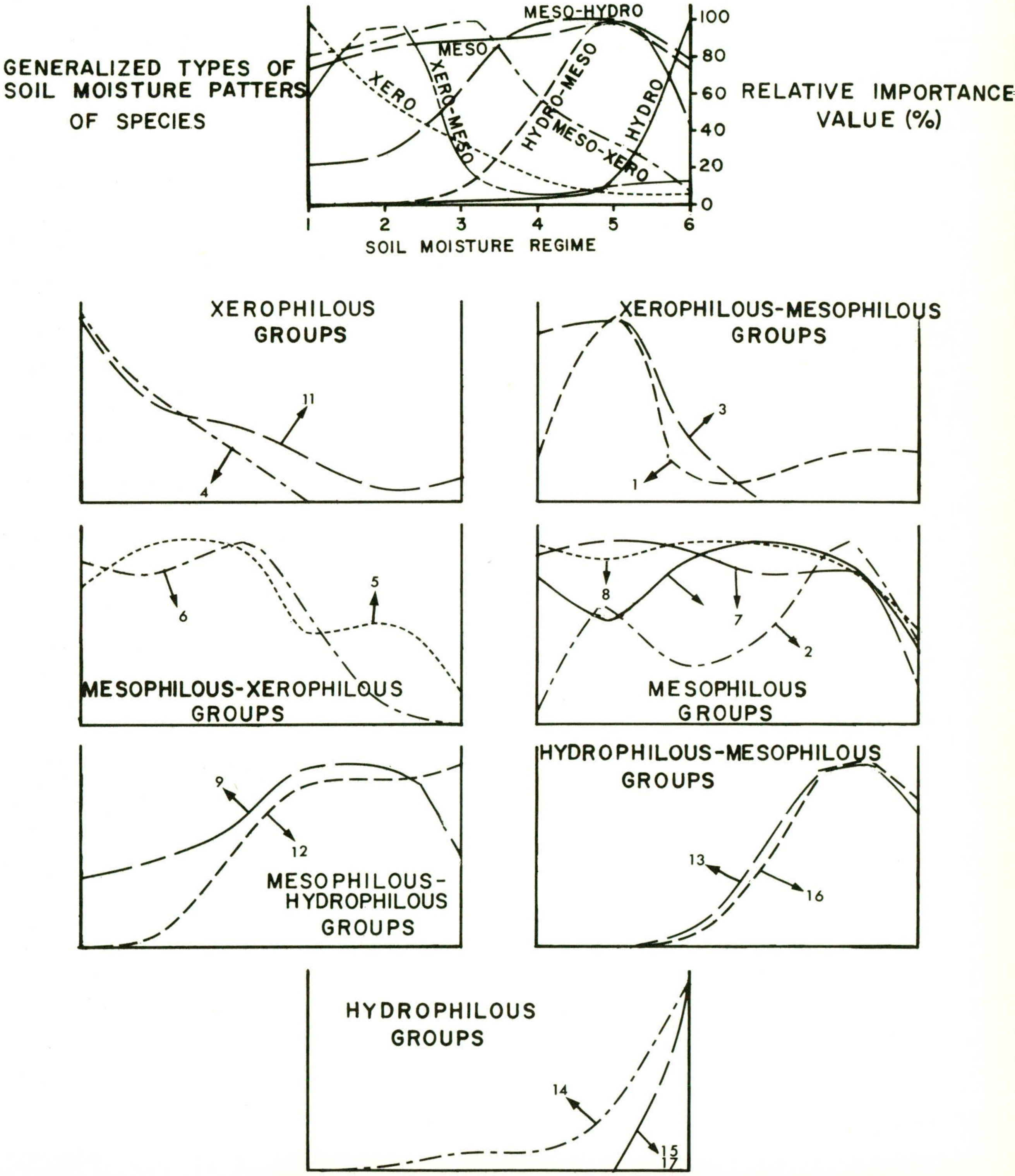
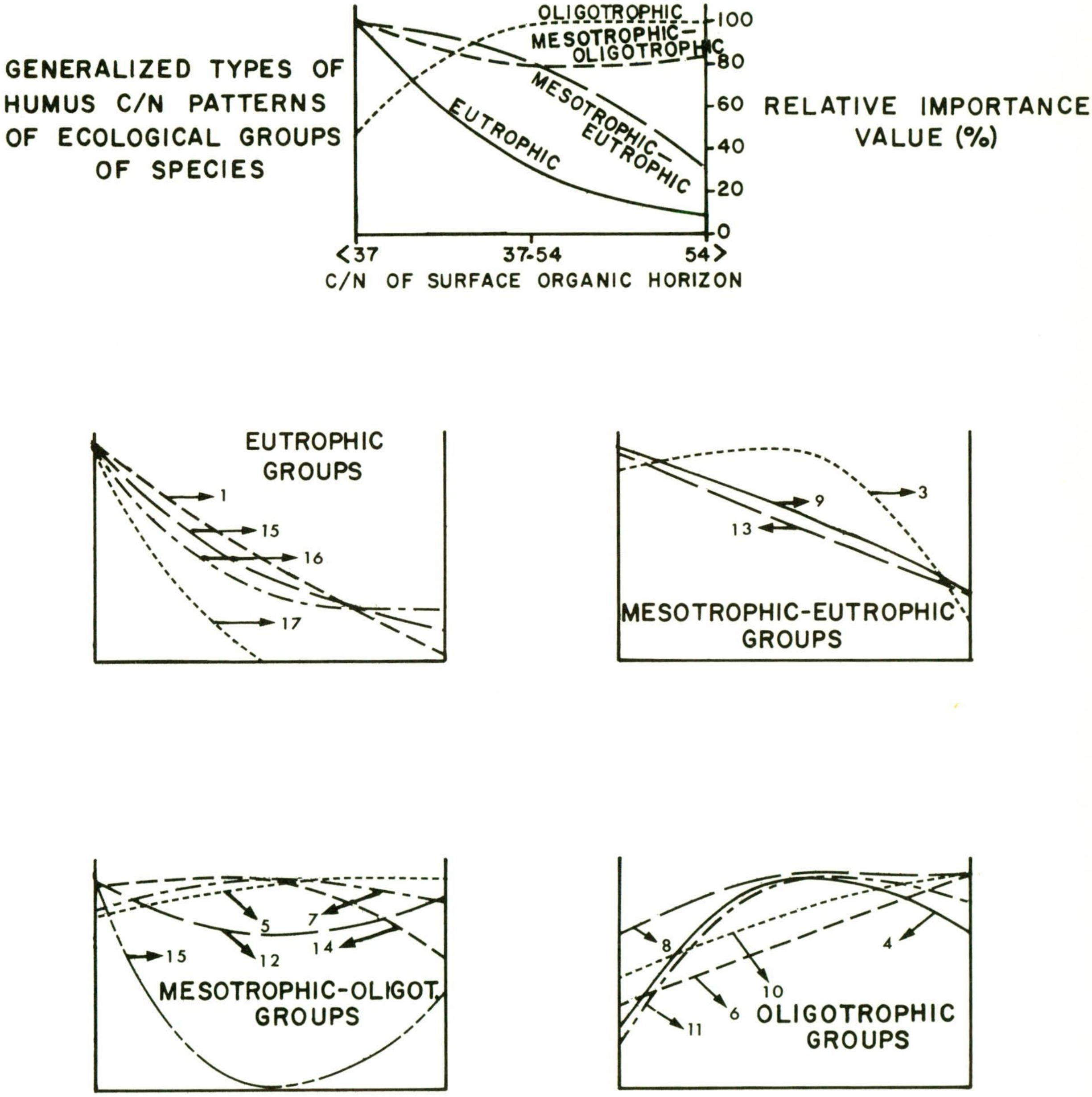


FIGURE: 4 ; THE PATTERNS OF ECOLOGICAL GROUPS OF SPECIES IN RELATION TO THE GRADIENT OF C/N IN THE SURFACE ORGANIC HORIZON .



(b) The forest types

The major floristic differences between the forest types are shown in table 4 which gives the average Importance Value of each ecological group of species by forest type. The complete vegetation synthesis table in appendix provides a complete account of the floristic variation within, as well as between forest types.

Since the forest types are distinguished by means of the presence and abundance of certain ecological groups of species which are themselves related to certain environmental conditions, it is possible to assess the relationships between each of these forest types and the ecological factors studied, i.e. soil moisture regime and nutrient status in the surface organic horizon. The average Importance Value of each ecological group by forest type from table 4 was used to obtain the data of appendix 11, which summarizes the ecological structure of the forest types in the Nicauba Research Forest. From that appendix, the ecological spectra of figure 5 were derived. The relative position of each forest type along the gradients of soil moisture and nutrient status is illustrated in figure 6.

TABLE 4. VEGETATION SYNTHESIS TABLE SHOWING THE IMPORTANCE VALUES OF ECOLOGICAL GROUPS OF SPECIES IN EACH FOREST TYPE

SHADED VALUES INDICATE A DIFFERENTIAL VALUE OF THE GROUP IN THE FOREST TYPE.

ECOLOGICAL GROUPS OF SPECIES	BLACK SPRUCE - BALSAM FIR	BLACK SPRUCE - HYPNUM	BLACK SPRUCE - KALMIA - CLADONIA	BLACK SPRUCE - KALMIA	BLACK SPRUCE - KALMIA - SPHAGNUM	BLACK SPRUCE - SPHAGNUM - CHAMAEDAPHNE	SPHAGNUM - CHAMAEDAPHNE	BLACK SPRUCE - SPHAGNUM - ALNUS	ALDER SWAMP
	AP	HP.k	KP.t.cl	KP.t.s	KP.s	SP.c	SC	SP.a	Aln
1. SORBUS AMERICANA	**51**	0	5	2	4	7	4	4	14
2. HYLOCOMIUM SPLENDENS	**101**	12	3	24	18	30	14	**66**	**78**
3. MAIANTHEMUM CANADENSE	**123**	**119**	8	24	0	0	0	0	0
4. PINUS BANKSIANA	**100**	**140**	**163**	**65**	0	0	0	0	0
5. HYPNUM CRISTA-CASTRENSIS	**172**	**233**	**169**	**187**	66	55	0	**153**	**140**
6. DICRANUM UNDULATUM	**136**	**120**	**169**	**180**	**120**	0	0	42	0
7. CALLIERGON SCHREBERI	**198**	**191**	**161**	**170**	**140**	**146**	42	**156**	35
8. KALMIA ANGUSTIFOLIA	**168**	**215**	**221**	**228**	**223**	**207**	**140**	**199**	37
9. COPTIS GROENLANDICA	**112**	0	10	**56**	**86**	**70**	37	**100**	**70**
10. LEDUM GROENLANDICUM	50	**83**	**163**	**200**	**228**	**220**	**130**	**188**	0
11. CLADONIA ALPESTRIS	39	**117**	**174**	**85**	53	35	42	12	0
12. SPHAGNUM SPP.	22	0	16	**137**	**252**	**300**	**300**	**213**	**180**
13. CAREX TRISPERMA	0	0	5	12	**97**	**167**	**144**	**107**	0
14. CHAMAEDAPHNE CALYCULATA	0	0	4	12	14	**114**	**146**	0	0
15. ERIOPHORUM VIRGINICUM	0	0	0	0	0	0	**148**	0	0
16. ALNUS RUGOSA	0	0	0	4	16	39	0	**68**	**188**
17. MNIUM PUNCTATUM	0	0	0	0	0	0	0	0	**127**

FIGURE 5. ECOLOGICAL SPECTRA OF THE FOREST TYPES OF THE NICAUBA RESEARCH FOREST (% OF TOTAL IMPORTANCE VALUE)

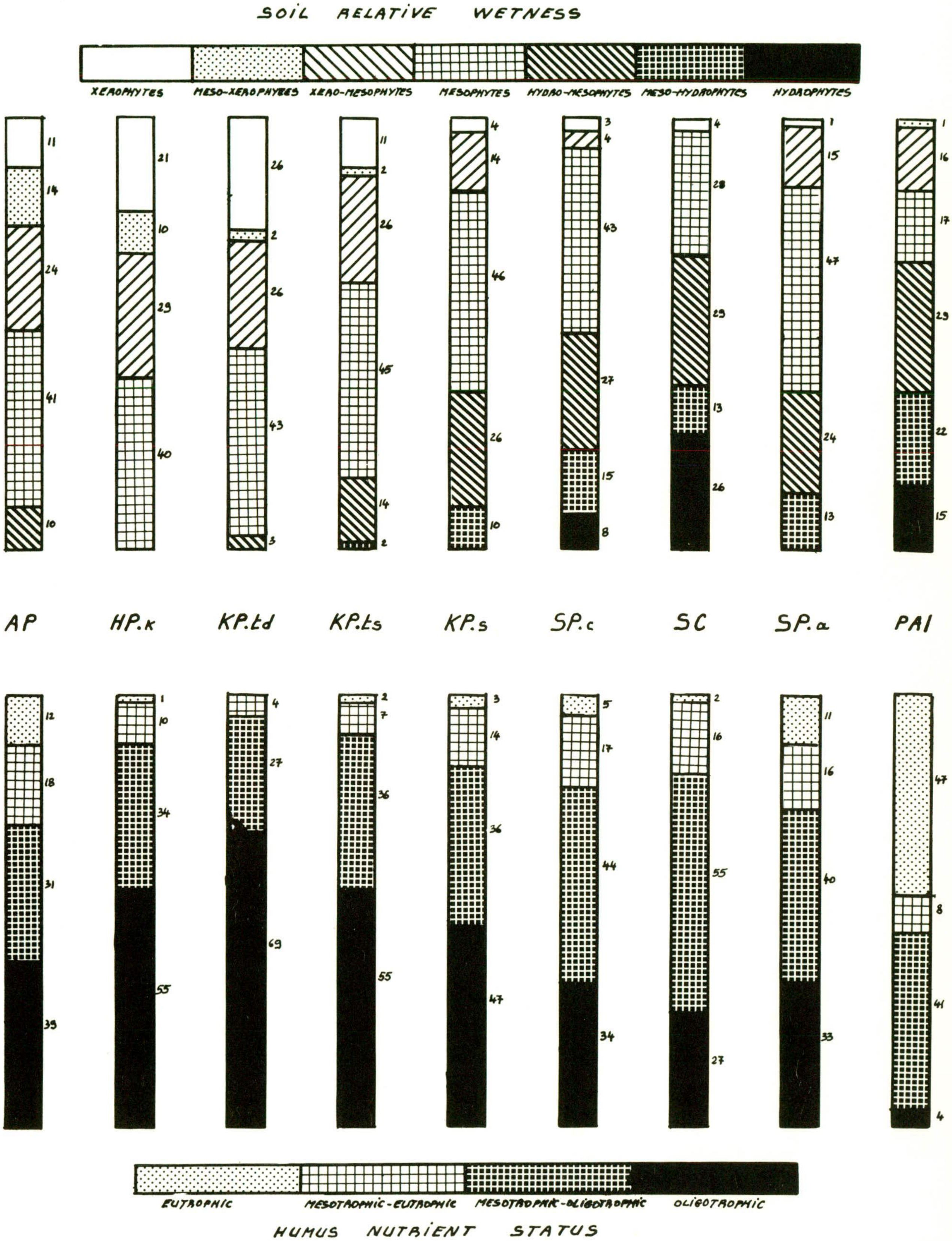
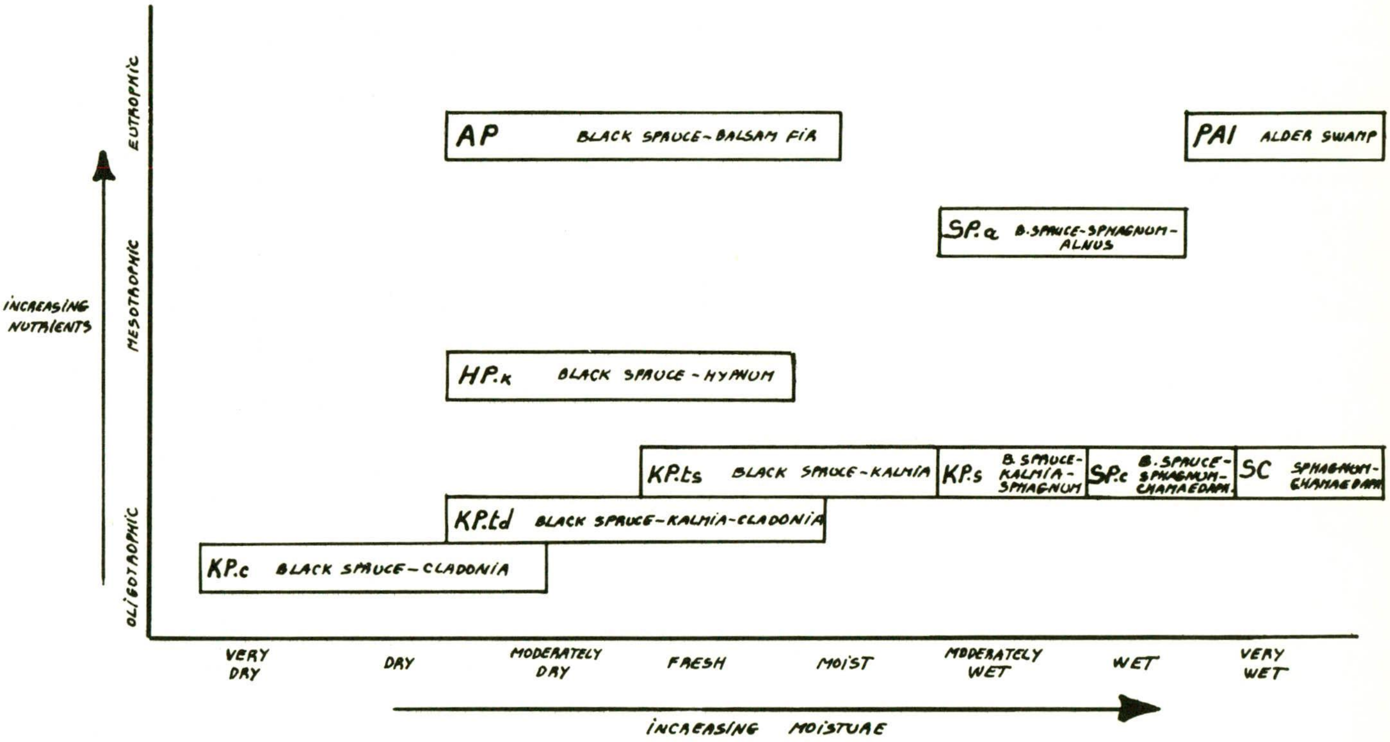


FIGURE 6. DISTRIBUTION OF FOREST TYPES IN RELATION TO SOIL MOISTURE AND NUTRIENTS



The description of the forest types which follows will give an account of their physiognomy and structure, floristic composition, and ecology.

A. The black spruce-balsam fir association (Abieti-Piceetum marianae)

This association is represented in the Nicauba Research forest by only one forest type: the black spruce-balsam fir type; AP

(1) Physiognomy and structure (Appendix 11):

- Generally overmature and multistoried black spruce-balsam fir forests with white birch as a common associate and jack pine often present.

- Ericaceous shrubs not abundant.

- Forbs more abundant than in the other conifer forest types.

- Mosses less abundant than in the other conifer forest types.

(2) Floristic composition (Tables 4 and 5, Vegetation table):

Floristically the richest among the forest types in the Nicauba Research Forest. Characterized by the ecological groups 1 (Sorbus americana), 2 (Hylocomium splendens) and 3 (Maianthemum canadense).

Differentiation with respect to:

a. the black spruce-Hypnum type (HP.k):

Presence of groups 1 (Sorbus americana), 2(Hylocomium splendens) and 9 (Coptis groenlandica).
Absence of groups 11 (Cladonia rangiferina) and 10 (Ledum groenlandicum).

b. The black spruce-Kalmia types:

Presence of groups 1 (Sorbus americana), 2 (Hylocomium splendens) and 3(Maianthemum canadense).
Absence of group 10 (Ledum groenlandicum) and 11 (Cladonia alpestris).
Lower abundance of Kalmia angustifolia.

c. all other types:

Absence of mesophilous-hydrophilous and hydrophilous groups.

(3) Ecology

- Soil water: moderately dry to fresh sites.

- Soil nutrients: eutrophic.

- Soil series: Chaudière (D).

- Landform: convex shaped and shallow till-covered hills.

Table 5 Characteristic species composition of the black spruce-balsam fir type (AP). (Differential species characterizing the forest type are underlined. Number of ecological group in parentheses). Species density: 23

Rank	Average Importance Value	Presence %	Species
1	260	100	Picea mariana (8)
2	244	100	Calliergon schreberi (7)
3	196	100	Cornus canadensis (7)
4	188	100	Abies balsamea (2)
5	188	100	Vaccinium myrtilloides (7)
6	180	100	Maianthemum canadense (3)
7	172	100	Hypnum crista-castrensis (5)
8	166	100	Kalmia angustifolia (8)
9	164	100	Gaultheria hispidula (7)
10	164	100	Betula papyrifera (3)
11	156	100	Clintonia borealis (2)
12	156	100	Hylocomium splendens (2)
13	140	100	Coptis groenlandica (9)
14	136	80	Dicranum undulatum (6)
15	134	100	Sorbus americana (1)
16	100	60	Pinus banksiana (4)
17	92	60	Dicranum fuscescens (3)
18	84	60	Aralia nudicaulis (1)
19	84	60	Lycopodium annotinum (9)
20	78	60	Amelanchier bartramiana (1)
21	78	60	Vaccinium pensylvanicum (8)
22	56	40	Linnaea borealis (2)
23	56	40	Alnus crispa (3)

B. The black spruce-Hypnum association (Hypno-Piceetum marianae)

This association is represented in the studied area by only one forest type: the black spruce-Hypnum type; HP.k

(1) Physiognomy and structure (Appendix 11):

- Moss-rich, dense black spruce forest with scattered white birch and jack pine.

- Ericaceous shrubs dispersed.

- Forbs almost absent.

- Complete moss cover.

(2) Floristic composition (tables 4 and 6, Vegetation table):

Characterized by the ecological groups 5 (Hypnum crista-castrensis), 7 (Calliergon shreberi), and 3 (Maianthemum canadense).

Differentiation with respect to:

a. the black spruce-balsam fir type (AP):

Absence of groups 1 (Sorbus americana), 2 (Hylocomium splendens) and 9 (Coptis groenlandica). Presence of groups 11 (Cladonia rangiferina) and 10 (Ledum groenlandicum).

b. the black spruce-Kalmia types:

Presence of group 3 (Maianthemum canadense). Lower abundance of groups 8 (Kalmia angustifolia), and 10 (Ledum groenlandicum).

c. all other types:

Absence of mesophilous-hydrophilous and hydrophilous groups.

(3) Ecology (Appendix 11, figures 4 and 5):

- Soil water: moderately dry to fresh sites.

- Soil nutrients: mesotrophic.

- Soil series: Aigremont (B).

- Landform: middle and upper convex slopes on kame moraines.

Table 6 Characteristic species composition of the black spruce-Hypnum type (HP.k). (Differential species characterizing the forest type are underlined. Number of ecological group in parentheses). Species density: 16.

Rank	Average Importance Value	Presence %	Species
1	300	100	Picea mariana (8)
2	247	100	Calliergon schreberi (7)
3	233	100	Hypnum crista-castrensis (5)
4	207	100	Kalmia argustifolia (8)
5	180	100	Vaccinium myrtilloides (7)
6	180	100	Gaultheria hispidula (7)
7	157	100	Cornus canadensis (7)
8	140	100	Vaccinium pensylvanicum (8)
9	140	100	Pinus banksiana (4)
10	140	100	Cladonia alpestris (11)
11	133	100	Dicranum fuscescens (3)
12	130	100	Betula papyrifera (3)
13	130	100	Alnus crispa (3)
14	120	66	Dicranum undulatum (6)
15	93	66	Cladonia rangiferina (11)
16	83	66	Maianthemum canadense (3)

C. The black spruce-Kalmia association (Kalmieto-Piceetum marianae)

This association was defined in Newfoundland by Damman (1964). It includes all the black spruce forests having a dense ericaceous shrub ground cover in which Kalmia angustifolia is the dominant species.

Four forest types have been recognized in this association:

1. the black spruce-Cladonia-Kalmia type: (KP.c)

This type was not sampled as it covers only 1.3 percent of the Nicauba Research Forest . The following description is based on observations collected during the field mapping.

(1) Physiognomy and structure:

- Open, irregular black spruce forest with scattered jack pine.

- Ericaceous shrubs abundant.

- Forbs almost absent.

- Complete moss and lichen cover.

(2) Floristic composition:

This forest type is similar to the black spruce-Kalmia-Cladonia type except for a much greater abundance of Cladonia rangiferina and Cladonia alpestris.

(3) Ecology (Figure 6):

- Soil water:dry sites.

- Soil nutrients: oligotrophic.

- Soil series: Gabriel (F).

- Landform: gently convex gneissic bedrock outcrops within the till plain.

2. the black spruce-Kalmia-Cladonia type; (KP.td)

(1) Physiognomy and structure (Appendix 11):

- Black spruce forest with scattered jack pine.

- Complete cover of ericaceous shrubs.

- Herbs and forbs almost absent.

- Complete moss and lichen cover.

(2) Floristic composition (tables 4 and 7, Vegetation table):

Characterized by the ecological groups 8 (Kalmia angustifolia), 10 (Ledum groenlandicum), 11 (Cladonia alpestris), 5 (Hypnum crista-castrensis), and 4 (Pinus banksiana).

Differentiation with respect to:

a. the black spruce-balsam fir type (AP):

Absence of groups 1 (Sorbus americana), 2 (Hylocomium splendens) and 9 (Coptis groenlandica).
Presence of groups 10 (Ledum groenlandicum) and 11 (Cladonia rangiferina).

b. the black spruce-Hypnum type (HP.k):

Absence of group 3 (Maianthemum canadense).
Greater abundance of species from groups 10 (Ledum groenlandicum) and 11 (Cladonia alpestris).

c. all other types:

Absence of mesophilous-hydrophilous and hydrophilous groups.

(s) Ecology (Appendix 11, figures 4 and 5):

- Soil water: moderately dry to fresh sites.

- Soil nutrients: oligotrophic.

- Soil series: Chibougamau (A) and Mignault (C).

- Landform: middle and upper convex slopes of the gently undulating till plain area and slightly convex or level areas on stratified drift.

Table 7 Characteristic species composition of the black spruce-Kalmia-Cladonia type (KP.td). Differential species characterizing the forest type are underlined. Number of ecological group in parentheses). Species density: 14.

Rank	Average Importance Value	Presence %	Species
1	289	100	Picea mariana (8)
2	260	100	Calliergon schreberi (7)
3	243	100	Kalmia angustifolia (8)
4	180	100	Vaccinium myrtilloides (7)
5	177	100	Cladonia alpestris (11)
6	170	100	Cladonia rangiferina (11)
7	169	100	Hypnum crista-castrensis (5)
8	169	100	Dicranum undulatum (6)
9	163	100	Pinus banksiana (4)
10	163	100	Gaultheria hispidula (7)
11	163	100	Ledum groenlandicum (10)
12	133	86	Vaccinium pensylvanicum (8)
13	51	43	Amelanchier bartramiana (1)
14	40	29	Cornus canadensis (7)

3. the black spruce-Kalmia type; (KP.ts)

(1) Physiognomy and structure (Appendix 11):

- Black spruce forest with occasional scattered jack pine.

- Complete cover of ericaceous shrubs.

- Herbs and forbs almost absent.

- Complete moss cover.

(2) Floristic composition (tables 4 and 8, Vegetation table):

Characterized by the ecological groups 8 (Kalmia angustifolia), 10 (Ledum groenlandicum), 11 (Cladonia alpestris), 12 (Sphagnum spp.) and 5 (Hypnum crista-castrensis).

Differentiation with respect to:

a. the black spruce-balsam fir (AP) and the black spruce-Hypnum (HP.k) types :

Absence of the groups 1 (Sorbus americana), 2 (Hylocomium splendens) and 3 (Maianthemum canadense).
Presence of the groups 10 (Ledum groenlandicum) and 12 (Sphagnum spp).

b. the black spruce-Kalmia-Cladonia type (KP.td):

Lower abundance of the groups 4 (Pinus banksiana) and 11 (Cladonia alpestris). Presence of the group 12 (Sphagnum spp).

c. all other types:

Absence of the hydrophilous groups 13 (Carex trisperma), 14 (Chamaedaphne calyculata), 15 (Eriophorum virginicum), 16 (Alnus rugosa) and 17 (Mnium punctatum).

(3) Ecology (Appendix 11, figures 4 and 5):

- Soil water: moist sites.

- Soil nutrients: oligotrophic.

- Soil series: Nicauba (E).

- Landform: gentle slopes on various landforms.

Table 8 Characteristic species composition of the black spruce-Kalmia type (KP.ts). (Differential species characterizing the forest type are underlined. Number of ecological group in parentheses). Species density: 17.

Rank	Average Importance Value	Presence %	Species
1	300	100	Picea mariana (8)
2	273	100	Calliergon schreberi (7)
3	233	100	Kalmia angustifolia (8)
4	200	100	Ledum groenlandicum (10)
5	187	100	Hypnum crista-castrensis (5)
6	180	100	Dicranum undulatum (6)
7	167	100	Gaultheria hispidula (7)
8	152	83	Vaccinium pensylvanicum (8)
9	136	100	Sphagnum spp. (12)
10	123	83	Vaccinium myrtilloides (7)
11	118	83	Cornus canadensis (7)
12	112	83	Cladonia alpestris (11)
13	88	66	Coptis groenlandica (9)
14	83	66	Cladonia rangiferina (11)
15	78	66	Maianthemum canadense (3)
16	65	50	Pinus banksiana (4)
17	55	50	Hylocomium splendens (2)

4. the black spruce-Kalmia-Sphagnum type; (KP.s)

(1) Physiognomy and structure (Appendix 11):

- Black spruce forest, somewhat open and irregular.
- Complete cover of ericaceous shrubs.
- Herbs and forbs almost absent.
- Complete moss cover.

(2) Floristic composition (tables 4 and 9, Vegetation table):

Characterized by the ecological groups 8 (Kalmia angustifolia), 10 (Ledum groenlandicum), 12 (Sphagnum spp.), and 13 (Carex trisperma).

Differentiation with respect to:

a. the black spruce-Kalmia (KP.ts) and the black spruce-Kalmia-Cladonia (KP.td) types:

Absence or lower abundance of groups 4 (Pinus banksiana), 5 (Hypnum crista-castrensis), and 11 (Cladonia alpestris). Presence or greater abundance of groups 13 (Carex trisperma) and 12 (Sphagnum spp.).

b. the black spruce-balsam fir (AP) and the black spruce-Hypnum (HP.k) types:

Absence of groups 1 (Sorbus americana), 2 (Hylocomium splendens), 3 (Maianthemum canadense), 4 (Pinus banksiana), 5 (Hypnum crista-castrensis).
Presence of groups 10 (Ledum groenlandicum), 12 (Sphagnum spp.) and 13 (Carex trisperma).

c. all other types:

Absence of groups 14 (Chamaedaphne calyculata), 15 (Eriophorum virginicum), 16 (Alnus rugosa), and 17 (Mnium punctatum).

(3) Ecology (Appendix 11, figures 4 and 5)

- Soil water: moderately wet sites.
- Soil nutrients: oligotrophic.
- Soil Series: Ducharme (G).
- Landform: very gentle slopes and depressions.

Table 9 Characteristic species composition of the black spruce-Kalmia-Sphagnum type (KP.s). (Differential species characterizing the forest type are underlined. Number of ecological group in parentheses). Species density: 15.

Rank	Average Importance Value	Presence %	Species
1	292	100	Picea mariana (8)
2	252	100	Sphagnum spp. (12)
3	228	100	Ledum groenlandicum (10)
4	212	100	Kalmia angustifolia (8)
5	204	100	Calliergon schreberi (7)
6	164	100	Vaccinium pensylvanicum (8)
7	164	100	Gaultheria hispidula (7)
8	128	100	Lycopodium annotinum (9)
9	120	80	Dicranum undulatum (6)
10	114	80	Vaccinium myrtilloides (7)
11	114	80	Carex trisperma (13)
12	106	80	Rubus chamaemorus (13)
13	78	60	Cornus canadensis (7)
14	78	60	Cladonia rangiferina (11)
15	78	60	Alnus rugosa (16)

D. The black spruce-Sphagnum association (Sphagno-Piceetum marianae)

Two forest types have been recognized in this association:

1. the black spruce-Sphagnum-Chamaedaphne type; SP.c

(1) Physiognomy and structure (Appendix 11):

- Open, irregular, black spruce forest
- Complete cover of ericaceous shrubs.
- Herbs and forbs almost absent.
- Complete moss cover.

(2) Floristic composition (tables 4 and 10, Vegetation table):

Characterized by the ecological groups 8 (Kalmia angustifolia), 10 (Ledum groenlandicum), 12 (Sphagnum spp.), 13 (Carex trisperma) and 14 (Chamaedaphne calyculata).

Differentiation with respect to:

a. the Sphagnum-Chamaedaphne type (SC)

Absence of group 15 (Eriophorum virginicum).
Greater abundance of species from groups 7 (Calliergon schreberi), 8 (Kalmia angustifolia), 9 (Coptis groenlandica) and 10 (Ledum groenlandicum).

b. the black spruce-Kalmia-Sphagnum type (KP.s):

Absence of group 6 (Dicranum undulatum).
Presence of group 14 (Chamaedaphne calyculata).

c. the black spruce-Sphagnum-Alnus (SP.a) and the alder-black spruce (PA.1) types:

Absence of groups 16 (Alnus rugosa), 17 (Mnium punctatum), 2 (Hylocomium splendens)and 5 (Hypnum crista-castrensis).
Presence of group 14 (Chamaedaphne calyculata).

d. all other types:

Presence or much greater abundance of groups 12 (Sphagnum spp.), 13 (Carex trisperma), and 14 (Chamaedaphne calyculata).
Absence of groups 4 (Pinus banksiana), 5 (Hypnum crista-castrensis), and 16 (Dicranum undulatum).

(3) Ecology (Appendix 11, figures 4 and 5):

- Soil water: wet sites.

- Soil nutrients: oligotrophic.

- Soil Series: Jourdain(I).

- Landform: closed depressions and in border of large peat bogs.

Table 10 Characteristic species composition of the black spruce-Sphagnum-Chamaedaphne type (SP.c). (Differential species characterizing the forest type are underlined. Number of ecological group in parentheses). Species density: 21.

Rank	Average Importance Value	Presence %	Species
1	300	100	Sphagnum spp. (12)
2	280	100	Picea mariana (8)
3	220	100	Chamaedaphne calyculata (14)
4	220	100	Ledum groenlandicum (10)
5	180	100	Kalmia angustifolia (8)
6	180	100	Rubus chamaemorus (13)
7	164	100	Vaccinium pensylvanicum (8)
8	160	100	Smilacina trifolia (13)
9	160	100	Carex trisperma (13)
10	160	100	Calliergon schreberi (7)
11	160	100	Gaultheria hispidula (7)
12	140	100	Kalmia polyfolia (14)
13	140	100	Coptis groenlandica (9)
14	140	100	Cornus canadensis (7)
15	125	100	Vaccinium myrtilloides (7)
16	125	100	Clintonia borealis (2)
17	125	100	Equisetum sylicaticum (16)
18	70	50	Andromeda glaucophylla (14)
19	70	50	Vaccinium oxycoccos (14)
20	70	50	Betula pumila (14)
21	70	50	Amelanchier bartramiana (1)

2. the black spruce-Sphagnum-Alnus type; (SP.a)

(1) Physiognomy and structure (Appendix 11):

- Closed black spruce forest with scattered balsam fir.
- High shrub cover of variable density consisting mainly of alder.
- Variable cover of ericaceous shrubs.
- Forbs more abundant than in the other conifer forest types except the black spruce-balsam fir type.
- Complete moss cover.

(2) Floristic composition (tables 4 and 11, Vegetation table):

Characterized by the ecological groups 2 (Hylocomium splendens), 5 (Hypnum crista-castrensis), 12 (Sphagnum spp.), 13 (Carex trisperma), and 16 (Alnus rugosa).

Differentiation with respect to:

a. the black spruce-Sphagnum-Chamaedaphne (SP.c) and the Sphagnum-Chamaedaphne (SC) types:

Absence of group 14 (Chamaedaphne calyculata) and 15 (Eriophorum virginicum).
Presence of groups 2 (Hylocomium splendens), 5 (Hypnum crista-castrensis) and 16 (Alnus rugosa).

b. the alder-black spruce type (PAl):

Absence of group 17 (Mnium punctatum).
Presence of groups 7 (Calliergon schreberi), 8 (Kalmia angustifolia), 10 (Ledum groenlandicum) and 13 (Carex trisperma).

c. the black spruce-Kalmia-Sphagnum type (KP.s):

Decreased abundance of species from groups 8 (Kalmia angustifolia), and 10 (Ledum groenlandicum).
Presence of groups 2 (Hylocomium splendens), 5 (Hypnum crista-castrensis), and 16 (Alnus rugosa).

d. the black spruce-Kalmia type (KP.ts):

Absence of groups 4 (Pinus banksiana), 6 (Dicranum undulatum), and 11 (Cladonia alpestris).
Presence of groups 2 (Hylocomium splendens), 13 (Carex trisperma), and 16 (Alnus rugosa).

e. all other types:

Absence of groups 4 (Pinus banksiana), 6 (Dicranum undulatum) and 11 (Cladonia alpestris).
Presence of groups 12 (Sphagnum spp.), 13 (Carex trisperma), and 16 (Alnus rugosa).

(3) Ecology (Appendix 11, figures 4 and 5):

- Soil water: moderately wet and wet sites.

- Soil nutrients: eutrophic.

- Soil Series: Rohault (H) and Bouteroue (J).

- Landform: very gentle slopes and level areas along streams.

Table 11 Characteristic species composition of the black spruce-Sphagnum-Alnus type (SP.a). (Differential species characterizing the forest type are underlined. Number of ecological group in parentheses). Species density: 26.

Rank	Average Importance Value	Presence %	Species
1	293	100	Picea mariana (8)
2	213	100	Sphagnum spp. (12)
3	213	100	Calliergon schreberi (7)
4	188	100	Hylocomium splendens(2)
5	188	100	Ledum groenlandicum (10)
6	175	100	Alnus rugosa (16)
7	173	100	Gaultheria hispidula (7)
8	168	100	Kalmia angustifolia (8)
9	153	100	Hypnum crista-castrensis (5)
10	137	83	Vaccinium pensylvanicum (8)
11	130	83	Rubus chamaemorus (13)
12	125	100	Vaccinium myrtilloides (7)
13	117	83	Lycopodium annotinum (9)
14	112	83	Abies balsamea (2)
15	112	83	Cornus canadensis (7)
16	107	83	Smilacina trifolia (13)
17	83	66	Equisetum sylvaticum (16)
18	83	50	Carex trisperma (13)
19	83	66	Coptis groenlandica (9)
20	73	66	Clintonia borealis (2)
21	55	50	Listera cordata (2)
22	42	33	Dicranum undulatum (6)
23	42	33	Linnaea borealis (2)
24	30	17	Oxalis montana (16)
25	30	17	Carex connescens (16)
26	23	17	Viburnum trilobum (16)

E. The Sphagnum-Chamaedaphne association (Sphagno-Chamaedaphnetum)

This association is represented in the Nicauba Research forest by one forest type: the Sphagnum-Chamaedaphne type; SC

(1) Physiognomy and structure (Appendix 11):

- Ericaceous shrubland with scattered black spruce.

- Complete Sphagnum moss cover.

(2) Floristic composition (tables 4 and 12, Vegetation table):

Characterized by the ecological groups 12 (Sphagnum spp.), 13 (Carex trisperma), 14 (Chamaedaphne calyculata), and 15 (Eriophorum virginicum).

Differentiation with respect to:

a. the black spruce-Sphagnum-Chamaedaphne type (SP.c):

Smaller abundance of species from groups 7 (Calliergon schreberi), 8 (Kalmia angustifolia), 9 (Coptis groenlandica), and 10 (Ledum groenlandicum).
Presence of group 15 (Eriophorum virginicum).

b. all other types:

Absence of groups 7 (Calliergon schreberi), 6 (Dicranum undulatum), 5 (Hypnum crista-castrensis).
Smaller abundance of species from group 8 (Kalmia angustifolia).
Presence of groups 14 (Chamaedaphne calyculata) and 15 (Eriophorum virginicum).

(3) Ecology (Appendix 11, figures 4 and 5):

- Soil water: very wet sites.

- Soil nutrients: oligotrophic.

- Soil Series: Epave (K).

- Landform: oligotrophic peat bogs.

Table 12 Characteristic species composition of the Sphagnum-Chamaedaphne Type (SC). (Differential species characterizing the forest type are underlined. Number of ecological group in parentheses). Species density: 17.

Rank	Average Importance Value	Presence %	Species
1	300	100	Sphagnum spp. (12)
2	273	100	Chamaedaphne calyculata (14)
3	207	100	Picea mariana (8)
4	180	100	Rubus chamaemorus (13)
5	167	100	Eriophorum virginicum (15)
6	140	100	Kalmia polyfolia (14)
7	140	100	Andromeda glaucophylla (14)
8	140	100	Vaccinium oxycoccos (14)
9	133	100	Smilacina trifolia (13)
10	130	100	Sarracenia purpurea (15)
11	130	100	Kalmia angustifolia (8)
12	130	100	Ledum groenlandicum (10)
13	120	100	Carex trisperma (13)
14	83	66	Vaccinium pensylvanicum (8)
15	83	66	Calliergon schreberi (7)
16	83	66	Cladonia rangiferina (11)
17	47	33	Cornus canadensis (7)

F. <u>The alder-black spruce association (Piceeto-Alnetum rugosae)</u>

Only one plot has been described in this association which is termed in this study the <u>Alder swamp</u> type (<u>PAl</u>). The type clearly separates from the other forest types present in the Nicauba Research Forest both physiognomically (Appendix 11) and floristically (Table 4 and Vegetation table). It occurs along streams on deep eutrophic peaty soils belonging to the Series Argenson (<u>L</u>).

G. <u>The white birch-black spruce association (Piceeto-Betuletum papyriferae)</u>

One forest type, the <u>white birch-black spruce</u> type (<u>PB</u>) occurs here and there throughout the Nicauba Research Forest on the well drained shallow till-covered bedrock areas. It was not described in this study although it closely resembles the black spruce-balsam fir type (<u>AP</u>) except for the dominance of white birch in the main stand. It is believed that it originates from fire in the black spruce-balsam fir type without adequate black spruce seed.

6. The Ecological types and the ecological map

In the present study the ecological type is defined as a forest type growing on a particular soil Series within a particular landform segment. The ecological type is therefore, basically, an integrated vegetation-soil-landform unit. It results from an a priori integration of those environmental factors which,significantly affect the forest ecosystems[1/]. The integration is called "a priori" because the landform, soil and vegetation units do result from the integrated ecological units. In other words, the boundaries between the units of landform, soil, and vegetation were defined on the basis of the criteria which are most active at the level of the forest ecosystem. Therefore, even if, in this paper, the ecological types are described "a posteriori" for descriptive purpose only, they were defined "a priori", and do not result from the superposition of separate classifications of landforms, soil, and vegetation.

The 14 ecological types present in the Nicauba Research Forest are mapped on the ecological map reproduced in appendix. The map can be used also as a landform map, a soil map or a vegetation map by colouring the corresponding ecosystem components.

The relative area covered by each ecological type, landform, soil series, and forest type is indicated in appendices 13, 14, 15 and 16.

An identification key has been constructed (table 13) for the practical recognition of the ecological types of the Nicauba Research Forest.

[1/] In the present study the Rowe's definition of ecosystem is used: "A perceivable unit of the landscape,homogeneous both as to the form and structure of the land and as to the vegetation supported thereon". (Rowe, 1962).

TABLE 13. IDENTIFICATION KEY OF THE ECOLOGICAL TYPES OF THE NICAUBA RESEARCH FOREST

VEGETATION	PICEA MARIANA, KALMIA ANGUSTIFOLIA, VACCINIUM PENSYLVANICUM											MNIUM PUNCTATUM RUBUS PUBESCENS DRYOPTERIS DISJUNCTA VIOLA INCOGNITA ATHYRIUM FILIX FEMINA RIBES GLANDULOSUM RIBES LACUSTRE
	BETULA PAPYRIFERA MAIANTHEMUM CANADENSE DICRANUM FUSCESCENS		LEDUM GROENLANDICUM									
	PINUS BANKSIANA, HYPNUM CRISTA CASTRENSIS						CAREX TRISPERMA RUBUS CHAMAEMORUS SMILACINA TRIFOLIA					
	ABIES BALSAMEA SORBUS AMERICANA HYLOCOMIUM SPLENDENS CLINTONIA BOREALIS LINNAEA BOREALIS TRIENTALIS BOREALIS AMELANCHIER BARTRAM. ARALIA NUDICAULIS LYCOPODIUM OBSCURUM PYROLA SECUNDA ACER SPICATUM DRYOPTERIS SPINULOSA STREPTOPUS AMPLEXIF. PTERIDIUM LATIUSCUL. LISTERA CORDATA	CLADONIA ALPESTRIS, CLADONIA RANGIFERINA (more abundant in Vegetation type KP.c)										
	CALLIERGON SCHREBERI, VACCINIUM MYRTILLOIDES, GAULTHERIA HISPIDULA, CORNUS CANADENSIS							ERIOPHORUM VIRGINIC. SARRACENIA PURPUR.	CALLIERGON SCHREBERI, VACCINIUM MYRTILLOIDES, GAULTHERIA HISPIDULA, CORNUS CANADENSIS			
	DICRANUM UNDULATUM						CHAMAEDAPHNE CALYCULATA KALMIA POLYFOLIA ANDROMEDA GLAUCOPHYLLA VACCINIUM OXYCOCCOS BETULA PUMILA		ABIES BALSAMEA, ALNUS RUGOSA EQUISETUM SYLVATICUM, OXALIS MONTANA HYLOCOMIUM SPLENDENS, TRIENTALIS BOREALIS CLINTONIA BOREALIS, LINNAEA BOREALIS HYPNUM CRISTA-CASTRENSIS			
						SPHAGNUM SPP.						
FOREST ASSOCIATION	BLACK SPRUCE-BALSAM FIR FOREST	BLACK SPRUCE-HYPNUM FOREST	BLACK SPRUCE - KALMIA FOREST					OPEN B. SPRUCE-SPHAGNUM FOREST	ERICACEOUS BOG	CLOSED B. SPRUCE-SPHAGNUM FOREST		ALDER SWAMP
FOREST TYPE	B. SPRUCE-B. FIR AP	B. SPRUCE-HYPNUM HP.k	B. SPRUCE-CLADONIA-KALMIA KP.c	B. SPRUCE-KALMIA-CLADONIA KP.td		B. SPRUCE-KALMIA KP.ts	B. SPRUCE-KALMIA-SPHAGNUM KP.s	B. SPRUCE-SPHAGNUM-CHAMAED. SP.c	SPHAGNUM-CHAMAED. SC	B. SPRUCE-SPHAGNUM-ALNUS SP.a		ALDER SWAMP PAl
ECOLOGICAL TYPE	**AP/D**	**HP.k/B**	**KP.c/F**	**KP.td/A**	**KP.td/C**	**KP.ts/E**	**KP.s/G**	**SP.c/I**	**SC/K**	**SP.a/H**	**SP.a/J**	**PAl/L**
SOIL SERIES	D CHAUDIÈRE	B AIGREMONT	F GABRIEL	A CHIBOUGAMAU	C MIGNAULT	E NICAUBA	G DUCHARME	I JOURDAIN	K EPAVE	H ROHAULT	J BOUTEROUE	L ARGENSON
LANDFORM	tg SHALLOW TILL OVER BEDROCK	km KAME MORAINE	gn GNEISSIC ROCK OUTCROP	bt BASAL TILL	cd, sd ICE-CONTACT STRATIFIED DRIFT, OUTWASH MATER.	bt, km BASAL TILL KAME MORAINE	VARIABLE					
TEXTURAL CHARACTERISTICS OF THE SOIL PARENT MATERIAL	WELL GRADED FINE SANDY LOAM	POORLY GRADED GRAVELLY LOAMY SAND	—	WELL GRADED FINE SANDY LOAM	WELL SORTED VERY GRAVELLY COARSE SAND	VARIABLE						
SOIL DRAINAGE	GOOD & EXCESSIVE	GOOD & EXCESSIVE	EXCESSIVE & GOOD	GOOD & EXCESSIVE	EXCESSIVE & GOOD	MODERATELY GOOD	IMPERFECT	POOR	VERY POOR	IMPERFECT	POOR	VERY POOR
										WITH SEEPAGE		
SOIL SUBGROUP	LITHIC HUMO-FERRIC PODZOL	ORTHIC HUMO-FERRIC PODZOL	LITHIC REGOSOL	ORTHIC HUMO-FERRIC PODZOL		GLEYED HUMO-FERRIC PODZOL	GLEYED HUMIC PODZOL		SPHAGNO-FIBRISOL	GLEYED HUMIC PODZOL		TYPIC MESISOL
								OCCASIONALLY: SPHAGNO FIBRISOL			OCCASIONALLY: MESISOL	
SURFACE ORGANIC HORIZON	HUMI-FIBRIMOR	FIBRIMOR					FIBRIC PEATY MOR		—	HUMO-FIBRIC PEATY MOR		—
	3-5 in.	4-7 in.	2-8 in.	4-10 in.	1-3 in.	4-15 in.	4-15 in.	10-20 in.	> 24 in.	3-15 in.	10-20 in.	> 24 in.

B. FOREST SURVEY

1. SAMPLING METHOD

As outlined by Hatcher and Jurdant (1965), the forest was stratified on aerial photographs into broad landform classes that were transferred to the base map along with age classes and cover types obtained from Company maps. Within a given landform, stand age class and cover type, a one per cent random sampling was carried out. Permanent tenth-acre square sample plots were established on parallel lines whose starting points were chosen at random. Plots were located at random along these lines, at a density equivalent to one plot per 10 chains of line. A total of 150 plots on 27 transects were established in the 1964-1965 field seasons. The number of plots by ecological types, landforms, soil series and forest types are provided in appendices 12 to 15.

On each of the plots the following data were recorded: a) d.b.h. of living trees in one-inch-classes, by species, of trees 0.6 inch d.b.h. and over, b) d.b.h. of trees judged to have died between 1954 and 1964, c) three to five diameter/height/age measurements on dominant, co-dominant and intermediate softwood species and d) a brief general plot description with notes on vegetation, slope, aspect and location.

In the office, the tally sheets were summarized, the site index and stocking factor calculated for each ecological type and local volume tables constructed. The relations diameter-height were graphically presented for the four main species encountered in the forest.

The number of trees, basal area, total and merchantable volumes were also calculated from the tally sheets and converted in per acre values. They are given per species, per ecological type and per d.b.h. classes, i.e. 1 to 3 inches, 4 to 9 inches and 10 inches and more.

The merchantable volumes are calculated at one-foot stump and three-inch top for the softwoods and at five-foot stump and three-inch top for the hardwoods.

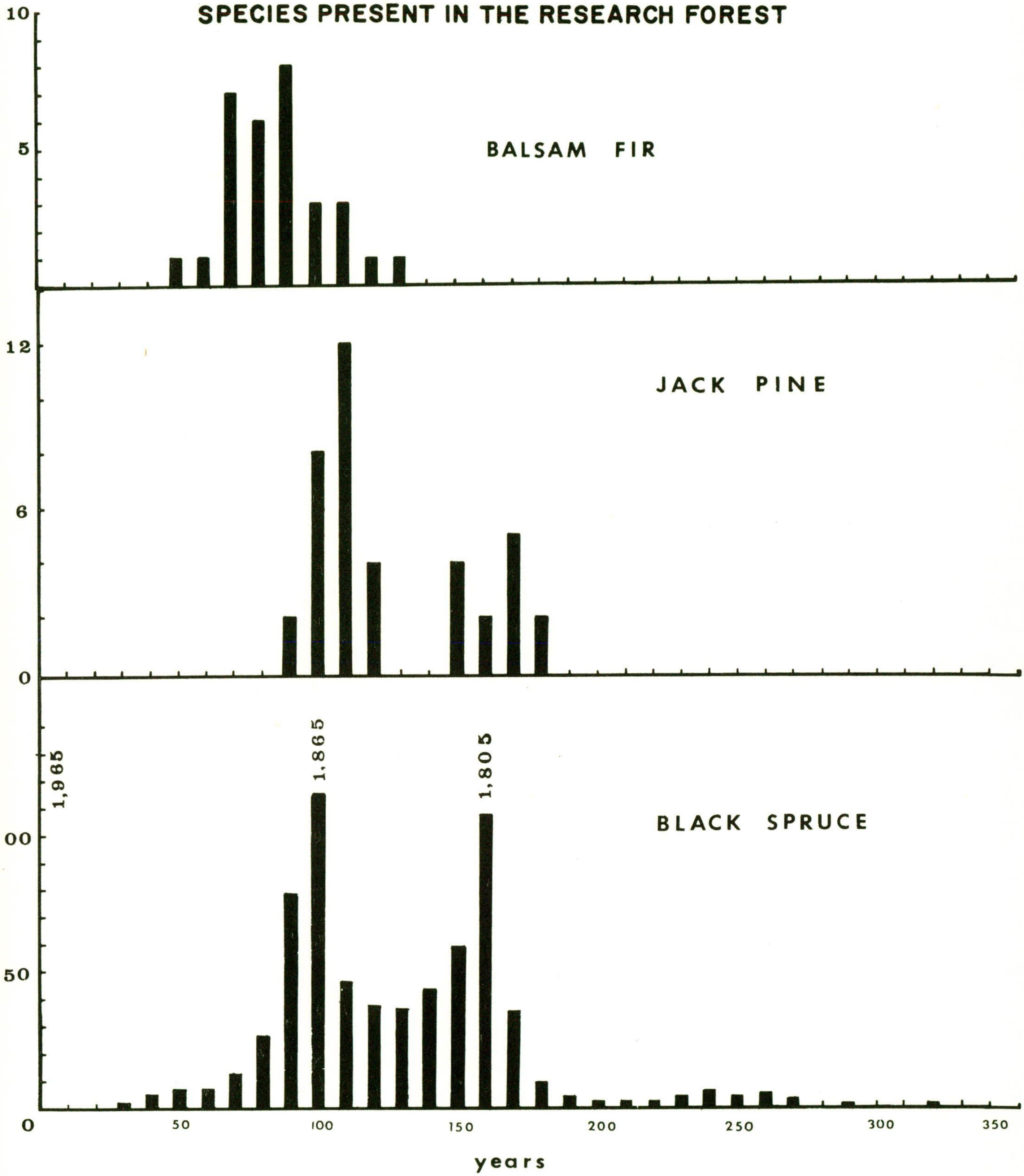
2. STRUCTURE OF THE FOREST

The Nicauba Research Forest is formed by two relatively even-aged parts of fire origin. The eastern part is the most recent burned area, about 100 years old, whereas the western part is older, with a mean age of 160 years. Thus, it appears that two fires passed through the Nicauba Research Forest, one near 1805 which destroyed the entire forest, and the other near 1865 which destroyed only the eastern section (Frisque, 1968). This is confirmed by the fact that charcoal is present in the surface organic horizon.

Both the younger part of the forest and the older require silvicultural treatment to obtain greater reproduction but, in addition, the older part is really overmature and, apart from its research designation, should be cut.

Figure 7 indicates the age distribution of the major coniferous species present in the Research Forest. The data were obtained from the 150 plots. The age curves for black spruce and jack pine show two peaks near 100 and 160 years. Balsam fir shows a characteristic decline in numbers after 90 years. One can note that the jack pine peak is older than the one for black spruce. This can be in contradiction with observations where both species generally germinated immediately after fire, with seed of both coming from the serotinous cones characteristic of jack pine and black spruce. Probably, according to Vincent (1965) jack pine regenerates immediately after fire on dry sandy sites and behaves as a pioneer species. Also, black spruce has difficulty in establishing itself against the ericaceous shrubs competition (Kalmia, Ledum and Vaccinium) which recolonize quickly the ground after fire.

Fig. 7 AGE DISTRIBUTION OF THE MAJOR CONIFEROUS SPECIES PRESENT IN THE RESEARCH FOREST



Concerning the lag of time between fire and black spruce regeneration, the same observation has been made by MacArthur and Gagnon (1961) in the Gaspé burns. Their work indicates a period of eight growing seasons after fire before the peak value of regeneration appears. We note the same trend in Nicauba. This post-fire pattern is also noted by Hatcher (1963) in Lake St.Pierre, P.Q. On the other hand, the high regeneration jump for both jack pine and black spruce following fire indicates that there was a seed source over the whole area.

3. STAND DATA BY ECOLOGICAL TYPF

Number of trees, basal area, total and merchantable volumes per acre are given in appendix 16 by diameter class, per ecological type and for black spruce, jack pine, balsam fir and white birch. These values are also given in terms of total softwoods versus total hardwoods per acre for a same ecological type. Some scattered trembling aspen are included in the total hardwoods values but do not appear in the number of trees column because there was always less than 1.0 tree per acre. The softwoods merchantable volumes were calculated from the Nicauba local volume tables (see section 4) and the hardwoods merchantable volumes from the volume tables of Honer (1967). The following table presents the number of trees per acre by diameter class. The values derive from appendix 16 and are the averages for all the ecological types where the species is found.

Diameter class (in.)	Black spruce	Balsam fir	Jack pine	White birch
1-3	599	46	0	4
4-9	307	22	23	30
10 and over	9	6	2	14
Number of ecological types with at least 1 tree per acre	13	9	10	7

From these figures, it appears that black spruce is present in all the ecological types (13)* of the Research Forest but that there are only 9 trees of 10 inches and over per acre. On the other hand, the 1 to 3 inches black

* One ecological type PA1/L is not included in the forest survey. Its representativeness is 0.5% of the total area and it occurs only along streams on deep eutrophic peaty soils.

spruce are mainly of layer origin (Stanek, 1968) that means a lack of natural regeneration from seed despite the high number of trees per acre. Jack pine behaves as a really even-aged species and shows no regeneration at the time of the survey. At the same time, white birch gives the higher average in the 10 inches and over class.

Appendices 17 and 18 indicate respectively the average tree composition by number of trees and the average tree composition by volume, by ecological types and in percent of the total value. From these two appendices, it is noteworthy that in the type PB/D, black spruce represents 44% in number of trees whereas balsam fir has only 10% (Appendix 17). At the same time, in appendix 18, the figures are inversed and balsam fir represents 33% in volume whereas black spruce has only 9%. The same trend appears with jack pine in type KP.td/C where the number of trees is 91% for black spruce and 9% for jack pine whereas the volume is 67% for black spruce and 33% for jack pine.

The data appearing in appendix 18 are graphically presented in figure 8. This graph shows that the heavy mixed stands have a good total volume but to the prejudice of black spruce which tolerates with difficulty the competition of an other species in the site where it is not the more important species. The data presented in appendices 16 to 18 and in figure 8 will be discussed in a more detailed way in the section 5 entitled: "Relationship between stand data and ecological types".

Concerning the amount of dead trees, black spruce are healthy in the boreal forest region, The biggest mortality of mature trees being 17% in km-KP.ts/E and HP.k/B types. The mean percentage of dead trees for the 13 ecological types is 11% with an estimated standard deviation of the population of 3.87 and an estimated standard error of the mean of 1.07.

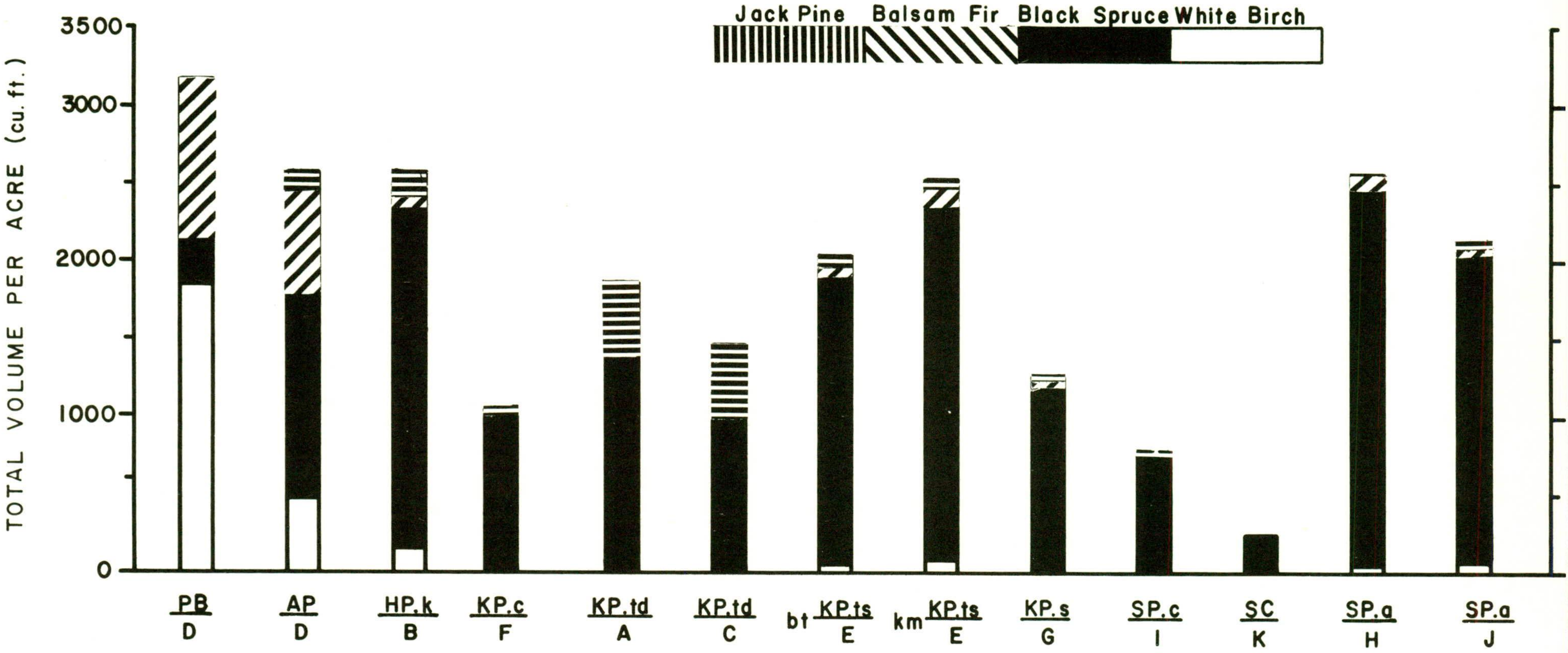


FIGURE 8 : AVERAGE TREE COMPOSITION BY VOLUME OF THE ECOLOGICAL TYPES

(height of bars proportional to the total volume)

4. LOCAL VOLUME TABLES

The local volume tables have been constructed for the Research Forest in 1965. The total volumes were obtained from tables in "Interpolated Volume Tables" D.F.S. Miscellaneous Series No. 3, 1944 as follows:

Black Spruce:	Table 9
Balsam Fir:	Table 7

The merchantable volumes (one-foot stump, three-inch top) were obtained from tables in "Form Class Volume Tables", second edition, D.F.S. 1948 as follows:

Black Spruce:	Table 125
Balsam Fir:	Table 3

The tables appear in appendix 20. Volumes for diameter classes beyond those marked with an asterisk (*) were obtained by extrapolation of the volume curve on double logarithmic paper. The height values were calculated by the Dwight method. Figure 9 represents the diameter height relationship for the four principal species found in the Nicauba Research Forest, namely black spruce, balsam fir, jack pine and white birch. The curves were derived from the local volume tables.

It is interesting to note from figure 9 that, in the first year, the height growth is faster for white birch followed by black spruce and then by balsam fir. At a height of 35 feet, i.e. a diameter at breast height of 5 inches, the order is inversed and balsam fir becomes the faster growing species, followed by black spruce and then by white birch. The data for jack pine were not available for the first years.

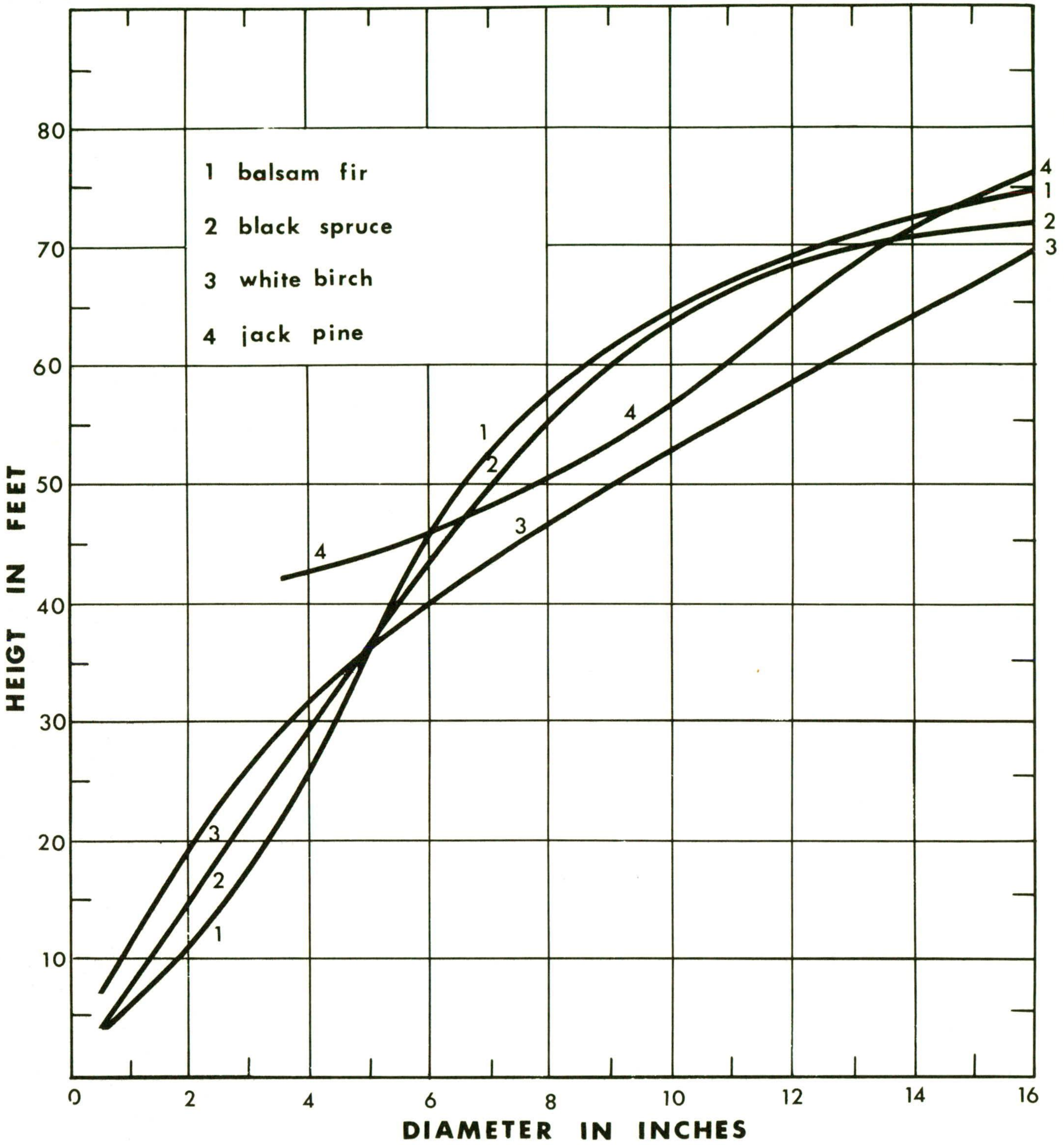


FIGURE 9

DIAMETER-HEIGHT RELATIONSHIP FOR THE FOUR PRINCIPAL SPECIES FOUND IN THE RESEARCH FOREST

5. RELATIONSHIP BETWEEN STAND DATA AND ECOLOGICAL TYPES

a. Stand characteristics of the ecological types

Appendix 19 shows the mean age, the mean height, the stocking factor, the site index, the total and merchantable volumes and their corresponding mean annual increments, by ecological type and per acre. The land capability for forestry is also mentioned in order to permit comparison with the Canadian land survey.

The stocking factor has been calculated for the softwoods only. Although the stocking factor expresses the relation of actual volume to normal volume, the relation of the actual basal area to the normal basal area per acre has been employed to calculate it (Plonski, 1960). The normal basal areas used are those given by Vézina and Linteau (1968) for fully stocked stands of pure black spruce or fully stocked stands of spruce-fir, with respect to the site classes.

The low mean age (60 years old) of type PB/D is due to the presence of white birch which had probably delayed the regeneration of black spruce.

All the stocking factors are above 50% except for type PB/D which has an important white birch component, namely 46% (see appendix 17), and for type SC/K which, with a site index of 9, is more a muskeg type than a forest type. This last type appears in white on the aerial photography of the Research Forest in the first page of this report.

Figure 10 shows the distribution of site index of each ecological type. The mean tree heights of Nicauba in relation with age and site index are in strong accordance with those given by Linteau (1955) for the Northeastern Coniferous Section.

b. Total and merchantable volumes

With reference to appendices 16 to 19 it appears that total and merchantable volumes are low. These values amply illustrate the characteristic structure of the Research Forest, namely a large number of trees per acre with a low volume, and is typical of the Boreal Forest Region. The very low values, less than 500 cubic feet per acre, are those of improductive stands such as found in the bogs or in the inundated area.

In figures 11 and 12, both total and merchantable volumes per acre for each ecological type are plotted in relation with the site indexes. It is noteworthy that a strong relation exists between the volume and the site index. The calculation was made between a site index of 20 and 45. Thus, the type SC/K, with a site index of 9, has not been included. The two dashed lines are the confidence limits at 1 percent.

Figure 11 shows the relation between the site index and the total volume. The regression coefficient is 0.97 and the equation of the regression line is : Tot. Vol. = -1460.8 + 105.25 (S.I). Figure 12 shows the relation between the site index and the merchantable volume. The regression coefficient is 0.98 and the equation of the regression line is : Merch. Vol. = -1775.5 + 105.15 (S.I).

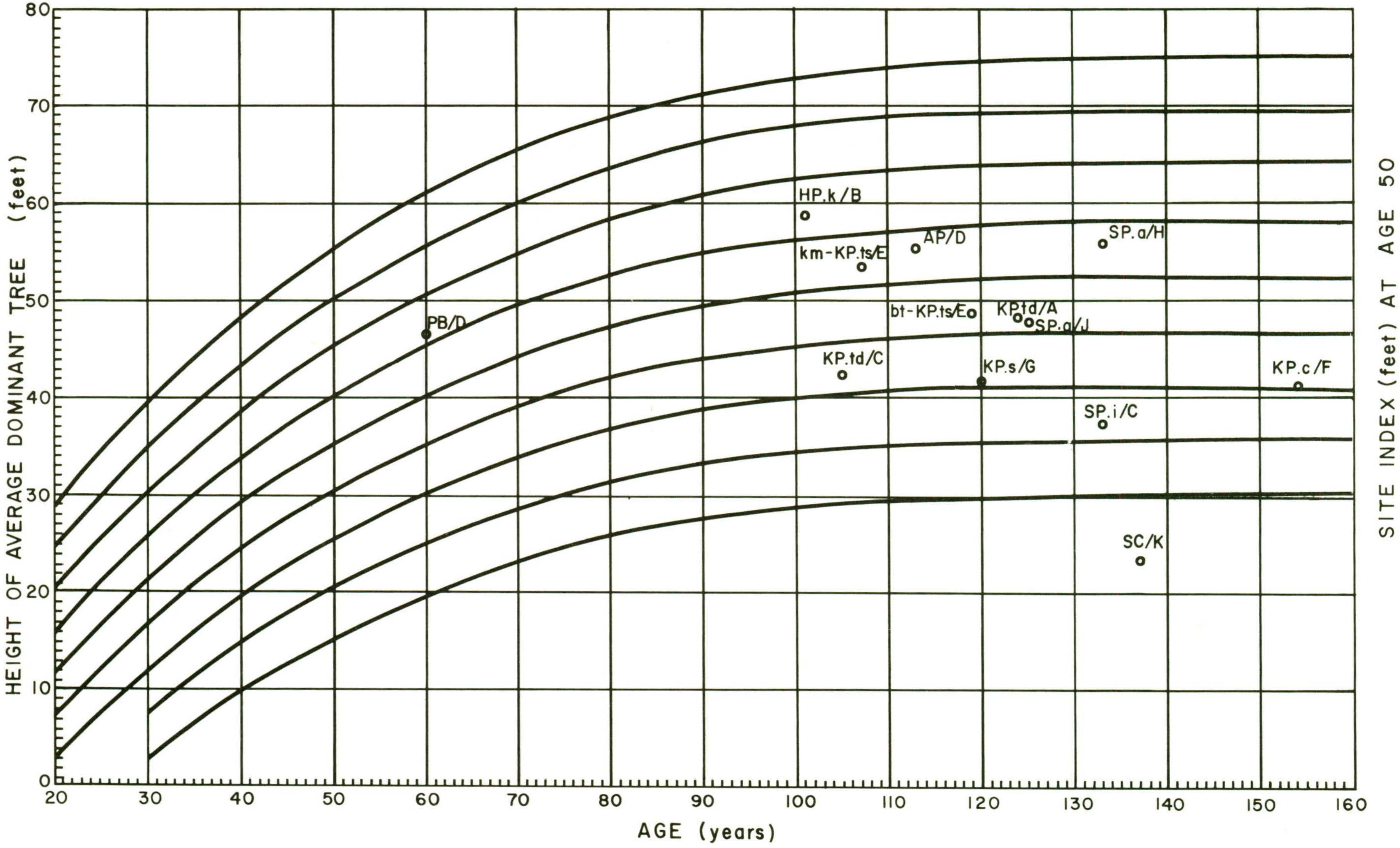


Fig. 10 SITE INDEX OF EACH ECOLOGICAL TYPE. THE CURVES ARE FROM LINTEAU (1955)

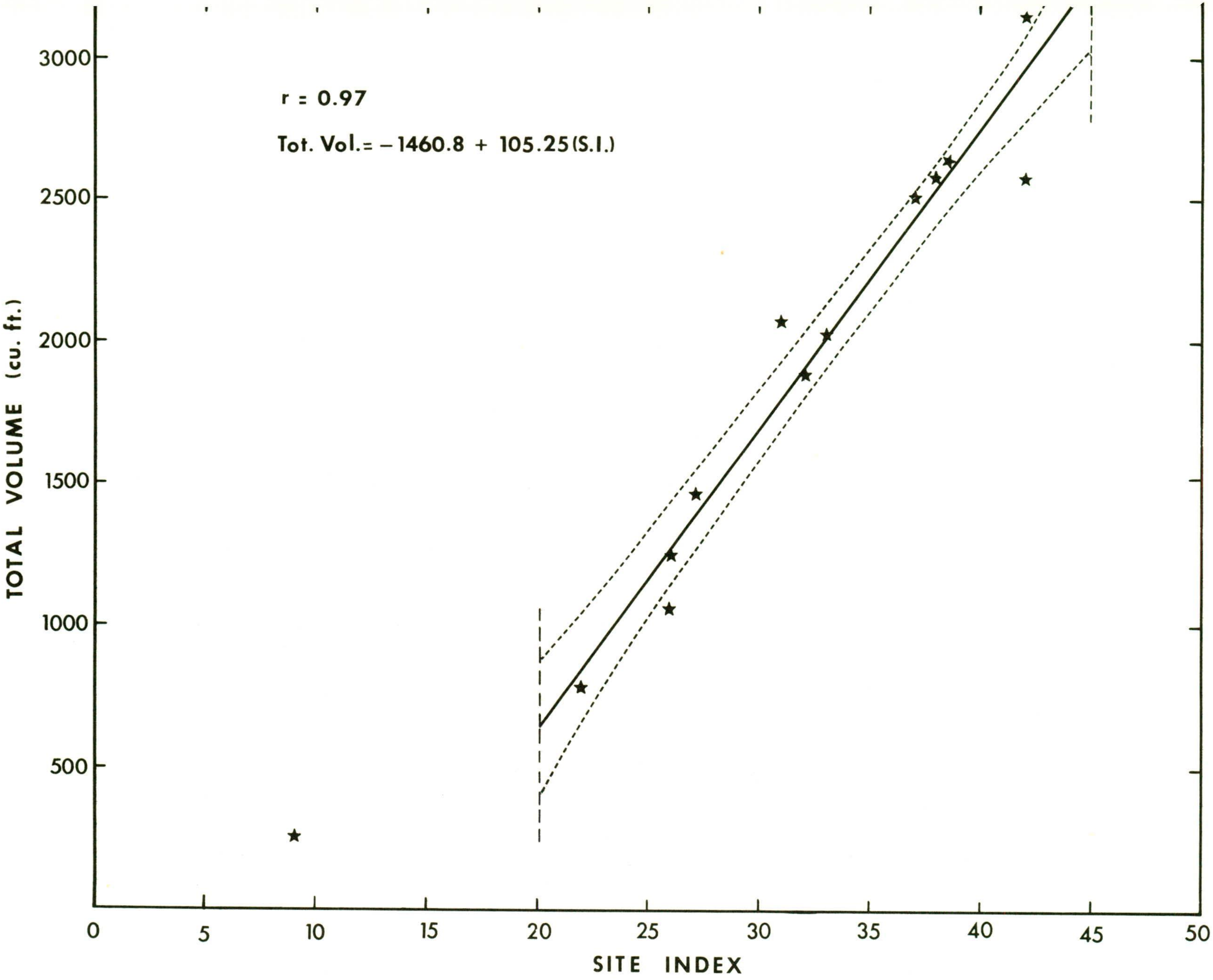
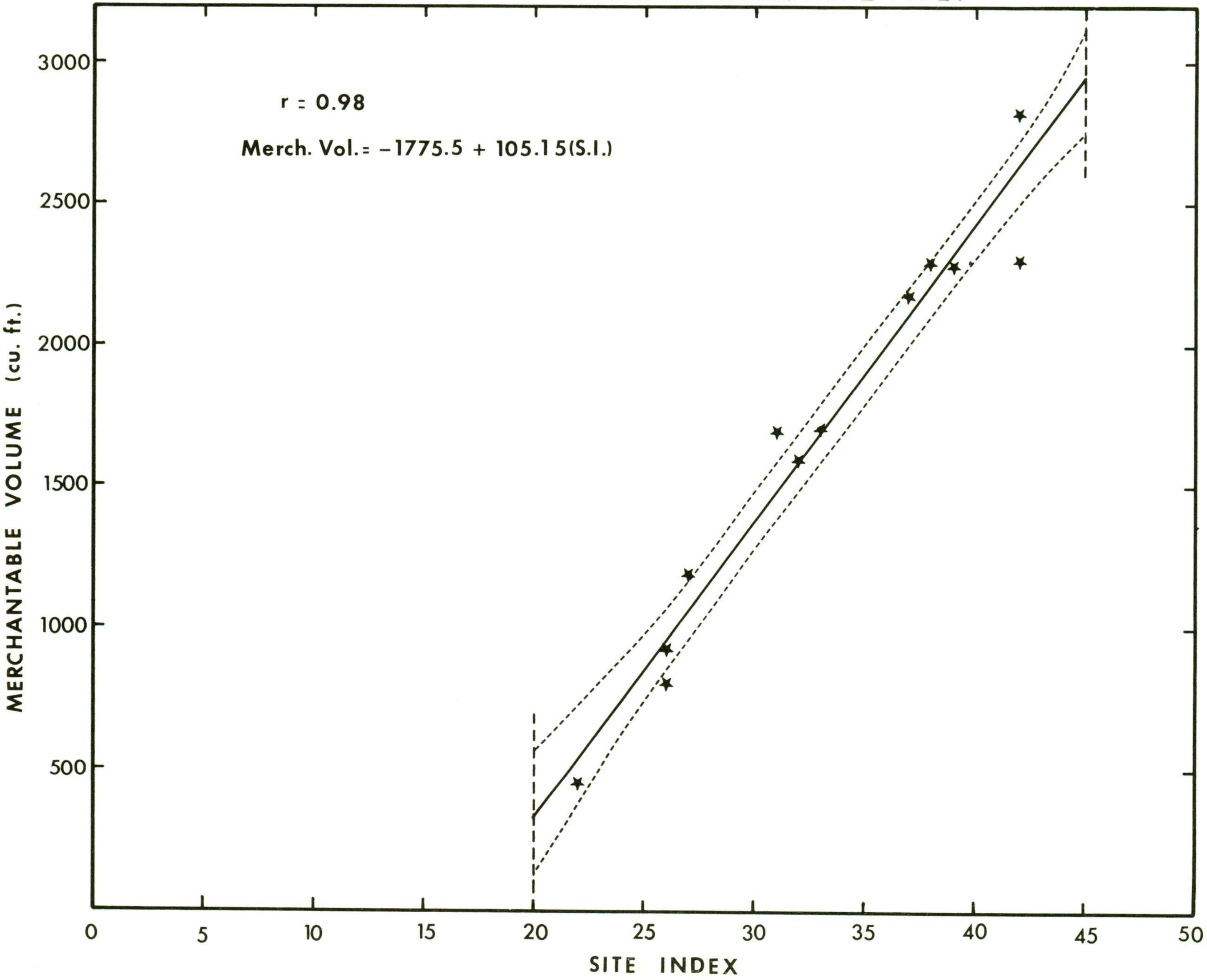


Fig. 11 RELATIONSHIP BETWEEN TOTAL VOLUME AND SITE INDEX. EACH DOT REPRESENTS THE MEAN PER ECOLOGICAL TYPE.

Fig. 12 RELATIONSHIP BETWEEN MERCHANTABLE VOLUME AND SITE INDEX. EACH DOT REPRESENTS THE MEAN PER ECOLOGICAL TYPE.



In table 14, the total volume values from Nicauba are compared with other values obtained through the black spruce range. In order to obtain a valuable comparison, the values have been separated in good, medium and poor sites. Furthermore, the Nicauba results have been corrected to obtain significant data for a 100% stocked stand. The types PB/D and SC/K have not been included, the first having an unusual proportion of white birch and the second being a bog with only 49 cubic feet per acre of merchantable volume.

One can remember that the observed data are those appearing in appendix 16 and that those of table 14 do not represent the field values but are those of a hypothetical fully stocked stand, which does not occur in the Research Forest.

It is interesting to note from table 14 that the values obtained for the Nicauba Research Forest in broad lines, correspond well with those given by Vézina and Linteau (1968) for the whole Province of Quebec, Hatcher (1963) for Lake St.Pierre, Que. and Kabzems (1953) for Saskatchewan concerning total volume, and the basal area. However, the number of trees per acre in Nicauba is the biggest except for Lake St.Pierre (Que.) and for the medium sites in Saskatchewan. Lake St.Pierre, which is a little further north, has a smaller volume associated with a bigger number of trees per acre than Nicauba. On the other hand, it seems that the good sites in Nicauba produce less volume than those of the whole Province of Quebec, Alberta and Ontario and that the medium and poor sites have a lower total volume than those of Saskatchewan, Alberta and Ontario.

Table 14. Comparison of Nicauba [illegible]

Site (Values, per acre at 100-120 years)	Nicauba Que. Lat. 49°27'N	Lake St.Pierre Que. (Hatcher, 1963) Lat. 50°10'N	Saskatchewan (Kabzems, 1953)	Quebec (Vézina, Linteau, 1968)	Alberta (Horton, Lees, 1961)	Ontario (Plonski, 1960)
Good						
Number of trees	1,203	1,681	775	610	-	672
Basal area, sq.ft.	162	161	159	155	196	176
Total volume, cu.ft.	3,531	3,326	3,350	4,000	4,225	4,658
Medium						
Number of trees	1,059	2,032	1,415	910	-	993
Basal area, sq.ft.	131	139	151	130	172	164
Total volume, cu.ft.	2,422	2,282	2,915	2,460	3,090	3,774
Poor						
Number of trees	2,939	-	1,845	1,350	-	1,315
Basal area, sq.ft.	121	-	126	109	150	148
Total volume, cu.ft.	1,547	-	2,141	1,510	2,050	2,664

Comparing the Nicauba data with those of Vézina and Linteau (1968) which were calculated for the whole Province of Quebec, the following conclusions can be drawn. In the good sites, the number of trees in Nicauba is twice as much as for Quebec, but with 469 cubic feet less per acre. In the medium sites the values are similar for both Nicauba and Quebec. In the poor sites, Nicauba has again a number of trees twice as much as the whole Province of Quebec but with a similar total volume in this case.

However, if we consider the observed values (Appendix 16) with their low stocking factor, it appears that the values of the Nicauba Research Forest are poorer especially for the so called good sites. It is doubtful that there are, in Nicauba, good pure black spruce sites. The better sites in the Quebec's boreal forest seem likely to be Canadian medium sites, as showed by the land capability for forestry values in table 14.

The Research forest has, on 2,600 acres, a total volume of 3,424, 525 cubic feet with a M.A.I. of 31,043 cubic feet. That means a total volume of 1,317 cubic feet per acre with a M.A.I. of 11.94 cubic feet. This M.A.I. is relatively low and decreases each year.

Indeed, from Vézina and Linteau (1968) the black spruce M.A.I. curve decreases after 85 years in the site class II and does not increase after 100 years in the site classes III and IV. More especially, since the black spruce regeneration is extremely low, if no regeneration management is applied, the potential timber growth will quickly decrease.

c. Productivity in relation to the ecological type

The site index gives the best ecological signification at the level of soil series except for the serie F, a very shallow soil where site index is a very poor indicator because the dominant trees usually grow in fracturated areas.

Because there is interaction between landform and soil drainage, there is no relationship between productivity and landform except in the ecological type KP.ts/E where a difference is found whether it is located on ground moraine or kame moraine (bt or km).

Also the landform type is significant in the forest type KP.ts/E since bt-KP.ts/E has only 8% of dead black spruce whereas km-KP.ts/E has 17%.

Following soil series, it appears that the best stands grow on shallow till over gneissic bedrock. They are followed by the drifts and moraines imperfectly and poorly drained, but with seepage. The drifts and moraines without seepage give poorer stands and finally, on very poorly drained soils with or without seepage, the growth is very low to nil (site index 9).

The best estimation of both the total and merchantable volumes is given by the site index (see fig. 11, 12 and appendix 19) where the differences between the ecological types appear clearly. The first group of 5 good sites is composed by the types HP.k/B; PB/D; AP/D; SP.a/H and km-KP.ts/E, all of them having a site index above 35 at age 50 and a total and merchantable volume respectively above 2,500 and 2,000 cubic feet per acre. The second group of medium sites can be divided in 2 sub-groups. The first sub-group, composed of the ecological types bt-KP.ts/E, KP.td/A and SP.a/J, has a site index ranging from 30 to 35 and a total volume between 2,000 and 2,500 cubic feet and a merchantable volume between 1,500 and 2,000 cubic feet. The second sub-group, formed of the sites KP.td/C; KP.s/G and KP.c/F has a site index from 25 to 30, a total volume between 1,000 and 1,500 cubic feet and a merchantable volume varying between 500 and 1,500 cubic feet. Finally the third group is the poor sites namely

SP.c/I and SC/K with a site index below 25 and a total and merchantable volume below 1,000 and 500 cubic feet respectively.

However, one can note that the type PB/D which represents only 0.4% of the total area of the Research Forest is more of hardwood type than of softwood type, indeed the total volume of white birch is higher than that of softwoods. The type SC/K, with a site index of 9 and a total volume of 255 cubic feet per acre, is also a non-significant one.

Considering all the factors involved, the most black spruce producer type is km-HP.k/B (black spruce-Hypnum on well drained kame moraine). This type has a good site index (42), a stocking factor of 70%, the actual forest composition is good with a high proportion of softwood especially black spruce, with a total volume of 2,593 cubic feet and a M.A.I. of 25.7 cubic feet per acre at age 101, a thin humus and a better drainage. Furthermore, the soil texture is favourable for road construction because a great proportion of gravel is found but the type represents only 3.8% of the total area.

In figure 13, the total volume per acre and per ecological type is showed in relation with diameter class and separately for softwoods and hardwoods, the hardwoods being mainly white birch. The only two ecological types to have important components of hardwoods are PB/D and AP/D. One can note that white birch gives the main volume with the 10 inches and over class, whereas softwoods give it in the 4 to 9 inches class.

If we consider the total production per ecological type, the white birch-black spruce is the best type but black spruce represents only 9% of the total volume, balsam fir having 33% and white birch 58%.

The other types are, by decreasing order, the black spruce-Hypnum, black spruce-balsam fir, black spruce-Sphagnum, black spruce-Kalmia-Cladonia and finally Sphagnum-Chamaedaphne. The most common type is black spruce-Kalmia which takes up 1,300 acres that means about 50% of the total area with a total volume of softwoods varying from 2,510 cubic feet per acre for black spruce-Kalmia on moderately well drained kame moraine to 1,059 cubic feet per acre for black spruce-Cladonia-Kalmia on gneissic bedrock outcrops.

Concerning the occurrence of the main associate woody species, one can note that balsam fir is a component of the ecological type PB/D and AP/D (more than 100 merchantable cubic feet per acre). According to the ecological classification, balsam fir occurs mainly on shallow till with a warmer microclimate. Its regeneration in these locations is abundant but when arriving at a height of 6 feet, the terminal shoot is destroyed by moose that choose these warmer microclimates with balsam fir as winter refuges.

Jack pine is present in types KP.td/A, KP.td/C, HP.k/B, AP/D and KP.ts/E with a merchantable volume of more than 100 cubic feet.

It seems that jack pine is more independent of landform and is limited to the drier sites. The proportion of jack pine increases with soil dryness, especially in the coarser materials. White birch is found in types PB/D, AP/D and HP.k/B with a total volume of 100 cubic feet per acre and more. Like balsam fir, it is favoured by fine textured and friable soil materials of the shallow till and the kame moraine.

CONCLUSIONS

The ecological survey of the Micauba Research Forest provided detailed information on the ecology of the forest ecosystems of the area. The ecological classification based on the integration of vegetation and soils

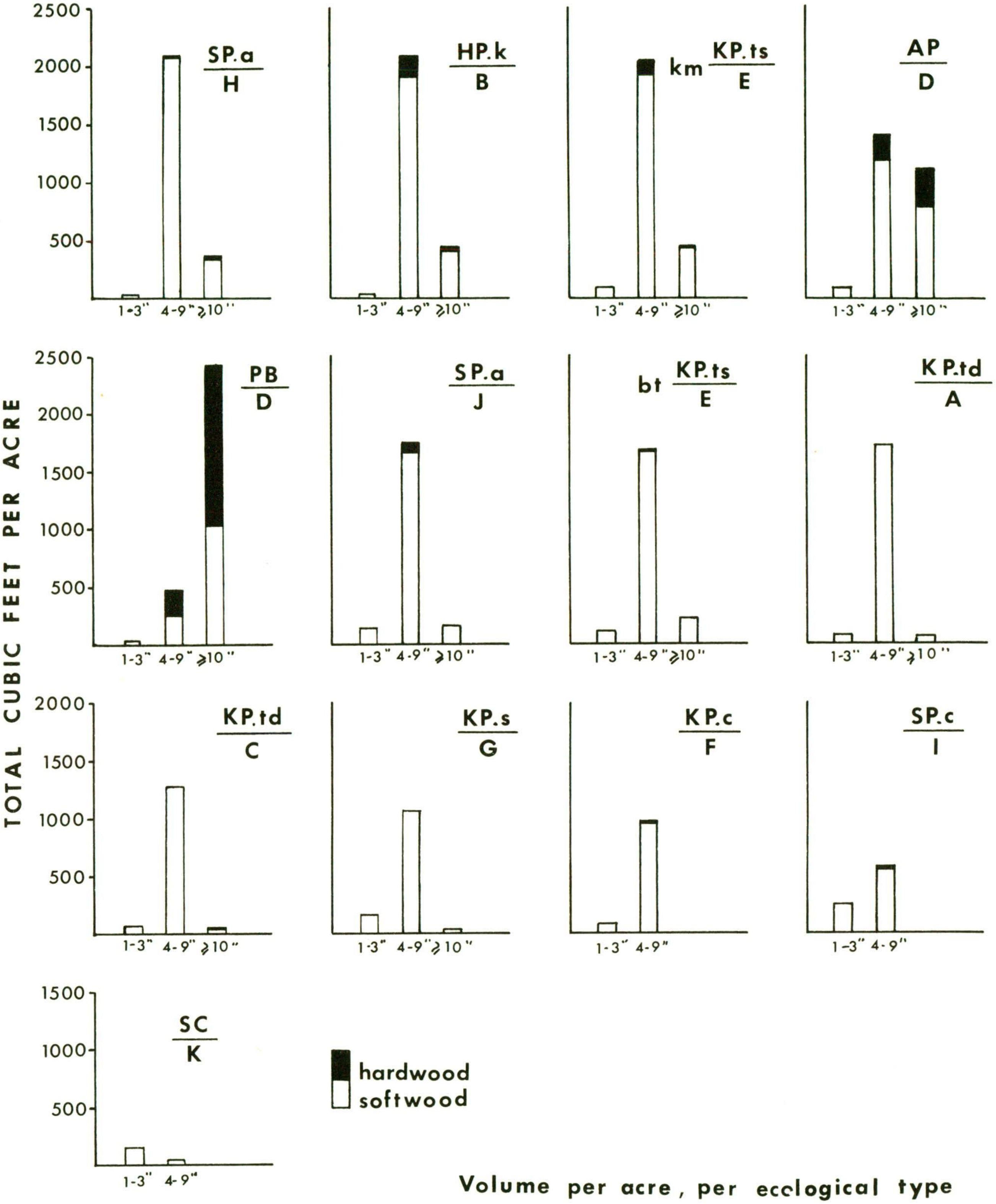


FIGURE 13

Volume per acre, per ecological type by diameter group within a geomorphic framework of landforms subdivided the research forest into smaller ones which:

(1) are ecologically homogeneous, i.e. homogeneous for the greatest possible number of environmental factors which significantly affect the vegetation-environment relationships.

(2) are ecologically significantly different in relation to each other.

(3) provide specific information on the following land features:

- structure and physiognomy of vegetation
- composition of vegetation
- physiography and landforms
- texture, petrography, and depth of the surficial geological materials
- type of underlying bedrock
- soil profile development
- soil fertility (in the broad sense)
- nature and properties of the surface organic horizons
- soil drainage and soil moisture regime
- rate of growth of the major tree species occurring in the unit.

The ecological and forest surveys of the Nicauba Research Forest allow us to make the following general conclusions:

(1) the area studied has 14 ecological types each with a different potential timber growth,

(2) all ecological types are characterized by a large number of trees per acre, and low volume per acre,

(3) the identification key provided may be used by the practicing forester to characterize stands in which he is working,

(4) the best sites of the Nicauba Research Forest are medium sites when compared with black spruce sites throughout Canada,

(5) the timber growth potential varies largely from one Soil Series to another, with the soils with seepage showing the best growth,

(6) the depth of the surface organic horizon varies from 1 to 20 inches depending on the Soil Series,

(7) half of the Nicauba Research Forest is overmature and even if the stands origin from fire, they have a large number of stems of layer (1 to 3 inches),

(8) it is highly desirable to construct local volume tables. Indeed, the local volume tables for the Nicauba Research Forest differ markedly from those calculated over a broader area,

(9) the most common Nicauba forest type (17.7% of the total area) is the black spruce-Kalmia-Sphagnum type (KP.s) which forms the KP.s/G ecological type i.e. black spruce-Kalmia-Sphagnum on the Ducharme Soil Series with an imperfect drainage and without seepage. This ecological type has 1,365 trees per acre, 950 of them are in the 1 to 3 inches diameter class, 415 are in the 4 to 9 inches class and none in the 10 inches and over. The total volume is 1,258 cubic feet per acre with a basal area of 81 square feet. There is no hardwoods in this type and black spruce forms 99% by number of trees and 96% by volume of the stand. The stocking factor is 68% and the site index, at an age of 50 years, is 26,

(10) the best softwood ecological type is the black spruce-Sphagnum-Alnus type on the Rohault Soil Series with an imperfect drainage but with seepage (SP.a/H). However it covers only 4.2% of the total area.

This type gives a total volume of 2,556 cubic feet per acre with 875 trees per acre, 330 trees are in the 1 to 3 inches class, 390 in the 4 to 9 inches and 22 in the 10 inches and over. The basal area is 118 square feet per acre. The stocking factor is 74% and the site index, at 50 years, is 38. Black spruce forms 84% by number of trees and 93% by volume of the stand. The remaining is composed of balsam fir. The black spruce-Hypnum (HP.k) forest type gives similar results but it is found on well to excessively drained soils belonging to the Aigremont Series. It has less trees per acre but includes some jack pine and white birch,

(11) the poorest type of the Nicauba Research Forest is the Sphagnum-Chamaedaphne forest type on the very poorly drained soils, without seepage, of the Epave Soil Series (SC/K). It occurs on 7% of the total area. The total volume is 255 cubic feet per acre. The stocking factor is 23 and the site index,at 50 years, is 9. This type has 1,338 black spruce from 1 to 3 inches in diameter and 54 in the 4 to 9 inches class,

(12) although the black spruce-Kalmia association, which covers about 50% of the total area, produces a total volume of 2,510 cubic feet in the best forest types to 1,059 cubic feet in the poorer forest types, the mean total volume for the whole Research Forest is only 1,317 cubic feet per acre,

(13) the main associate woody species are balsam fir, jack pine and white birch. Balsam fir occurs in 2 ecological types, mainly on shallow tills with a warmer microclimate. Jack pine prefers drier sites and coarser soil materials and is found in 5 ecological types.

White birch is favoured by soil of fine texture and occurs in 3 ecological types of which 2 are balsam fir types.

It is noteworthy that when balsam fir and especially white birch are present, they form a great percentage of the stand composition either by number of trees or by volume.

It is believed that this survey provides the ecological framework for forest research projects. This framework will permit further studies on many aspects of silviculture, silvics and ecology of black spruce in the boreal forest of Quebec. Since this part of the boreal forest will likely provide a large part of the future timber needs, well documented short, as well as long term studies are urged.

The present ecological land survey allows the forester to ask the question: "WHAT are the problems?" Research studies will answer the HOW, but the ecological survey will still be needed to indicate WHERE the research findings can be applied and extrapolated to other areas.

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Appendix 1. Average mechanical analyses of surficial materials from the landforms of the Nicauba Research Forest

Landform	Gravel	Sand: very coarse	Sand: coarse	Sand: medium	Sand: fine	Sand: very fine	Silt	Clay	Characteristics of the textural curve: Slope at inflexion point	Characteristics of the textural curve: Particle size at inflexion point	Number of samples
	%	%	%	%	%	%	%	%	(degrees)	(mm.)	
Ground moraine (bt)	17	6	11	15	24	25	26	3	50	0.17	14
Shallow till over bedrock (tg)	15	7	12	15	22	14	28	2	47	0.19	6
Water-worked drift complex (wd)	14	6	10	13	28	15	24	4	52	0.16	5
Kame moraine (km)	29	8	19	19	24	11	16	3	56	0.36	4
Stratified drift (sd) and ice-contact stratified drift (cd)	66	31	32	15	7	4	8	3	69	1.18	3
Glacio-lacustrine deposit (ld)	0	0	1	7	75	11	5	1	80	0.15	2

Appendix 2. Morphogenetic classification of the soils of the Nicauba Research Forest

Order	Great-Group	Sub-Group	Series	Symbol
Podzolic	Humic Podzol	Gleyed Humic Podzol	Ducharme	G
			Rohault	H
			Jourdain	I
			Bouteroue	J
	Humo-Ferric Podzol	Orthic Humo-Ferric Podzol	Chibougamau	A
			Aigremont	B
			Mignault	C
		Gleyed Humo-Ferric Podzol	Nicauba	E
		Lithic Humo-Ferric Podzol	Chaudière	D
Regosolic	Regosol	Lithic Regosol	Gabriel	F
Organic	Fibrisol	Sphagno-Fibrisol	Epave	K
	Mesisol	Typic Mesisol	Argenson	L

Appendix 3. Classification of the soils of the Nicauba Research Forest by landform and drainage class

Landform	Soil Drainage								
	Excessively drained	Well drained	Moderately well drained	imperfectly drained		poorly drained		very poorly drained	
				without seepage	with seepage	without seepage	with seepage	without seepage	with seepage
Ground moraine (bt) Water-worked drift (wd)	A: Chibougamau								
Kame moraine (km) Ice-Contact stratified drift (cd)	B: Aigremont								
Stratified drift (sd)	C: Mignault		E Nicauba	G Ducharme	H Rohault	I Jourdain	J Bouteroue	K Epave	L Argenson
Shallow till over bedrock (tg)	D: Chaudière								
Gneissic bedrock outcrops (gn)	F: Gabriel								

Appendix 4. Classification of surface organic horizons and major properties of representative samples in each associated soil series of the Nicauba Research Forest

Group	Subgroup	Associated Soil Series	Reaction	Organic matter	Total Nitrogen	C/N ratio	Cation exchange capacity	Base saturation	No. of samples
			(pH)	%	%		(m.e./ 100 grs.)	%	
mor[1]	humi-fibrimor[1]	D: Chaudière	3.4	80	1.38	33	161	10	4
	fibrimor[1]	A: Chibougamau	3.3	93	0.88	63	161	6	4
		B: Aigremont	3.3	94	1.02	53	144	6	3
		C: Mignault	3.5	87	1.18	44	141	9	2
		E: Nicauba	3.3	89	0.89	60	160	7	4
peaty mor[1]	humo-fibric peaty mor	H: Rohault	3.4	94	0.95	57	158	10	2
		J: Bouteroue	4.3	87	1.79	29	164	23	4
	fibric peaty mor	G: Ducharme	3.4	89	0.85	62	153	10	5
		I: Jourdain	3.7	96	1.18	47	155	16	2

[1] Classification proposed by Bernier (1968)

Appendix 5. Chemical data for representative profiles of the Soil Series from the Nicauba Research Forest

Soil Series	Horizon	Depth	Reaction	Organic matter	Total nitrogen	C/N ratio	Total exchanbe-able cations	Cation exchange capacity	Base satura-tion	Free iron	Δ Fe
		(in.)	(pH)	%	%		(m.e./100grs.)	(m.e./100grs.)	%	%	%
A: Chibougamau	FH	4-0	3.3	95.20	0.905	66	4.6	169.2	2.7	-	-
(plot no.5038)	Ae	0-3	3.6	0.91	0.031	17	-	-	-	0.02	-
	Bfh(c)	3-5	4.6	10.10	0.156	37	1.2	43.9	2.8	1.08	0.90
	Bf(c)	5-10	5.5	2.10	0.054	22	0.4	23.9	1.7	1.15	0.97
	C	10+	5.3	0.14	0.014	6	-	-	-	0.18	-
B: Aigremont	FH	7-0	3.1	93.80	1.706	51	7.0	148.0	4.8	-	-
(plot no. 5004)	Ae	0-3	4.1	0.57	0.034	10	1.6	11.3	14.1	0.07	-
	Bfh	3-3.5	4.2	9.17	0.210	25	1.1	46.6	2.5	2.24	2.03
	Bf1	3.5-6	5.3	4.16	0.131	18	1.5	31.0	4.7	1.33	1.12
	Bf2	6-12	5.3	3.40	0.098	20	1.0	27.8	0.4	1.00	0.79
	C	10+	5.0	0.92	0.020	27	1.4	14.4	9.8	0.21	-
C: Mignault	FH	1-0	3.6	89.20	1.083	51	13.1	135.8	9.7	-	-
(plot no. 5022)	Ae	0-2	3.8	1.16	0.020	34	1.7	12.5	14.0	0.02	-
	Bfh(c)	2-8	5.0	5.19	0.095	32	0.5	32.9	1.5	1.64	1.43
	C	8+	5.3	0.27	0.014	11	1.6	11.4	14.5	0.21	-
D: Chaudière	FH	3-0	3.5	76.70	1.388	35	20.9	162.8	12.8	-	-
(plot no. 5006)	Ae	0-3	3.9	0.87	0.025	20	1.3	11.1	12.2	0.07	-
	Bfh	3-6	4.9	11.00	0.235	27	0.3	52.1	0.6	3.23	3.00
	Bf	6-13	5.1	3.82	0.107	21	0.1	29.1	0.4	1.08	0.85
	C	13-25	5.0	0.74	0.022	19	1.2	18.1	6.7	0.23	-
	R	25+	-	-	-	-	-	-	-	-	-
E: Nicauba	FH	9-0	3.5	93.6	0.823	71	9.0	152.5	5.9	-	-
(plot no. 5016)	Ae	0-3	4.6	2.3	0.017	79	1.8	16.5	11.0	0.07	-
	Bfh	3-5	5.3	8.7	0.156	32	1.6	55.8	2.9	1.39	1.28
	Bfg	5-12	5.9	1.3	0.042	18	0.8	13.4	6.0	0.35	0.24
	Cg	12+	5.4	0.3	0.039	4	1.9	10.4	18.3	0.11	-

Appendix 5 (Continued)

Soil Series	Horizon	Depth (in.)	Reaction (pH)	Organic matter %	Total nitrogen %	C/N ratio	Total exchangeable cations (m.e./100grs.)	Cation exchange capacity (m.e./100grs.)	Base saturation %	Free iron %	Δ Fe %
G: Ducharme (plot no. 5039)	FH	12-0	3.3	94.5	0.872	66	13.1	163.5	8.0	-	-
	Ae	0-2	3.7	2.4	0.017	84	-	-	-	0.09	-
	Bh1	2-6	4.5	10.3	0.192	31	0.9	55.5	1.7	0.44	0.29
	Bh2	6-12	4.7	3.5	0.045	44	1.8	21.1	8.6	0.35	0.20
	Cg	12+	4.5	0.6	0.059	6	-	-	-	0.15	-
H: Rohault (plot no. 5034)	FH	15-0	3.4	94.8	0.984	60	20.9	184.9	11.3	-	-
	Ae	0-2	4.4	3.2	0.079	24	-	-	-	0.05	-
	Bh1	2-6	4.7	5.7	0.094	36	1.4	25.0	5.7	0.18	0.09
	Bh2	6-16	5.1	2.4	0.073	19	1.3	15.5	8.4	0.15	0.06
	Cg	16+	4.9	0.8	0.017	27	-	-	-	0.09	-
I: Jourdain (plot no. 5019)	FH	20-0	3.6	95.8	1.240	48	21.4	143.3	14.9	-	-
	Ae	0-2	4.1	3.7	0.073	29	1.7	17.0	10.3	0.02	-
	Bh1	2-5	4.5	20.5	0.220	54	1.6	71.4	2.3	0.10	0.05
	Bh2	5-9	4.9	3.4	0.062	32	1.4	29.1	4.8	0.05	0.00
	Bh3	9+	5.0	2.5	0.041	28	1.1	18.4	6.3	0.05	-
J: Bouteroue (plot no. 5031)	FH	18-0	4.2	90.5	1.928	29	32.3	163.2	19.8	-	-
	Ae	0-2	-	-	-	-	-	-	-	-	-
	Bh	2+	-	-	-	-	-	-	-	-	-
K: Epave (plot no. 5007)	Of	surf.	3.5	97.4	1.097	57	10.6	164.4	6.4	-	-
L: Argenson (plot no. 5010)	Om	surf.	4.4	84.1	2.626	20	46.3	179.6	25.8	-	-

Appendix 6. Textural data for representative profiles of the Soil Series from the Nicauba Research Forest

Soil Series	Horizon	Gravel	Sand: very coarse	Sand: coarse	Sand: medium	Sand: fine	Sand: very fine	Silt	Clay	Characteristics of the textural curve: Slope at inflexion point	Characteristics of the textural curve: Particle size at inflexion point
		%	%	%	%	%	%	%	%	(degrees)	(mm.)
A: Chibougamau (plot no. 5038)	Ae	3	4	7	4	11	36	36	2	45	.11
	Bfh(c)	43	11	16	19	19	10	21	4	49	.43
	Bf(c)	39	9	5	29	23	10	20	4	52	.26
	C	24	6	14	18	23	14	24	1	50	.22
B: Aigremont (plot no. 5004)	Ae	2	4	10	15	23	14	33	1	50	.20
	Bfh	28	-	-	-	-	-	-	-	-	-
	Bf1	20	6	10	16	20	14	29	5	45	.15
	Bf2	15	8	10	16	24	12	28	2	52	.19
	C	21	6	12	18	29	13	20	2	57	.20
C: Mignault (plot no. 5022)	Ae	6	9	12	17	22	12	25	3	47	.22
	Bfh(c)	52	38	21	10	8	5	14	4	72	1.80
	C	65	-	-	-	-	-	-	-	-	-
D: Chaudière (plot no. 5006)	Ae	6	6	11	17	21	13	30	2	47	.21
	Bfh	17	2	13	19	22	12	25	7	51	.27
	Bf	24	9	14	17	20	11	27	2	47	.31
	C	21	7	18	18	19	10	16	2	50	.62
E: Nicauba (plot no. 5016)	Ae	8	5	9	9	16	15	44	2	45	.05
	Bfh	7	5	11	12	19	14	35	4	43	.13
	Bfg	14	6	12	13	21	12	32	4	45	.18
	Cg	14	6	11	13	29	15	25	1	53	.13
G: Ducharme (plot no. 5039)	Ae	5	7	4	31	23	12	20	3	53	.30
	Bh1	32	6	11	16	25	13	26	3	51	.20
	Bh2	27	6	9	14	28	17	23	3	56	.12
	Cg	23	8	14	17	25	14	19	3	50	.19

Appendix 6 (Continued)

Soil Series	Horizon	Gravel	Sand					Silt	Clay	Characteristics of the textural curve	
			very coarse	coarse	medium	fine	very fine			Slope at inflexion point	Particle size at inflexion point
		%	%	%	%	%	%	%	%	(degrees)	(mm.)
H: Rohault	Ae	7	5	12	19	26	13	23	2	52	.22
(plot no. 5034)	Bh1	15	5	10	15	24	15	27	4	49	.17
	Bh2	13	5	12	18	30	15	17	3	57	.15
	Cg	8	4	8	18	31	16	21	2	58	.18
I: Jourdain	Ae	5	6	12	16	21	13	31	1	47	.21
(plot no. 5019)	Bh1	5	4	9	15	23	15	30	4	49	.16
	Bh2	9	6	10	16	28	15	21	4	54	.13
	Bh3	10	6	11	13	26	16	24	4	53	.14

Appendix 7. Vegetation classification of the Nicauba Research Forest

SYMBOL	LATIN NOMENCLATURE ASSOCIATION -Sub-Association, Variant	ENGLISH NOMENCLATURE ASSOCIATION -Vegetation Type	FRENCH NOMENCLATURE ASSOCIATION -Type de Végétation
*AP	ABIETI-PICEETUM marianae	BLACK SPRUCE-BALSAM FIR	PESSIERE NOIRE A SAPIN
HP	HYPNO-PICEETUM marianae	BLACK SPRUCE-HYPNUM	PESSIERE NOIRE A HYPNUM
*HP.k	-kalmietosum	bl. spruce-Hypnum	Pessière noire à Hypnum
KP	KALMIETO-PICEETUM marianae	BLACK SPRUCE-KALMIA	PESSIERE NOIRE A KALMIA
*KP.c	-cladonietosum	bl. spruce-Cladonia-Kalmia	Pessière noire à Cladonia-Kalmia
*KP.td	-typicum var. Cladonia	bl. spruce-Kalmia-Cladonia	Pessière noire à Kalmia-Cladonia
*KP.ts	-typicum var. Sphagnum	bl. spruce-Kalmia	Pessière noire à Kalmia
*KP.s	-sphagnetosum	bl. spruce-Kalmia-Sphagnum	Pessière noire à Kalmia-Sphagnum
SP	SPHAGNO-PICEETUM marianae	BLACK SPRUCE-SPHAGNUM	PESSIERE NOIRE A SPHAIGNE
*SP.c	-chamaedaphnetosum	bl. spruce-Sphagnum-Chamaedaphne	Pessière noire à Sphaigne et Chamaedaphne
*SP.a	-alnetosum	bl. spruce-Sphagnum-Alnus	Pessière noire à Sphaigne et Aulne
*SC	SPHAGNO-CHAMAEDAPHNETUM	SPHAGNUM-CHAMAEDAPHNE	LANDE TOURBEUSE A SPAIGNE ET CHAMAEDAPHNE
*PAl	PICEETO-ALNETUM rugosae	ALDER-BLACK SPRUCE	AULNAIE A EPINETTE NOIRE
*PB	PICEETO-BETULETUM papyriferae	WHITE BIRCH-BLACK SPRUCE	BETULAIE BLANCHE A EPINETTE NOIRE

* In the present study, these vegetation units are considered as the Forest Types.

Appendix 8. Average Importance Value and Relative Importance Value of ecological groups for classes of soil moisture regime

Ecological group	Classes						Classes					
	1	2	3	4	5	6	1	2	3	4	5	6
	Average Importance Value						Relative Importance Value					
1. Sorbus americana	5	21	2	3	6	6	24	100	10	14	29	29
2. Hylocomium splendens	0	43	24	34	68	30	0	63	35	50	100	44
3. Maianthemum canadense	69	75	24	0	0	0	92	100	32	0	0	0
4. Pinus banksiana	220	125	65	0	0	0	100	57	30	0	0	0
5. Hypnum crista-castrensis	140	189	187	99	112	35	74	100	99	52	59	19
6. Dicranum undulatum	160	146	180	106	17	0	89	81	100	59	9	0
7. Calliergon schreberi	167	181	170	144	153	40	92	100	94	80	84	22
8. Kalmia angustifolia	200	200	228	224	193	114	96	88	100	98	85	50
9. Coptis groenlandica	35	43	56	89	91	45	39	47	62	98	100	50
10. Ledum groenlandicum	180	126	200	220	195	98	82	57	91	100	89	45
11. Cladonia alpestris	200	105	85	48	11	31	100	52	42	24	5	15
12. Sphagnum spp.	0	17	137	243	240	270	0	6	51	90	89	100
13. Carex trisperma	0	2	12	81	148	108	0	1	8	55	100	73
14. Chamaedaphne calyculata	0	2	12	10	38	110	0	2	11	9	35	100
15. Eriophorum virginicum	0	0	0	0	0	111	0	0	0	0	0	100
16. Alnus rugosa	0	0	4	28	62	47	0	0	6	45	100	76
17. Mnium punctatum	0	0	0	0	0	32	0	0	0	0	0	100

Appendix 9. Average Importance Value and Relative Importance Value of ecological groups for classes of C/N ratio of the surface organic horizon.

Ecological group	Classes			Classes		
	1	2	3	1	2	3
	Average Importance Value			Relative Importance Value		
1. Sorbus americana	22	10	1	100	45	4
2. Hylocomium splendens	82	33	12	100	40	15
3. Maianthemum canadense	48	53	11	91	100	21
4. Pinus banksiana	33	100	73	33	100	73
5. Hypnum crista-castrensis	125	145	151	83	96	100
6. Dicranum undulatum	55	100	143	39	70	100
7. Calliergon schreberi	144	168	147	86	100	87
8. Kalmia angustifolia	158	212	210	74	100	99
9. Coptis groenlandica	91	65	30	100	71	33
10. Ledum groenlandicum	102	160	189	54	85	100
11. Cladonia alpestris	23	95	85	24	100	89
12. Sphagnum spp.	157	115	144	100	73	92
13. Carex trisperma	84	55	35	100	65	42
14. Chamaedaphne calyculata	27	28	18	96	100	64
15. Eriophorum virginicum	26	0	12	100	0	46
16. Alnus rugosa	44	14	11	100	32	25
17. Mnium punctatum	11	0	0	100	0	0

Appendix 10. Classification of ecological groups of species according to their synecological amplitude for soil moisture and nutrients in humus layer

Ecological factors		Ecological groups
Soil moisture	Humus nutrients	
Xerophytes 1/	Oligotrophic 4/	4. Pinus banksiana 11. Cladonia alpestris
Meso-xerophytes	Eutrophic 5/	1. Sorbus americana
	Mesotrophic 6/-oligotrophic	3. Maianthemum canadense
Xero-mesophytes	Mesotrophic-oligotrophic	5. Hypnum crista-castrensis
	Oligotrophic	6. Dicranum undulatum
Mesophytes 2/	Eutrophic	2. Hylocomium splendens
	Mesotrophic-oligotrophic	7. Calliergon schreberi
	Oligotrophic	8. Kalmia angustifolia 10. Ledum groenlandicum
Hydro-mesophytes	Mesotrophic-eutrophic	9. Coptis groenlandica
	Mesotrophic-oligotrophic	12. Sphagnum spp.
	Eutrophic	16. Alnus rugosa
	Mesotrophic-eutrophic	13. Carex trisperma
Hydrophytes 3/	Eutrophic	17. Mnium punctatum
	Mesotrophic-oligotrophic	14. Chamaedaphne calyculata 15. Eriophorum virginicum

1/ small water requirements or tolerance; 2/ moderate water requirements or tolerance; 3/ large water requirements or tolerance; 4/ small nutrient requirements or tolerance; 5/ large nutrient requirements or tolerance; 6/ moderate nutrient requirements or tolerance.

Appendix 11. Ecological structure of the forest types in the Nicauba Research Forest

FOREST TYPE	Black spruce-balsam fir	Black spruce-Hypnum	Black spruce-Kalmia-Cladonia	Black spruce-Kalmia	Black spruce-Kalmia-Sphagnum	Black spruce-Sphagnum-Chamaedaphne	Sphagnum-Chamaedaphne	Black spruce-Sphagnum-Alnus	Alder - Black spruce
	AP	HP.k	KP.td	KP.ts	KP.s	SP.c	SC	SP.a	PAl
VEGETATION STRATA	Percent cover								
Trees	71	75	63	71	68	60	17	78	0
High shrubs	32	10	12	11	15	12	23	30	90
Low shrubs	49	47	76	87	96	97	87	57	20
Herbs and forbs	25	4	1	4	4	5	22	17	80
Mosses and lichens	84	100	100	100	100	100	100	99	50
ECOLOGICAL GROUPS	Average Importance Value								
WETNESS Xerophytes	139	257	337	150	53	35	42	12	0
WETNESS Meso-Xerophytes	174	119	26	26	4	7	4	4	14
WETNESS Xero-Mesophytes	308	353	338	367	186	55	0	195	140
WETNESS Mesophytes	517	501	548	622	609	603	326	609	150
WETNESS Hydro-Mesophytes	134	0	26	193	338	370	337	313	250
WETNESS Meso-Hydrophytes	0	0	5	16	113	206	144	175	188
WETNESS Hydrophytes	0	0	4	12	14	114	294	0	127
NUTRIENTS Eutrophic	152	12	8	30	38	76	18	138	407
NUTRIENTS Mesotrophic-eutrophic	235	119	36	92	183	237	181	207	70
NUTRIENTS Mesotrophic-oligotrophic	392	424	350	506	472	615	636	522	335
NUTRIENTS Oligotrophic	493	675	890	758	624	462	312	441	37
TOTAL NUMBER OF SPECIES	42	22	23	31	29	25	27	37	26
SPECIES DENSITY	23	16	14	17	15	21	17	26	26

Appendix 12. The ecological types of the Nicauba Research Forest by decreasing order of area distribution

Ecological (Forest type/Soil Series)	Area acres	Area percent	Number of plots (Forest Survey)
KP.s/G	460	17.7	32
bt-KP.ts/E	348	13.4	31
KP.td/A	234	9.0	9
AP/D	187	7.2	13
SC/K	182	7.0	5
SP.c/I	166	6.4	8
HP.k/B	127	4.9	15
SP.a/H	109	4.2	13
km-KP.ts/E	79	3.0	11
SP.a/J	49	1.9	8
KP.td/C	34	1.3	2
KP.c/E	34	1.3	2
PB/D	10	0.4	1
PAl/L	13	0.5	0
Inundated area	232	8.9	-
Cutover area	174	6.7	-
Lakes and rivers	162	6.2	-
Total	2600	100.0	150

Appendix 13. The landforms of the Nicauba Research Forest by decreasing order of area distribution

Landform	Area acres	Area percent	Number of plots (Forest Survey)
bt: Ground moraine	982	37.8	60
bg: Bog	479	18.4	9
wd: Water-worked drift	380	14.6	35
tg: Shallow till over bedrock	252	9.7	15
km: Kame moraine	236	9.1	25
sd: Stratified drift	57	2.2	3
gn: Bedrock outcrops	34	1.3	2
cd: Ice-contact stratified drift	18	0.7	1
Lakes and rivers	162	6.2	--
Total	2600	100.0	150

Appendix 14. The soil series of the Nicauba Research Forest by decreasing order of area distribution

Soil Series	Area acres	Area percent	Number of plots (Forest Survey)
E: Nicauba	494	19.0	42
G: Ducharme	481	18.5	32
A: Chibougamau	275	10.6	9
D: Chaudière	231	8.9	14
K: Epave	182	7.0	5
I: Jourdain	166	6.4	8
B: Aigremont	127	4.9	15
H: Rohault	114	4.4	13
J: Bouteroue	55	2.1	8
C: Mignault	34	1.3	2
F: Gabriel	34	1.3	2
L: Argenson	13	0.5	0
Inundated area	232	8.9	-
Lakes and rivers	162	6.2	-
Total	2600	100.0	150

Appendix 15. The Forest Types of the Micauba Research Forest by decreasing order of area distribution

Forest type	Area acres	Area percent	Number of plots (Forest Survey)
KP.s: Black spruce-Kalmia-Sphagnum	460	17.7	32
KP.ts: Black spruce-Kalmia	427	16.4	42
KP.td: Black spruce-Kalmia-Cladonia	268	10.3	11
AP: Black spruce-balsam fir	187	7.2	13
SC: Sphagnum-Chamaedaphne	182	7.0	5
SP.c: Black spruce-Sphagnum-Chamaedaphne	166	6.4	8
SP.a: Black spruce-Sphagnum-Alnus	158	6.1	21
HP.k: Black spruce-Hypnum	127	4.9	15
KP.c: Black spruce-Cladonia-Kalmia	34	1.3	2
PAl: Alder-black spruce	13	0.5	0
PB: White birch-black spruce	10	0.4	1
Inundated area	232	8.9	-
Cutover area	174	6.7	-
Lakes and rivers	162	6.2	-
Total	2600	100.0	150

Ecological type	Diameter class (in.)	Number of trees						Basal area (sq.ft.)		Total volume (cu.ft.)		Merch.Volume (cu.ft.)	
		black spruce	balsam fir	jack pine	white birch	total softwood	total hardwood	total softwood	total hardwood	total softwood	total hardwood	total softwood	total hardwood
SP.a/J	1-3	842	30	0	0	872	0	17	0	159	0	-	-
	4-9	409	11	1	12	421	12	81	3	1694	55	1492	44
	10 +	10	0	0	0	10	0	6	0	169	0	161	0
	total	1261	41	1	12	1303	12	104	3	2022	55	1653	44
SP.a/H	1-3	330	98	0	1	428	1	8	0	73	1	-	-
	4-9	390	35	0	5	425	5	96	1	2089	28	1882	24
	10 +	22	0	0	1	22	1	14	1	394	9	376	8
	total	742	133	0	7	875	7	118	2	2556	38	2258	32
bt-KP.ts/E	1-3	541	13	0	1	554	1	11	0	103	1	-	-
	4-9	399	8	7	4	414	4	80	1	1675	20	1473	15
	10 +	11	1	1	1	13	1	8	0	224	9	214	8
	total	951	22	8	6	981	6	99	1	2002	30	1687	23
km-KP.ts/E	1-3	364	16	0	2	380	2	8	0	79	2	-	-
	4-9	411	26	8	20	445	20	91	4	1949	76	1736	58
	10 +	17	2	3	1	22	1	13	1	390	14	372	12
	total	792	44	11	23	847	23	112	5	2418	92	2108	70
KP.td/A	1-3	403	2	1	0	406	0	8	0	77	0	-	-
	4-9	354	0	75	0	429	0	83	0	1720	0	1503	0
	10 +	2	0	3	0	5	0	3	0	90	0	85	0
	total	759	2	79	0	840	0	94	0	1887	0	1588	0
KP.td/C	1-3	690	0	0	0	690	0	11	0	105	0	-	-
	4-9	280	0	95	0	375	0	65	0	1297	0	1116	0
	10 +	5	0	0	0	5	0	3	0	76	0	73	0
	total	975	0	95	0	1070	0	79	0	1478	0	1189	0
PB/D	1-3	70	0	0	10	70	10	2	0	17	8	-	-
	4-9	110	0	0	100	110	100	15	22	263	442	215	356
	10 +	0	40	0	80	40	80	34	59	1046	1385	1014	1234
	Total	180	40	0	190	220	190	51	81	1326	1835	1229	1590

Ecological type	Diameter class (in.)	Number of trees: black spruce	balsam fir	jack pine	white birch	total softwood	total hardwood	Basal area (sq.ft.): total softwood	total hardwood	Total volume (cu.ft.): total softwood	total hardwood	Merch. Volume (cu.ft.): total softwood	total hardwood
AP/D	1-3	380	219	0	8	599	8	11	0	93	5	-	-
	4-9	170	101	3	35	274	35	56	9	1208	182	1110	147
	10 +	24	8	7	14	39	14	27	12	805	304	771	254
	total	574	328	10	57	912	57	94	21	2106	491	1881	401
KP.s/G	1-3	944	6	0	0	950	0	20	0	175	0	-	-
	4-9	405	2	8	0	415	0	61	0	1083	0	914	10
	10 +	0	0	0	0	0	0	0	0	0	0	0	0
	total	1349	8	8	0	1365	0	81	0	1258	0	914	0
HP.k/B	1-3	243	32	0	5	275	5	5	0	52	3	-	-
	4-9	324	17	25	33	366	33	88	9	1954	145	1768	114
	10 +	21	0	3	2	24	2	14	1	413	26	394	24
	total	588	49	28	40	665	40	107	10	2419	174	2162	138
SP.c/I	1-3	1187	0	0	0	1187	0	26	0	228	0	-	-
	4-9	311	0	1	0	312	0	36	0	561	0	450	0
	10 +	0	0	0	0	0	0	0	0	0	0	0	0
	total	1498	0	1	0	1499	0	62	0	789	0	450	0
KP.c/F	1-3	455	0	0	0	455	0	11	0	97	0	-	-
	4-9	375	0	5	0	380	0	55	0	962	0	803	0
	10 +	0	0	0	0	0	0	0	0	0	0	0	0
	Total	830	0	5	0	835	0	66	0	1059	0	803	0
S.c/K	1-3	1338	0	0	0	1338	0	23	0	191	0	-	-
	4-9	54	0	0	0	54	0	5	0	64	0	49	0
	10 +	0	0	0	0	0	0	0	0	0	0	0	0
	total	1392	0	0	0	1392	0	28	0	255	0	49	0

Species	PB/D	AP/D	HP.k/B	KP.c/F	KP.td/A	KP.td/C	bt KP.ts/E	km KP.ts/E	KP.s/G	SP.c/I	SC/K	SP.a/H	SP.a/J
						Percent of the total number of trees per acre							
Black spruce	44	59	83	99	90	91	96	91	98	100	100	84	96
Balsam fir	10	34	7	0	0	0	2	5	1	0	0	15	3
Jack pine	0	1	4	1	10	9	1	1	1	0	0	0	0
White birch	46	6	6	0	0	0	1	3	0	0	0	1	1
Total softwood	54	94	94	100	100	100	99	97	100	100	100	99	99
Total hardwood	46	6	6	0	0	0	1	3	0	0	0	1	1
No. of trees per acre	410	969	705	835	840	1070	937	870	1365	1499	1392	882	1315

Species	PB/D	AP/D	HP.k/B	KP.c/F	KP.td/A	KP.td/C	bt KP.ts/E	km KP.ts/E	KP.s/G	SP.c/I	SC/K	SP.a/H	SP.a/J
	Percent of the total volume per acre												
Black spruce	9	50	82	98	73	67	94	86	96	99	100	93	95
Balsam fir	33	24	2	0	0	0	2	6	1	0	0	6	1
Jack pine	0	7	9	2	27	33	3	4	3	1	0	0	1
White birch	58	19	7	0	0	0	1	4	0	0	0	1	3
Total softwood	42	81	93	100	100	100	99	96	100	100	100	99	97
Total hardwood	58	19	7	0	0	0	1	4	0	0	0	1	3
Total volume per acre(cu.ft.)	3161	2597	2593	1059	1887	1478	2032	2510	1258	789	255	2594	2077

Ecological Type	Age (years)	Height (feet)	Stocking factor(%) (softwoods only)	S.I.	Tot.Vol. (cu.ft./acre)	M.A.I. (cu.ft./ acre/year)	Merch.Vol. (cu.ft./ acre)	M.A.I. (cu.ft./ acre/year)	Land capability for forestry[2/]
HP.k/B	101	58.5	70	42	2593	25.7	2300	22.8	4
PB/D	60	46.5	37	42	3161	52.7	2819	47.0	4
AP/D	113	55.2	61	39	2597	23.0	2282	20.2	4
SP.a/H	133	55.6	74	38	2594	19.5	2290	17.2	4
km-KP.ts/E	107	53.5	82	37	2510	23.5	2178	20.4	4
bt-KP.ts/E	119	48.9	74	33	2032	17.1	1710	14.4	5W
KP.td/A	124	48.0	70	32	1887	15.2	1588	12.8	5M
SP.a/SJ	125	47.8	75	31	2077	16.6	1697	13.6	5W
KP.td/C	105	42.3	61	27	1478	14.1	1189	11.3	6M
KP.s/G	120	41.7	68	26	1258	10.5	914	7.6	6W
KP.c/F	154	41.2	52	26	1059	6.9	803	5.2	6MR
SP.c/I	133	37.1	51	22	789	5.9	450	3.4	7W
SC/K	137	23.5	23	9	255	1.9	49	0.4	7W

[1/] The ecological types are ranged by decreasing site index.
[2/] This classification is the one used by the Canada Land Inventory (McCormack 1967).

Appendix 20

Local Volume Tables for the

Nicauba Research Forest

(Volume tables 1 to 5)

VOLUME TABLE NO. 1

Black Spruce

Use for: black spruce and jack pine in the following forest types:

KP.td, HP.k, km.KP.ts, bt.KP.ts, AP, SP.a, SP.a, KP.td, P.B.
A B E E D H J C D

D.b.h. inches	Height feet	Total Volume cubic feet	Merchantable Volume cubic feet
1	8.5	.030	
2	16.5	.188	
3	24.0	.563	
4	31.5	1.25	0.9
5	38.5	2.30	1.8
6	45.5	3.87	3.3
7	52.0	5.94	5.4
8	58.0	8.55	8.0
9	63.0	11.7	11.1
10	67.0	15.3	14.6
11	70.5	19.5	18.6
12	73.0	24.0	22.9
13	75.0	28.9*	27.7*
14		35.0	33.0
15		40.9	38.8

VOLUME TABLE NO. 2

Black Spruce

Use for: black spruce and jack pine in the following forest types:

KP.s, / G   SP.c, / I   KP.c / F

D.b.h. inches	Height feet	Total Volume cubic feet	Merchantable Volume cubic feet
1	5.5	.024	
2	13.5	.164*	
3	21.5	.518	
4	29.5	1.19	0.9
5	37.0	2.23	1.8
6	44.0	3.75	3.2
7	50.0	5.75	5.2
8	54.0	8.04	7.5
9	57.5	10.8*	10.2
10		14.1	13.7
11		17.7	17.6

VOLUME TABLE NO. 3

Black Spruce

Use for: black spruce and jack pine in the following forest type:

$\frac{SC}{K}$

D.b.h. inches	Height feet	Total Volume cubic feet	Merchantable Volume cubic feet
1	7.0	.029	
2	14.5	.172*	
3	20.5	.500	
4	25.0	1.05	0.8
5	27.0	1.74*	1.4*
6		2.72	2.4
7		3.95	3.2

VOLUME TABLE NO. 4

Balsam Fir

Use for: balsam fir in all forest types

D.b.h. inches	Height feet	Total Volume cubic feet	Merchantable Volume cubic feet
1	6.0	.023	
2	11.0	.155*	
3	18.0	.481	
4	27.5	1.16	1.1
5	37.5	2.34	2.3
6	47.0	4.08	3.9
7	53.5	6.21	6.0
8	58.0	8.70	8.5
9	61.5	11.6	11.4
10	65.0	15.0	14.6
11	68.0	19.0	18.4
12	70.0	23.2	22.5
13	72.0	28.0	27.1
14	74.0	33.3	32.3
15	75.0	38.6	37.6
16	76.5	44.8	43.6
17	77.0	50.9*	49.5*
18		56.4	55.3

VOLUME TABLE NO. 5

White Birch

(L.V.T. for white birch, Sault-au-Cochon River, 1947)
Use for all hardwoods in all forest types

D.b.h. inches	Height feet	Total Volume cubic feet
1	11.0	.067
2	18.5	.313
3	26.0	.806
4	31.8	1.56
5	36.0	2.57
6	40.0	3.89
7	43.5	5.48
8	46.5	7.35
9	49.5	9.56
10	52.5	12.2
11	55.5	15.2
12	58.2	18.7
13	61.0	22.5
14	64.0	26.8
15	66.8	31.5
16	69.6	36.7
17	72.5	42.3
18	75.4	48.6
19	78.3	55.1
20	81.2	62.1
21	83.5	68.7
22	85.5	75.7
23	87.3	82.5
24	89.5	89.5