ECOLOGY AND PRODUCTIVITY OF THE NORTHERN HARDWOOD FORESTS OF QUEBEC

by

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A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy to the
University of Michigan
1963

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ECOLOGY AND PRODUCTIVITY OF THE NORTHERN HARDWOOD FORESTS OF QUEBEC

(Abstract)

By Guy J. Lemieux

The purpose of this study was to prepare an ecological classification of the natural, unmanaged, uneven-aged tolerant hardwood forests of Quebec and to evaluate their productivity. The importance of such a study arises from the fact that a classification and evaluation of sites is essential as a basis for silviculture and management.

A total of 174 1/5-acre plots was established throughout Halliday's L-4 region (25,000 sq. m.) with the help of topographic maps and aerial photographs. Following the ecosystematic approach, both the physical environment and the plant community were studied. For the purpose of evaluation, in each plot a complete tally was taken of all trees by species and one-inch diameter classes, and some 20 to 25 trees were measured for height and diameter and bored for age counts and diameter growth studies.

The ecological classification resulted in 15 ecosystem types identified by the plant community. These types are distributed among eight associations, ten sub-associations and one variant sensu Braun-Blanquet, for which association tables are presented. In five associations, the principal species is sugar maple, with yellow birch, beech, basswood or elm as associates. There are two associations of black ash, one with yellow birch and one with American elm, and one association of yellow birch with balsam fir. The physical environment of each ecosystem type is described and some significant chemical properties of the soil are given. Artificial ecological transects show the relationship between the various types and the landscape.

A general qualitative assessment of the productivity of these types is already possible from the ecological data. In addition, a quantitative evaluation is made of each type for each species through the height-age relationship. The relative position of the height-age curves agrees with the ecological data.

Diameter-age curves are also presented but there are discrepancies between their relative position and site quality as indicated by the ecological data and the height-age curves. It seems that the present sampling was not selective enough to compensate the effect of suppression on diameter growth. These curves do however give an idea of the average diameter growth rate found in these unmanaged stands.

A second set of curves of height and diameter over age shows average maximum values attainable if trees are free to grow throughout their lives. According to these curves, sizes actually attained in unmanaged conditions at 100 years could be attained 30 to 40 years earlier with proper silviculture.

Clear bole length was also measured and though there is a broad correlation with site quality, trees vary so much in this respect even inside one plot that no conclusive results are obtained in the unmanaged stands.

Though the height-age curves agree with the ecological data and give a quantitative measure of site quality, their use as site-index curves, that is quick reference curves, is not recommended in unmanaged stands. Height variation is too large even in individual plots.

The easiest to use indicator of site quality is the ecosystem type defined by its plant community and environment.

PREFACE

Countless discussions on the management of northern hardwoods in Quebec convinced me of the necessity of undertaking an investigation on the ecology and productivity of these forests.

Though substantial research has been carried on in the even-aged forests of spruce and fir in the boreal region, little has been done in the forests of maple, beech and yellow birch. The multiplicity of species and uneven-aged structure of the stands probably explain to a great extent the reluctance of research foresters to attack this problem.

Yet something had to be done to answer some of the questions about the ecological requirements of the various species involved and the rate of growth of these forests if any sound silviculture and management practices are to be elaborated.

My decision to tackle this problem was not taken without some apprehension but I was convinwed that at least a partial answer could be found if not the final solution.

I am deeply indebted to my professors at the University of Michigan and to my immediate supervisor, Dr. A. Linteau, for most stimulating and helpful lectures and discussions which made my task much easier.

I also wish to thank my employer, the Government of Canada, and the University of Michigan for the grants and fellowships which enabled me to pursue this research as partial fulfillment for a doctor's degree.

Finally, I would like to thank Messrs. R. Keable and A. Choquette for their fine draftsmanship in the preparation of the figures and graphs.

Quebec, P.Q.
December 1963

Guy J. Lemieux

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

Figure Page

INTRODUCTION

The economy of the Province of Quebec depends to a great extent on forest industry. Vast areas of its territory are heavily forested and must remain so, for topography and climate preclude any extensive agricultural development and settlement except at the southern margin, in the St.Lawrence lowlands. The greater portion of these forests is made up of conifers, mainly spruce and fir, and they are the mainstay of the pulp and paper industry. But south of this conifer forest there is also a large area of tolerant hardwoods the importance of which is twofold. These forests support a host of small industries: sawmills, flooring and furniture manufacturers, etc. Also, as these forests occur naturally in the settled part of the Province, they form the greater part of the farm woodlots and are an important source of revenue to the farmers, particularly the marginal ones who manage to survive because of this revenue from their woodlot.

Forest research, up to now, has overlooked the hardwoods in Quebec and concerned itself primarily with the conifer forest, the great provider of the pulp and paper industry which comprises all the big companies and brings in the biggest revenues to the Province. Yet the situation and need for research are far more critical in the hardwoods.

There are hundreds of small industries relying on hardwoods for a living and the market requires quality, not just volume as the pulp industry does. The greater part of the hardwood forests have been high-graded more than once so that their actual state is pitiful. Some thrifty young second-growth stands do exist, but they are in the minority. Most existing stands are the remains of "selective" cuttings (selection of the best trees!) where canker-ridden wolf-trees were the only seed trees left and still dominate the stands. The only decent natural hardwood stands left are found in the Ottawa valley in rough, difficultly accessible country and in scattered private woodlots of the more prosperous farms. Quality requirements of the market command a more intelligent silviculture and management of the remaining natural forests and reclamation of the massacred ones, so that a continuous supply of high quality trees of the proper species can be obtained. An added incentive to intelligent silviculture of these forests is the fact that they are far richer and faster growing than the boreal conifer forests and their response to treatment much more exciting. But a sound silviculture must be based first on the proper ecological knowledge of the forests studied. The various forest stands and their habitats must be described and their productivity evaluated. The physiology and genetics of the component species must be studied. Investigations in pathology and entomology are also required. We have just started scratching the surface of such fundamental knowledge in Northern Hardwoods. What is more, if we want to make use of the natural forests still in existence, we must act now!

The present work is a small contribution to the elucidation of the first problem, namely the classification of the various hardwood stands and their habitats, and a first evaluation of their productivity. It is imperative to draw a clear distinction between classification of habitats which belongs to the field of ecology and evaluation which belongs in our case to forest mensuration.

The present investigation is concerned with a description and classification of the various habitats naturally supporting tolerant hardwoods, either pure or mixed with softwoods, and an evaluation of the growth potential of each valuable hardwood species in each forest-habitat type.

It is hoped that the present work will be a step forward in our knowledge of northern hardwoods, and serve as a basis for further research in their silviculture and management.

PART I

DESCRIPTION OF THE AREA

GEOGRAPHICAL LOCATION

The area investigated in this study is located in the southwest portion of the Province of Quebec (Fig. 1). It consists of a crescent band extending from Quebec City (71° W long.) to Lake Temiscamingue

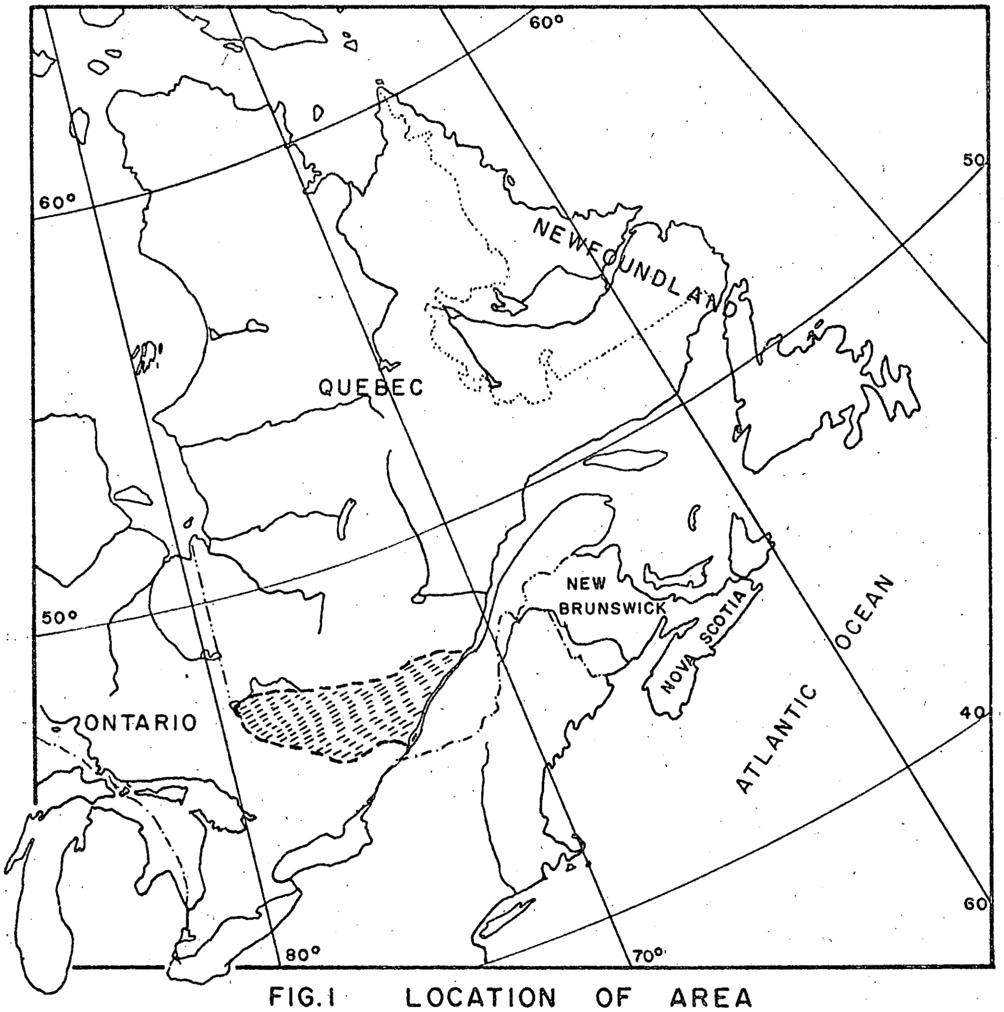


FIG. I LOCATION OF AREA

200 100 0 200 400

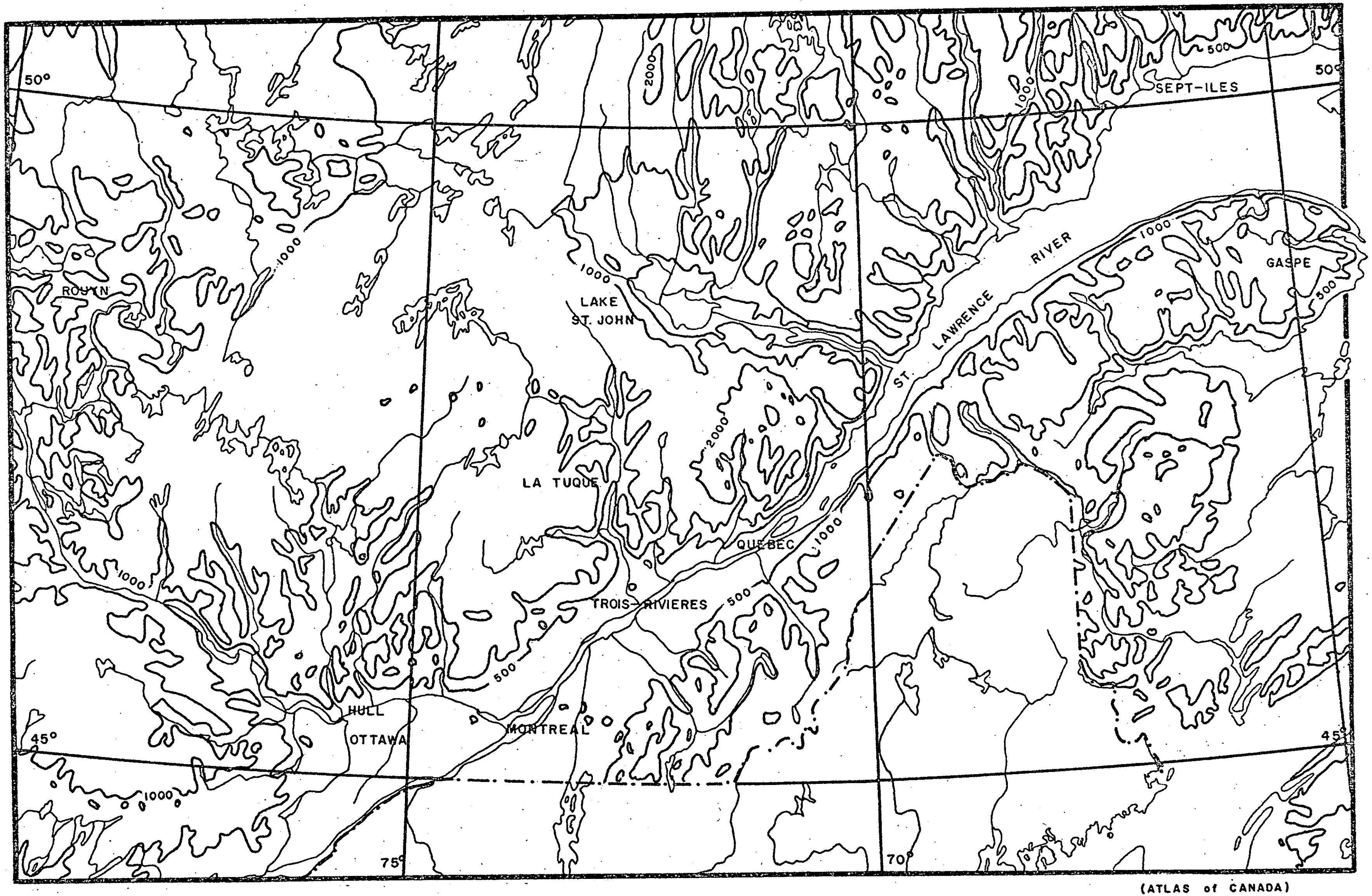
SCALE: ONE INCH to 315.6 MILES

(79° W long.). The width of this band varies from 25 to 100 miles and its area is about 25,000 square miles. It is limited to the south by the escarpment of the Laurentian plateau as it rises abruptly from the Ottawa and St.Lawrence lowlands and to the north by the boreal forest of spruce and fir.

This part of the Shield forms a uniform plateau with a slight dip to the northwest and a local relief seldom exceeding 200 feet. The average altitude varies from 1700 to 1800 feet north of Quebec to 1200 feet in the western part (Fig. 2). Altitude reaches 3000 feet at one place only, the Mont-Tremblant massif, north of Montreal. Finally it drops to 800 feet in two long north-south troughs: the Gatineau-Lièvre and the St.Maurice valleys.

Most of this plateau despite its northwestern dip drains south through tributaries of the St.Lawrence and Ottawa Rivers. The main tributaries are, from east to west: the Montmorency, the Jacques-Cartier, the Ste-Anne, the St-Maurice, the Rouge, the Lièvre, the Gatineau, the Coulonge and the Dumoine. The northwestern part of the area first drains west through the head of the Ottawa River and the Kipawa than south and east to the St.Lawrence.

The bedrock is generally close to the surface and covered with a thin veneer of glacial till and waterlaid materials. Agriculture then has very little future in this area and settlement is quite thin in the eastern half while the western portion is wild country, much of it inaccessible. The denser settlement of the Lièvre-Gatineau and St-Maurice valleys follows the extensive alluvial deposits and the re-entrants of marine deposits which penetrate to about 50 miles up these valleys.



(ATLAS of CANADA)

FIG. 2 OROGRAPHY

50 25 0 50 100

SCALE: ONE INCH to 78.91 MILES

GEOLOGY

Bedrock (Fig. 3)

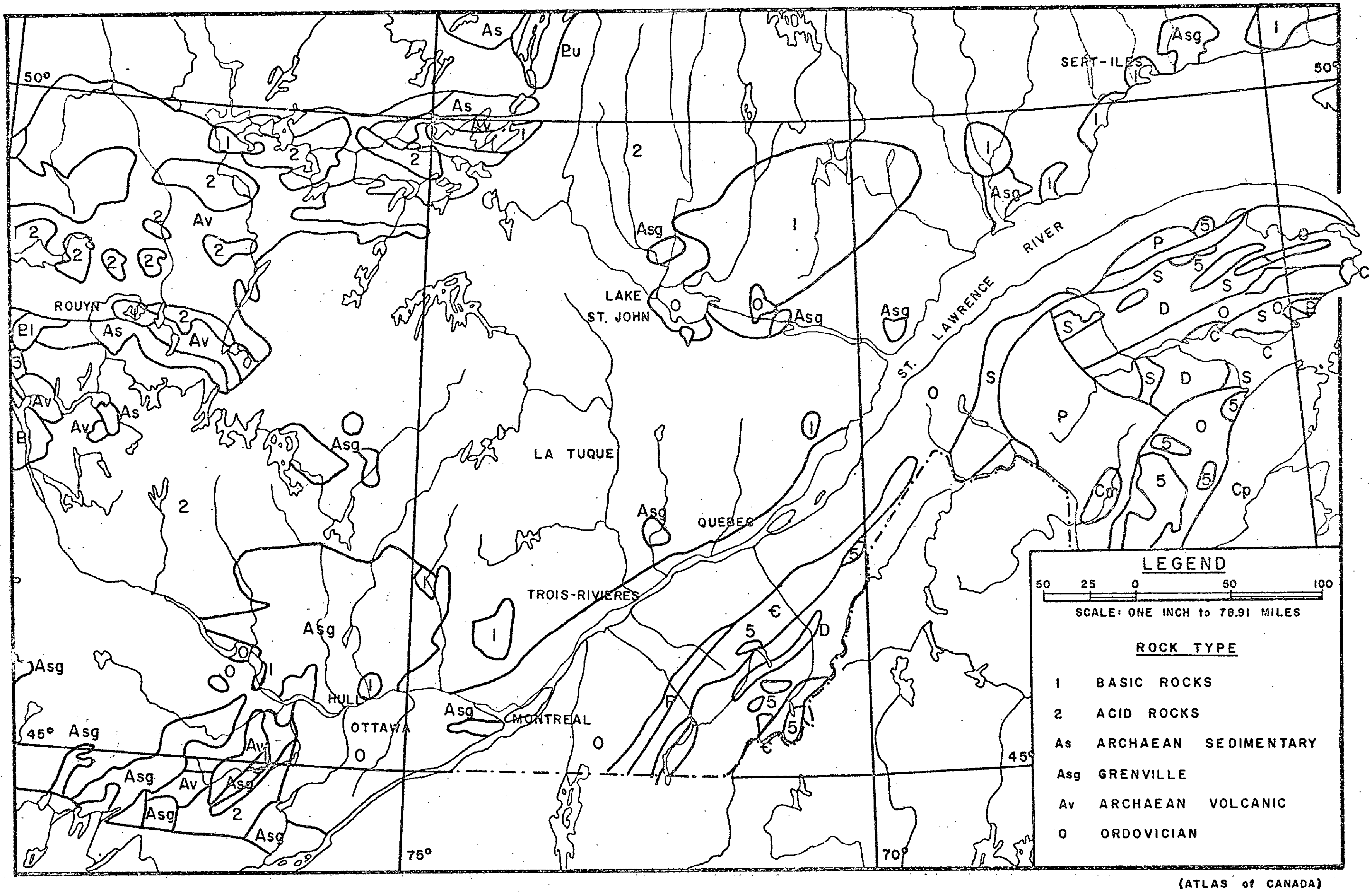
The area under study is, as said above, part of the Canadian Shield. The southern margin coincides with the line between the pre-Cambrian and Palaeozoic rocks. According to Clark and Stearn (1960):

> "About 80 per cent of the area of the Canadian Shield is composed of granite gneiss within which are set elongate, podlike bodies of metamorphosed sedimentary and volcanic rocks ... Most geologists now believe that the gneiss which forms so much of the Shield is the product of repeated intrusions and that as many as 30 or 40 intrusive cycles will be identified when the Shield has been investigated in detail. The granites now blendto form an almost homogeneous mass".

The podlike bodies are remnants of the oldest sediments and volcanics on record. They are of Archean age (Early pre-Cambrian). Their sporadic distribution can be best explained if they are interpreted as the lower parts of eugeosynclines that have been almost engulfed during orogeny by the granite that now surrounds them. Prolonged exposure to erosion may have still reduced their areal distribution. The commonest sedimentary rocks are graywacke and conglomerate while the volcanics are strongly metamorphosed lavas now designated as greenstones. Petrographic studies show that most of the greenstones were andesites, basalts and ryolites. Beds of tuff and agglomerate were also associated with the flows.

Both sedimentary and volcanic rocks have been converted to schists, and in more intensely deformed areas to gneisses.

The archaean sedimentary and volcanic rocks are not the only record of the pre-Cambrian eras. They are overlain unconformably by much different rocks assigned to the Proterozoic (late pre-Cambrian). Most of these rocks are quartzose sandstone, limestone and dolomite,



(ATLAS of CANADA)

FIG. 3 BEDROCK GEOLOGY

with some feldspathic sandstone, shale and lava flows. They are relatively undisturbed, compared to the intense deformation of the Archean groups.

> "Iron formation is a common sediment in Proterozoic sequences and nearly all the major iron ores of the Shield are found in beds of this type", (Clark and Stearn, 1960).

In the map (Fig. 3) outliers of these two series of rocks can be noticed immediately to the north and west of the area under study.

The most important pre-Cambrian series in the area proper is the Grenville series. There is still no agreement whether to classify the Grenville as Archean or Proterozoic. The important point is the presence of this series with its particular rock content. It is

> "a complex of more or less granitized sedimentary gneisses associated with large amounts of crystalline limestone and with a little lava ... The Grenville rocks, which extend from Lake Huron for a still undetermined distance along the north shore of the St.Lawrence River, were originally composed of sandstone, arkose, shale, limestone, and minor lava flows." (Harrison, in Stockwell, 1957)

However these rocks have been metamorphosed to marble schist, garnet gneiss, quartzite and amphibolite. The sequence at the type locality of Grenville is from top to bottom crystalline limestone, garnet gneiss and quartzite. These layers over most of the region have been intensely folded and intruded by gabbro, anorthosite, diorite and syenite. If one adds effect of weathering and erosion, and crystalline limestone is most susceptible to this effect (Mackay, 1949), it is not surprising that the typical sequence is not often found undistrubed and that these sediments have been preserved only at the bottom of the geosynclines. It seems more than a coincidence that the larger known areas of outcrops of these rocks are concentrated from the Black River region across the Lièvre-Gatineau valleys to the Grenville township region, that is in the trough of lower elevation mentioned before (compare Figs. 2 and 3). According to Mackay (1949), the Gatineau valley largely developed on Grenville limestone and the Thurso and Nation Valley Railway also follows for a great part of its route, a depression eroded in soft crystalline limestone. In many areas, the upper layer of limestone is gone and the garnet gneiss with or without sillimanite is at the surface. But wherever present at the surface, crystalline limestone as well as basic rocks such as greenstone and anorthosite could be highly significant when the acidity and amount of nutrients in the soils of that area are considered.

Detailed distribution of rocks in areas studied were found in the following authors: (Adams 1896, Aubert de la Rue 1948, 1948b, Auger 1952, Barlow 1899, Béland 1954, Béland & Bergeron 1959, Béland 1961, Béland 1954, Bell 1889, Clark 1948, Clark & Lunde 1950, Collins 1914, Crosby 1944, Cummings & al. 1955, Denis 1936, Denis 1937, Ells 1897, 1900, 1902, Faessler & Leverdière 1936, Faessler 1940, 1948, Gill 1949, 1957, Gillies 1952, Goudge 1935, Hannah 1952, Harry 1961, Henderson 1936, Johnston 1954, Laporte 1952, Logan 1847, 1854, 1857, 1863, Low 1893, Lunde 1951, 1954, MacGerrigle 1936, Mackay 1947, Mauffette 1948, 1949, 1950, 1953, Melihercsik 1949, Osann 1902, Osborne 1935, 1936a, 1936b, 1951, 1956, Betty 1932, 1933, 1934, Sabourin 1952, 1955, Smith 1950, Snelling 1962, Thomson 1956, Vennor 1878, 1881, Wilson 1946, Wilson 1914, 1915, 1918, 1921, 1924, 1925).

Pleistocene (Fig. 4)

The whole of the Province of Quebec was glaciated. As the Labrador ice cap was centered in Quebec, it is not surprising to find more gouging and polishing of bedrock than accumulation of deposits over

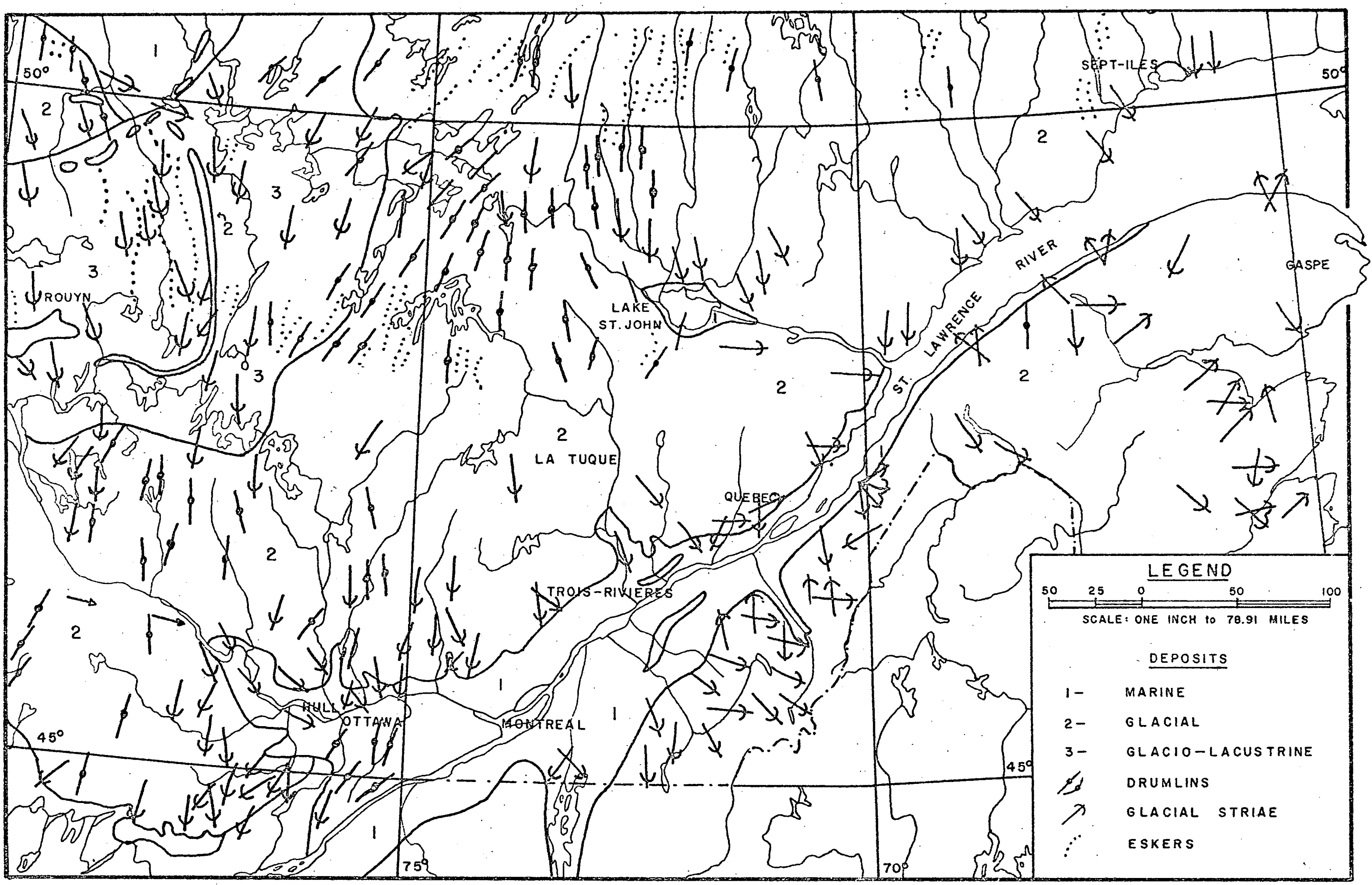


FIG. 4 PLEISTOCENE GEOLOGY

(ATLAS of CANADA)

most of the Shield. In the area studied, however, which occupies the southern margin of the plateau, tills reach two feet or more in depth on ridge tops as well as slopes. As the bedrock is mostly granitic, the tills are light-textured sands and sandy loams. In the few areas of finer textured rocks silt loams and loams can also be found.

All glacial tills studied in Quebec up to recently had proven to be of Wisconsin age. Lately, however, studies of the Pleistocene deposits in the St.Lawrence lowlands have revealed a till (The Becancour till) and organic deposits of "pre-classical Wisconsin" but apparently of post-Sangamon time (Terasmae 1958, Gadd 1960). The peat deposits have a carbon-14 date of 40,000 years. This older till is red, clayey and highly calcareous, but up to now it has been found only south of the region actually studied.

The southern margin of the Plateau as well as the valley reentrants were also invaded by the Champlain Sea. The highest Champlain Sea sand and pebble beaches are found at about 650 to 700 feet in the Ottawa area and 600 to 650 feet around Quebec (Low 1893; Mauffette 1950; Faessler 1947; Mackay 1949). The maximum elevation of clay or clay loam deposits has been reported as 575 feet in the Lièvre-Gatineau trough by Mauffette (1950). The average maximum elevation of these deposits reported elsewhere is between 500 to 550 feet (Low 1893; Faessler 1947). Mackay (1947), in a traverse between Quyon and Montebello, finds that on both sides of the Lièvre-Gatineau trough, the boundary between clay plains and the rock knob upland is abrupt because of the escarpment and that the 400-foot contour line approximates this boundary. In the trough itself, he reports clay plains up to 600 feet, 30 to 40 miles north of the lowlands. Mauffette (1950) also records varved clays above 460 feet.

These observations are most interesting if we then consider Goldring's (1920) study of the Champlain Sea. Through an inventory and analysis of Champlain Sea fossils, Goldring was able to separate three zonated types of deposits: normal marine (saline), brackish and fresh water. He based his conclusions on frequency distribution of species particular to each type of water and on dwarfing and other characters of the species different from normal. He also found that the distribution of marine and fresh-water species coincided with distribution of heavy clays and varved clays. From his map it can be seen that marine waters, consequently marine clay deposits, were confined to the St.Lawrence-Ottawa lowlands, that the brackish waters extended a short way upstream of the main tributaries among which the Lièvre, Gatineau and St.Maurice, and that further upstream only fresh water was to be found. Going back to Mackay (1947) and Mauffette (1950) one can draw the reasonable conclusion that true marine clay deposits are found up to 400 feet, brackish water deposits from 400 to 460 feet approximately and fresh water deposits (varves and others) above 460 feet. Such conslusions, if true, are of the greatest importance in assessing the fertility of the soils found in the area. According to Grim (1962), clay minerals seem to remain unmodified during deposition in fresh water but there is a strong suggestion that some are modified during deposition in marine water.

> "There is a tendency for micas which have been degraded in the weathering process by the partial removal of the interlayer cations to be regraded into better crystallized illite and chlorite."

Such changes in the clay fraction could not only affect the exchange capacity of the soil but also its physical characteristics as they affect compaction, puddling and drainage.

Consequently, it seems important to define more accurately the southern margin of the area studied as the line between the marine and brackish water deposits in the valleys and the marine deposits and till-covered slopes elsewhere.

VEGETATION

The area investigated is part of a larger vegetation complex centered on the Great Lakes and the St.Lawrence valley. It is limited to the north by the boreal forest of spruce and fir, and to the south by the deciduous forest of oaks and hickories. Frothingham (1915) was the first to consider this region as more than a transition between those two regions and he named it the "Northern Hardwood Region". He and Nichols (1935) showed that the limits of this region coincided with the limits of optimum range of eastern hemlock, white pine, red pine and yellow birch. They both recognised, however, that the dominant climax species on the mesic sites is sugar maple, the next most prominent species being yellow birch, beech, and hemlock and also the occasional white pine. The dry edaphic climax is commonly a community dominated by white pine and red pine while the wet sites support communities of boreal species: black spruce, balsam fir, white spruce and larch. They also recognized the existence of vast pineries maintained by repeated fires on sites which otherwise would also be occupied by the hardwoods. Nichols' work is a particularly detailed ecological study of this region, which he called the "Hemlock-White Pine-Northern Hardwood Region". Halliday (1937) preferred the term Great Lakes-St.Lawrence Region (the L Region).

A more intensive exploration also led ~~him~~ the latter to a subdivision of the region into sections:

> "Such differentiation can largely be traced to
> the effect of local climate, the underlying

> geologic structure, the character of the surface deposits, the topography, and the resulting drainage plan or to combinations of all these" (Halliday 1937).

In Quebec, the gneissic Laurentian scarp was separated as L-4, the Appalachian palaeozoic uplands as L-5, the lowlands invaded by the Champlain Sea as L-2 and L-3, the Lake St.John Basin as L-7 and the narrow band along the lower St.Lawrence estuary as L-6.

Finally, Rowe (1959) further subdivided the L-4 section into subsections. From an ecological point of view, one subdivision seems to be justified in Quebec, which corresponds to the Gatineau-Lièvre trough of lower elevation, underlain by fragments of Grenville limestone. Figure 5 is essentially based on Halliday's map with some of Rowe's modifications and slight contour modifications based on the writer's own experience. The area of the present investigation is confined to Section L-4a, b and c.

Treatment of the section as a whole does not imply by any means complete uniformity of vegetation. On the contrary, latitude and altitude control the range of most of the tree species of southern affinities. In a general north-south direction, the natural forest vegetation on the well-drained sites varies from sugar maple-yellow birch to sugar maple-beech to sugar maple-basswood. Red oak and ironwood are present on dry, warm hilltops in the southern half. Cold stony slopes support mixtures of yellow birch, spruce and fir, while dry ridges with thin soil support red pine, white pine, white birch and white spruce or hemlock, white cedar and red spruce to the southeast. Low lying wet sites support either black ash-elm or spruce-fir stands. Fire may bring about any number of mixtures of which red pine-white pine-white birch or aspen-white birch stands are the most common.

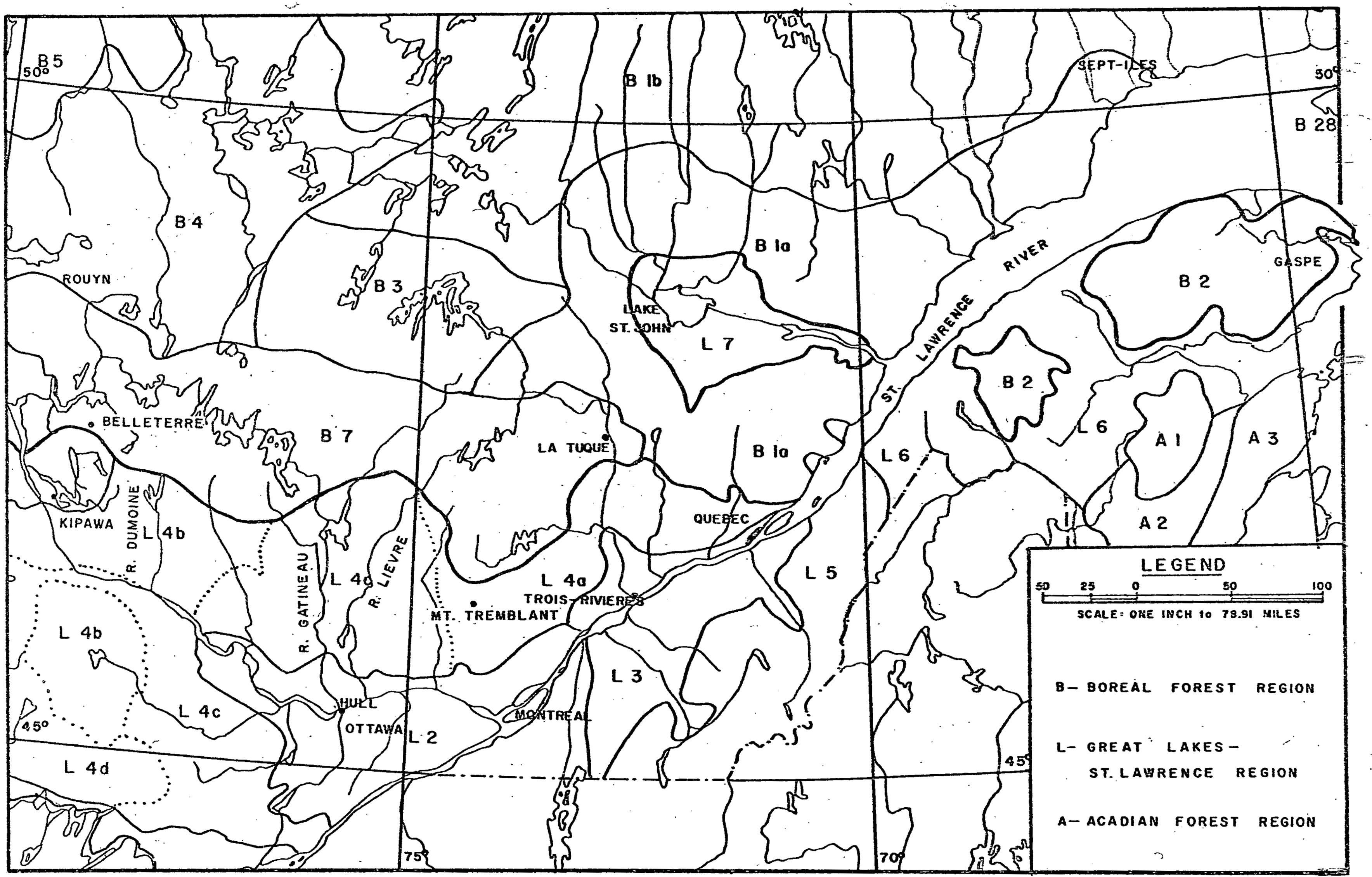


FIG. 5 FOREST REGIONS

(ATLAS of CANADA)

In the Gatineau-Lièvre trough, the presence of basswood, white ash, black cherry and butternut could be due either to the presence of limestone or to lower elevation. Basswood was not found above 1100 feet altitude either here or in the Algonquin uplands across the Ottawa River (Gordon 1955).

Classification of local site-types has been carried out over small areas such as Lake Edward and Valcartier using the lesser vegetation method of Cajander (1926) (Heimburger 1941), but no attempt has yet been made at a systematic approach to the whole area.

CLIMATE

The earliest plant geographers and climatologists have recognized the relationship between the life zones of the world and climate (Grisebach 1872, Schimper 1903, Köppen and Geiger 1936, Merriam 1898, Livingston and Shreve 1921). To define the climate types and life zones, various aspects of temperature and precipitation have been the most commonly utilized: mean annual temperature and precipitation, seasonal variations of both, length of growing season either as frost-free days, days with a mean temperature above 42°F or growing degree-days, presence or absence of dry seasons, etc. Thornthwaite (1931, 1948) in attempting a more complete and rational approach to climate classification integrated temperature and day-length to establish regions of different potential evapotranspiration or water need. When combined with monthly values of precipitation, potential evaporation made it possible to separate regions with seasonal water deficits from those with a water surplus. Potential evapotranspiration was also a measure of the thermal efficiency of a climate (Thornthwaite & Hare 1955).

Some investigators (Paterson 1956, 1959, Weck 1955, 1957, 1960) have elaborated mathematical formulae integrating temperature, precipitation, radiation and length of growing season. The resulting indices not only determined types of climate, but they related these climates to potential forest productivity. These indices have been discussed by Pardé (1958, 1959) and Lemieux (1961). They are of limited value in a regional site classification, where soil factors take precedence over climate in the separation of site-types.

Whatever the climatic factors or indices used, a necessary sequel to a classification is the mapping of the climate types. Two approaches have been used. One, termed "objective" mapping of climate, is to trace isolines of the various numerical values of the parameters used. Such an approach, though perhaps useful in meteorology, is of limited utility in climatology, that is in studies of meteorological events as they are related to the distribution of life on earth. First, the meteorological stations which supply the basic data are few and irregularly scattered across the continents. The actual location of each individual station might also be in a highly abnormal situation and not be representative of that region. Thus it becomes impossible to determine the boundaries of the climatic regions with any degree of accuracy. Secondly, the rounded-interval values of the isolines have often times very little relation to vegetation zones.

The other approach, based on the assumption that natural vegetation is the best integrator of climatic factors, is to sort out the stations by vegetation zones and to establish the average and range of the various factors for each zone. Such an approach seems much more logical, for after all we are trying to find a relation between life-zones and the climatic data which might determine them and it is much easier, especially today with the help of aerial surveys (Hare 1959), to map accurately life zones than such an intangible thing as climate. If attention is paid to altitude and actual spot-location of the stations, a reasonable correlation should then be found between vegetation regions and climatic data if such a relation does exist.

Previous investigators have shown that for the whole Province of Quebec there is no water deficiency at any time during the year (Köppen and Geiger 1936, Sanderson 1948, Villeneuve 1946). The region presently investigated is part of Köppen's D*f* b region: cold snow-forest climate, with no dry season and with warm summer. It is a climate type of limited distribution around the world. Other areas with the same overall type of climate are: a narrow band across Scandinavia at the level of Oslo and Stockholm, the Leningrad-Moscow area in Central European Russia, the Central plateau of Turkey and the Caucasus, and a small area in the Hokkaido-Vladivostok region. According to Sanderson (1948), using Thornthwaite's system, it is part of the moist subhumid microthermal region. But it is obvious to anybody familiar with the Province of Quebec that a more detailed subdivision is possible.

It is clear from a quick comparison of Figures 5 and 6 that precipitation alone is not a limiting factor in our case. The latitudinal arrangement of the forest regions as modified by topography seems, however, to indicate a relation with temperature. So the following values were compiled: mean annual temperature, mean temperatures of the coldest and the warmest month and mean temperature of May-June-July-August (the four principal months of the growing season here). Growing season was evaluated as number of days with a mean temperature equal to or higher than 42°F

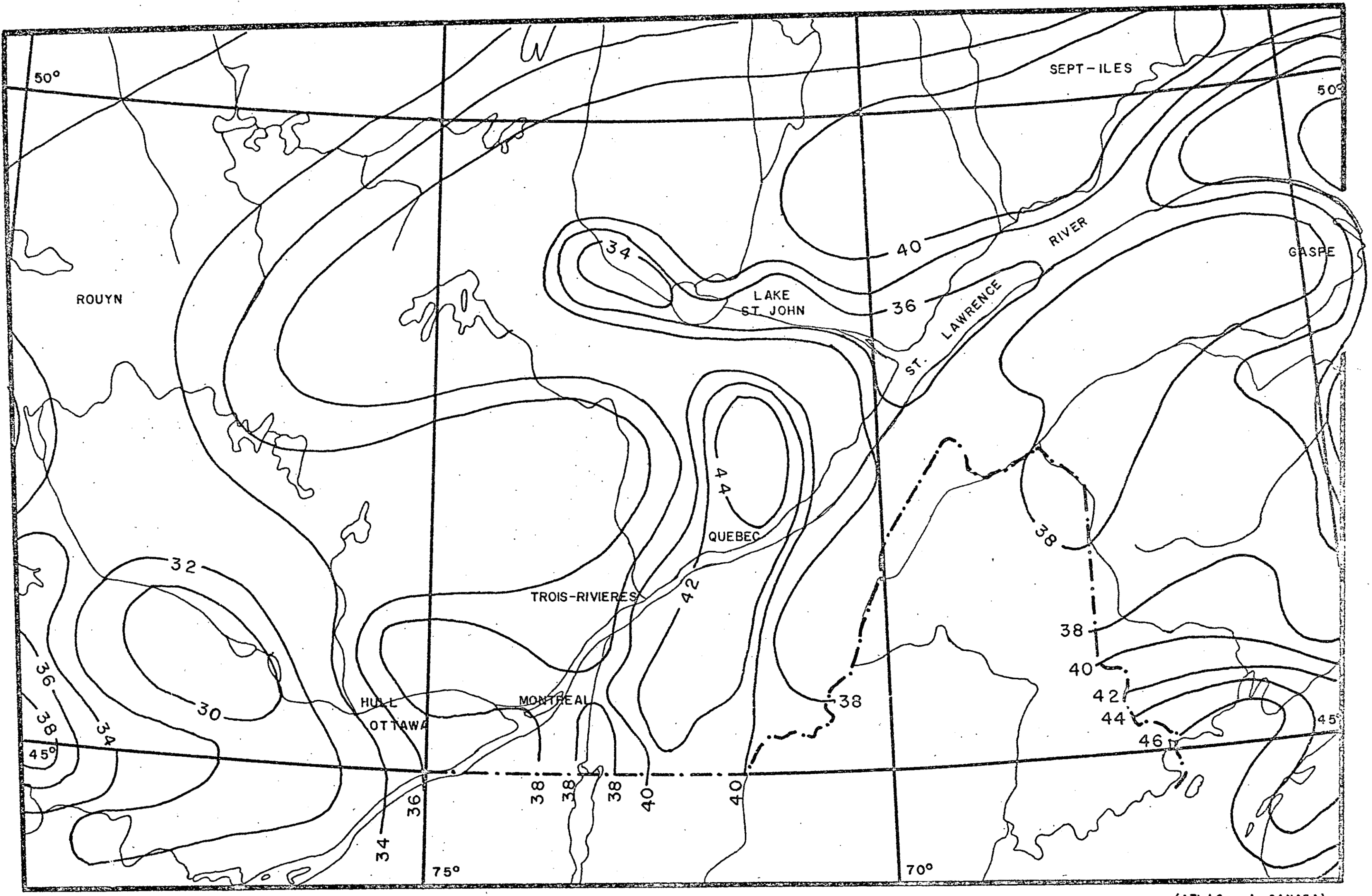


FIG. 6 ANNUAL PRECIPITATION (IN.)

(ATLAS of CANADA)

50 25 0 50 100

SCALE: ONE INCH to 78.91 MILES

as estimated from the smoothed curve of mean monthly temperatures (Boughner and Kendall 1959). Growing degree-days were also estimated from the same curves. Finally Thornthwaite's (1948) potential evapotranspiration was also calculated for each station. These data are listed for the whole Province and averaged by sections in Table 1. They were obtained from Cir. 3208 of the Department of Transport (Anon. 1959).

One cannot help but notice the remarkable uniformity of all the factors considered in each section and their definite gradation from the coldest (B-1b) to the warmest (L-2). It is also evident that some sections do not differ in climatic conditions. For instance, B-1a, B-3 and B-4 are parts of the same climatic region and their separation is strictly a matter of landtypes which cause a different distribution pattern of cover types but not a different potential productivity. This was confirmed by a summer of sampling in B-4 (Lemieux 1957) to compare growth data and forest types with those of B-1a and B-3 (Linteau 1955) (Linteau and Lemieux, to be published). Comparison of data for B-7, L-7 and L-6 brings out surprising results. The length of the growing season and potential evapotranspiration are the same in all three areas. The data for L-6, however, show a slight maritime influence: milder winter and cooler summer. The data are actually biased because all stations, except Causapscal and Matapédia, are located along the shore of the St.Lawrence River, the Gulf, or Chaleur Bay. This maritime influence during the summer would account for the lower number of growing degree-days, which is even lower than in section B-7. A more adequate network of inland stations would be necessary to characterize section L-6 properly.

Table 1 - Climatic Summaries by Forest Regions and Sections

Station	Lat.	Alt. (ft.)	M.An.T.[1/] (F°)	M.Ja.T. (F°)	M.Ju.T. (F°)	M.MJJA.T. (F°)	Growing Season (days)	Growing Degree-Days	PE (in.)
A- BOREAL FOREST REGION									
1. Section B-1b (Northern Half)									
Lake Manuan	50°38'	1625	28.6	-6.0	58.8	51.9	132	1400	15.6
Mistassini Post	50°30'	1255	29.4	-4.7	59.6	53.1	137	1600	16.4
Chibougamau	49°54'	1234	30.7	-3.2	59.9	53.8	145	1690	17.0
Av.			29.6	-4.6	59.4	52.9	138	1563	16.3
2. Section B-1a (Southern Half)									
Lake Onatchiway	49°00'	1050	32.8	-0.5	61.4	55.2	153	1833	18.2
Normandin	48°51'	450	33.4	-1.4	62.6	57.0	157	2066	18.9
Chute-aux-Galets	48°39'	500	33.3	-0.4	62.4	56.5	158	2029	18.9
Portage-des-Roches	48°18'	540	34.7	3.0	63.0	57.0	160	2138	19.2
Albanel	48°53'	417	34.8	1.4	63.8	57.8	163	2219	20.8
Av.			33.8	0.4	62.6	56.7	158	2057	19.2
3. Sections B-3 and B-4									
Amos	48°34'	1002	32.9	-1.0	62.2	56.5	155	2022	19.0
Barrage Gouin	48°23'	1325	33.4	1.8	62.3	57.3	154	1906	19.2
Parent	47°55'	1400	33.7	0.5	61.5	56.1	156	1972	19.2
Senneterre	48°25'	1030	34.0	1.2	63.4	57.4	159	2168	19.9
Val d'Or	48°06'	1000	34.1	2.6	62.4	56.8	162	2071	19.2
Rapide No. 2	47°54'	950	34.4	1.4	62.8	56.1	162	2292	19.5
Av.			33.7	1.1	62.4	56.7	158	2072	19.3

[1/] M.An.T. = mean annual temperature - M.Ja.T. = mean January temperature -
M.Ju.T. = mean July temperature - M.MJJAT. = mean temperature of May-June-July-August -
PE = potential evapotranspiration -

Table 1 - Climatic Summaries (continued)

Station	Lat.	Alt. (ft.)	M.An.T. (F°)	M.Ja.T. (F°)	M.Ju.T. (F°)	M.MJJA.T. (F°)	Growing Season (days)	Growing Degree-Days	PE (in.)
4. Section B-7 (Transition Zone)									
Rapide No. 7	47°46'	1020	36.1	4.0	63.6	57.7	168	2249	20.3
Manuan	47°54'	1171	35.1	4.5	62.5	57.0	162	2114	19.5
Rapide Blanc	47°43'	920	35.3	3.2	64.2	58.5	165	2323	19.2
B.Grand Lac Victoria	47°32'	1080	34.9	0.8	65.5	57.0	169	2209	20.1
B. Cabonga	47°18'	1225	36.1	6.4	63.2	58.0	165	2303	20.1
B. des Quinze	47°34'	870	37.3	5.8	65.6	59.9	171	2604	20.9
La Tuque	47°27'	551	36.9	4.4	65.0	59.6	172	2476	20.3
B. Mattawin	46°51'	1200	37.0	7.8	63.9	58.6	174	2330	20.7
Belleterre	47°25'	1065	35.5	2.0	62.2	56.7	168	2173	19.7
Av.			36.0	4.3	64.0	58.1	168	2310	20.0
B- GREAT LAKES - ST.LAWRENCE REGION									
1. Section L-7 (Lake St. John)									
Ile Maligne	48°35'	350	35.9	2.9	64.4	58.5	166	2311	20.1
Roberval	48°31'	590	35.4	1.2	65.3	58.9	170	2476	20.5
St-Félicien	48°48'	366	35.0	0.9	63.6	57.9	165	2250	20.1
Arvida	48°26'	375	36.7	4.2	65.2	59.3	172	2501	21.7
Bagotville	48°29'	536	36.0	2.9	63.8	58.5	167	2311	21.1
Kénogami	48°25'	485	35.9	2.1	64.8	59.1	168	2565	20.6
Chicoutimi	48°25'	180	37.0	4.6	65.6	59.1	170	2483	21.2
Chute à Murdock	48°31'	618	36.4	2.2	65.2	59.8	170	2525	19.9
Av.			36.0	2.6	64.7	58.9	168	2428	20.6

Table 1 - Climatic Summaries (continued)

Station	Lat.	Alt. (ft.)	M.An.T. (F°)	M.Ja.T. (F°)	M.Ju.T. (F°)	M.MJJA.T. (F°)	Growing Season (days)	Growing Degree-Days	PE (in.)
			2. Section L-6 (Lower St.Lawrence and Gaspé)						
Cap Chat	49°07'	87	37.3	12.1	61.7	55.2	165	1948	18.7
Gaspé	48°50'	92	37.5	11.0	64.6	56.7	167	2201	19.6
Mont-Joli	48°36'	150	37.7	10.0	63.9	57.4	169	2255	21.0
Mont-Louis	49°15'	21	38.4	12.8	63.8	56.7	167	2225	20.3
Price	48°36'	240	37.5	9.1	63.9	57.5	168	2256	20.1
Bic	48°25'	10	37.3	9.1	63.2	57.1	167	2170	19.8
Bonaventure	48°05'	64	38.5	13.0	63.9	57.0	167	2220	19.6
Causapscal	48°21'	100	35.3	5.0	63.4	57.1	160	2132	20.0
Matapédia	47°58'	53	36.9	7.0	64.1	58.0	167	2285	20.0
Port-Daniel	48°13'	225	37.6	12.0	63.0	56.2	163	2139	19.4
Baie St-Paul	47°35'	50	38.0	11.3	63.7	56.7	165	2174	21.0
La Malbaie	47°37'	50	37.8	10.4	63.6	57.9	169	2269	20.9
Av.			37.5	10.2	63.5	57.0	166	2189	20.0
			3. Section L-4 (Laurentian Plateau)						
Ste-Agathe-des-Monts	46°05'	1250	37.9	9.4	64.4	59.2	173	2476	19.6
Barrage Mercier	46°43'	740	38.5	8.8	65.3	60.2	178	2634	21.5
B. Témiscamingue	46°44'	519	39.8	10.6	66.6	60.8	178	2782	21.8
Mont-Laurier	46°34'	750	38.2	7.9	64.6	59.8	179	2598	21.3
Nominingue	46°27'	860	38.2	7.6	65.1	59.9	176	2568	21.1
Maniwaki	46°21'	559	39.5	9.8	66.7	61.8	180	2911	21.1
Notre-Dame-du-Laus	46°06'	680	39.5	10.0	66.4	61.3	180	2862	21.8
High Falls	45°31'	640	40.0	10.4	67.7	61.9	183	2984	22.2
Ville-Marie	47°20'	630	38.5	6.2	65.8	62.3	175	2714	20.3
North Bay A	46°20'	1210	37.8	10.0	64.8	59.2	173	2488	21.5
St-Tite	46°43'	465	37.9	7.0	65.5	60.3	176	2041	19.8
Ancienne Lorette	46°49'	245	39.3	10.3	66.6	61.0	173	2577	21.3
Av.			38.7	9.0	65.8	60.6	176	2686	21.1

Table 1 - Climatic Summaries (continued)

Station	Lat.	Alt. (ft.)	M.An.T. (F°)	M.Ja.T. (F°)	M.Ju.T. (F°)	M.MJJA.T. (F°)	Growing Season (days)	Growing Degree-Days	PE (in.)
4. Section L-5 (Appalachian Plateau)									
Ste-Rose-du-Dégelé	47°30'	495	37.5	8.6	64.1	58.3	172	2409	21.2
La Pocatière	47°22'	100	39.3	11.8	65.6	59.6	177	2600	20.9
Armagh	46°44'	1150	38.9	10.6	65.2	59.7	177	2610	22.3
Disraëli	45°55'	1005	38.0	10.2	64.4	58.9	175	2505	20.7
Lac Mégantic	45°36'	1314	38.8	12.0	64.5	59.1	174	2436	20.7
St-Ephrem	46°04'	1075	38.8	10.2	65.0	59.7	176	2629	20.5
Thedford-Mines	46°05'	1020	37.9	9.5	63.8	58.7	175	2409	20.3
Av.			38.4	10.4	64.6	59.1	175	2514	20.9
5. Section L-3 (St.Lawrence lowlands East)									
Huberdeau	45°59'	675	40.2	12.4	66.2	61.1	184	2812	21.7
Chalk River	46°00'	550	39.4	7.0	67.0	61.4	182	2897	21.8
St-Jérôme	45°48'	310	41.6	12.5	69.0	63.4	181	2857	22.1
Cap Rouge	46°45'	40	39.4	12.0	65.0	60.2	180	2702	21.3
Donnacona	46°40'	160	40.1	10.4	67.9	62.0	185	2967	22.5
Québec	46°48'	296	40.6	12.0	67.6	61.8	182	2924	21.3
Shawinigan Falls	46°32'	255	39.9	8.4	68.9	62.9	181	3071	21.3
Berthierville	46°02'	40	40.4	10.9	67.6	62.2	185	2985	22.2
St-Lin	45°51'	210	40.1	9.5	68.5	62.7	182	3034	22.0
Joliette	46°02'	192	40.6	10.3	69.1	63.5	184	3180	22.9
Nicolet	46°14'	74	40.9	11.2	68.4	62.8	185	3131	22.5
Trois-Rivières	46°21'	200	40.7	10.5	68.4	62.8	187	3100	22.2
Laurierville	45°18'	503	40.5	11.4	66.4	61.0	185	2819	21.9
Drummondville	45°53'	270	41.1	12.2	67.6	62.4	188	3101	22.2
Hemming Falls	45°52'	300	41.1	11.6	68.2	62.5	189	3094	22.2
Brome	45°12'	678	41.0	11.6	68.0	63.1	187	2880	21.8

Table 1 - Climatic Summaries (continued)

Station	Lat.	Alt. (ft.)	M.An.T. (F°)	M.Ja.T. (F°)	M.Ju.T. (F°)	M.MJJA.T. (F°)	Growing Season (days)	Growing Degree-Days	PE (in.)
				5. Section L-3 (continued)					
Beauceville	46°11'	557	39.5	10.7	66.0	60.1	181	2680	21.3
Lambton	45°52'	1225	39.3	12.1	65.1	60.1	181	2630	20.3
East Angus	45°30'	615	40.2	12.2	66.0	60.8	185	2832	22.0
Lennoxville	45°22'	498	41.2	13.2	66.6	61.3	185	2867	22.0
Sherbrooke	45°24'	620	42.0	14.8	67.8	62.4	187	3070	21.7
Av.			40.5	11.3	67.4	61.9	184	2935	21.9
				6. Section L-2 (Montreal area)					
Sorel	46°02'	48	40.8	9.7	69.0	63.4	190	3242	22.6
Chelsea	45°31'	329	41.2	11.5	68.8	63.4	189	3219	22.9
Renfrew	45°26'	416	41.0	10.7	67.8	62.6	187	3130	22.8
Pembroke	45°48'	410	42.3	12.4	69.0	63.9	192	3316	23.5
Ottawa	45°19'	413	41.9	12.2	69.1	63.6	190	3278	23.2
L'Assomption	45°49'	69	41.2	11.3	68.6	63.2	189	3217	21.3
St-Bruno	45°33'	200	39.5	10.0	66.4	61.3	193	3433	23.2
St-Hyacinthe	45°38'	102	43.0	14.8	69.8	64.4	190	3247	22.2
St-Laurent	45°31'	125	39.3	12.9	66.9	61.4	192	3395	23.8
Seigniory Club	49°39'	172	42.4	13.2	70.0	64.2	188	3162	22.8
Cedars	45°19'	132	41.0	14.2	66.2	61.0	195	3346	22.8
Farnham	45°17'	150	42.6	14.2	69.4	63.7	190	3107	22.5
MacDonald College	45°25'	90	41.9	14.2	67.7	62.5	196	3400	23.3
Montréal	45°27'	98	42.7	13.8	69.4	64.0	194	3421	23.8
Ste-Clotilde	45°19'	175	43.7	15.4	70.4	64.9	191	3107	23.0
St-Humbert	45°30'	102	41.9	14.2	67.9	62.7	192	3199	23.7
Av.			41.6	12.8	68.5	63.1	191	3264	23.0

Sections L-4 and L-5 are also similar with respect to climate and bedrock geology seems to be the most important differential factor.

Finally sections L-2 and L-3 seem well differentiated climatically, and both also differ from the other L sections.

PART II

ECOLOGY

INTRODUCTION

It was Tansley (1935) who recognized the relations between organisms and environment as one category of the physical systems of the universe, category which he called ecosystems.

> "They are of the most various kinds and sizes. They form one category of the multitudinous physical systems of the universe, which range from the universe as a whole down to the atom".

He also pointed out the philosophical implications of such a theory, implications which even today are not fully recognised and sometimes completely overlooked by many ecologists.

One essential property of any physical system is that it

> "shows organization, which is the inevitable result of the interactions and consequent mutual adjustment of their components. If organization of the possible elements of a system does not result, no system forms or an incipient system breaks up. There is in fact a kind of natural selection of incipient systems, and those which can attain the most stable equilibrium survive the longest. It is in this way that the dynamic equilibrium is attained. The universal tendency to the evolution of dynamic equilibria has long been recognised. Some systems develop gradually, steadily becoming more highly integrated and more delicately adjusted in equilibrium. The ecosystems are of this kind and the normal autogenic succession is a progress towards greater integration and stability. The "climax" represents the highest stage of integration and the nearest approach to perfect dynamic equilibrium that can be attained in a system developed under the given conditions and with the available components" (idem 1935).

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Tansley took a jump in the dark on this

Organization exists then both within and between the organism complex and the environment complex.

Another property of physical systems is that they exist at different levels of integration and that individual systems can be isolated inside each of these levels and consequently classified. Isolates are necessary!

> "The whole method of science is to isolate systems mentally for the purposes of study (idem)."

Actually systems we isolate mentally interlock or interact with one another or are parts of larger ones.

> "The isolation is then partly artificial, but it is the only possible way in which we can proceed (idem)".

But the isolates, though artificial to a certain extent, are not completely arbitrary. The natural systems mentioned above which have attained a more stable equilibrium are real and can be separated for study purposes, keeping in mind that they are parts of larger systems determined by different limiting factors, that they interact with neighbouring systems and that they may be in turn subdivided into smaller micro-ecosystems. In other words, arbitrariness lies only in the choice of the level at which we want to sort out ecosystems.

not arbitrary relative to defined purpose

not so

For instance, the life-zones of the world mentioned before can be considered as the primary terrestrial ecosystems, determined primarily by the great regional climatic complexes created by earth configuration and rotation. These zones can be subdivided into secondary ecosystems determined by regional climate and sometimes geological complex. A third level of subdivision is then possible where the ecosystems are determined by landform, topography, soil and microclimate. This is the practical level of interest to the forester for it results in units of reasonable size for mapping and management purposes and of relatively uniform productivity.

One thing must be kept in mind however. At all these levels, the complexity of the causative agents and their interactions preclude accurate sabdivisions of ecosystems strictly on the basis of these agents. If the ecosystem theory is correct, that is if any system really requires organisation and integration of its whole and of each of its components, and if an essential part of the functional processes of the ecosystem is biological, this means that the organised plant community must have the same areal limits as the physical part of the ecosystem and that delimitation of this community delimits the ecosystem as a whole. Such a delimitation circumscribes the area in which research on causative agents of each ecosystem can be concentrated.

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The determining, essential part then of the ecosystem is the community. In the case of natural, undisturbed ecosystems which have reached equilibrium, it is true that the boundaries of the community coincide with the primary stable parts of the physical environment such as topography and landform. However, this is not so in the case of the artificial, temporary ecosystems of secondary succession after fire or human intervention. Secondary succession is a succession of unstable ecosystems at first short-lived, then more and more stable till the original natural ecosystem is re-established. For instance, on a given landform in a single locality, depending on the intensity of the disturbance (e.g. fire) a variety of communities can become established, which form so many individual ecosystems and the limits of these ecosystems are those of the communities reflecting the degree of disturbance and not those of the stable primary components of the physical environment such as topography and landform. Present productivity is closely related to these temporary ecosystems, not to landform.

If one is interested in water yield, the essential part of the ecosystem is the basin or watershed.

not necessarily — see 65 in subarctic.

The importance of vegetation does not detract, however, from the utmost importance of classifying and mapping landforms and drainage patterns. Knowing the plant community might be sufficient to recognise and map the ecosystem on the ground, but more and more site classification and mapping of large areas is dom from aerial photographs. So we must know the relationships between each natural ecosystem and factors of the environment, such as landform, topography and drainage pattern, elements which are essential to stereoscopic interpretation of photographs. In forestry, it is also important to have a map of landtypes and landforms for the location of roads and road building materials.

Knowing the relation between natural ecosystems and landforms is also the only way to solve the problems of allogenic successions on the same landforms. The relation between the secondary community (secondary ecosystem) and the original natural community can only be established through history and their common tie to a given physical environment. This way the developmental trend of secondary communities can be established through careful study (Aichinger 1951a, 1951b).

In the present investigation, only the natural or very little disturbed ecosystems growing tolerant hardwoods in pure or mixed stands have been studied in an attempt to establish a basic framework to which can be tied later the secondary, allogenic and transitory ecosystems which presently occupy in part some of the sites.

METHOD OF STUDY

How actually identified?

In each ecosystem a study was made of the forest community and its soil profile, and of the most relevant elements of its physical environment, that is elements which can serve both as additional criteria for ground identification and as criteria for photo interpretation, and can influence choice of silvicultural treatment.

In the description of the forest community, a choice of a phytosociological method was made after due consideration was given to numerous published discussions on the subject (Curtis 1959, Whittaker 1962, Poore 1955, Becking 1957). It is obvious that once the existence of separable natural ecosystems is recognized, one cannot accept the theory of purely arbitrary segments along a gradient or a continuum. A classification of natural units is possible. That no two units are exactly alike is conceded from the start (Gleason 1939). No two individuals of a species are exactly alike either; yet we have species. The problem then remains that, admitting the existence of separable, discontinuous communities, what is the best way to describe them and on what basis should we group them into a classification? Cajander's (1926) emphasis on dominant species of the lesser vegetation has led to successful classification in the species-poor boreal forest of Europe and Eastern Canada (Linteau 1955; Ilvessalo 1929; Kujala 1945; Lafond 1956; Bellefeuille 1932). In the temperate regions of Europe, Braun-Blanquet's (1932) approach has been much more widely accepted (Tüxen 1954, 1960; Horvatt 1950, 1957; Ellenberg 1939, 1954; Etter 1947, 1953; Soo 1951, 1952; Moor 1951, 1958; Richard 1961; Lebrun et al 1949). More emphasis is given in this approach to plants of lesser abundance but of greater affinity to a community without for that matter neglecting abundance. The whole assemblage of species is taken into account, as well as the vigor and manner of distribution in the stand of each species. In this approach the manner of presentation of the results is also most important. All the individual species lists are grouped together in tables. By so doing, it is possible at first glance to see the variation between individual relevés of each community type. The characteristic species group of each community type is sorted out and allows quick reference for the classification of a new relevé.

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Species are arbitrary concepts too

Good hard

In the present investigation, Braun-Blanquet's scales of abundance-dominance and sociability have been used with slight modifications. The subdivisions of these scales are broad enough to be easy to apply and yet give a significant account of the physiognomy of a natural plant community where natural variability is inherent. The scale cannot be more precise than the nature of the thing measured. Counts of individuals, measured distances between individuals and all other pseudo-precise measurements of vegetation, especially forest vegetation, cannot add to the value of a vegetation study and are on the contrary quite misleading. In Braun-Blanquet's scale of abundance-dominance a species may be rare (r), present but covering less than 5 per cent (easy to overlook) (+), abundant and easy to find but covering less than 5 per cent of the area (1), covering 5 to 25 per cent of the area (2), 25-50 per cent (3) 50 to 75 per cent (4) or more than 75 per cent of the area (5). It must always be kept in mind that this scale is more a qualitative than a quantitative estimate.

The sociability scale admittedly is more difficult to apply or interpret and some phytosociologists shy away from it. Braun-Blanquet himself is not clear enough on this matter (1932, 1951). What constitutes an isolated individual, a tuft, a clump, a patch, a small colony or a pure population is a matter of scale and perspective. The writer has however maintained the use of this scale as it does, in his interpretation, add something to the description of the vegetation. Sociability in this study was appreciated in relation to the size of the individual plants and of a fifth-acre plot normally used in forest sampling and employed in this study.

For lesser vegetation (shrubs, herbs and mosses) sociability 1 indicates individual plants growing singly while sociability 2 indicates tufts of a few individuals. The degree of ramification of individuals must not be overlooked. Sociability 1 indicates that each "true" individual is separated from its neighbour by a distance equal to or greater than its height and sociability 2 that two or three individuals are closer than that to each other. Sociability 3, 4 and 5 for lesser vegetation and shrubs is appreciated in relation to the abundance-dominance scale and the size of the plot. If a species has an abundance-dominance, let us say, of 4, and it is well concentrated in one large colony, then sociability is given as 5. If it is distributed in three or four patches, sociability is given as 4, and if distributed in numerous small clumps all over the plot, sociability is given as 3.

The sociability scale is much more difficult to apply in the forest stratum: the observer lacks the proper perspective over the surrounding area to appreciate sociability realistically. The values 1, 2 and 3 were used, but not strictly as a sociability scale. They served more as a simple appreciation of distribution of individuals according to their regeneration habit. Sociability 1 indicates single trees, generally of seedling origin, while sociability 2 indicates clusters of stump sprouts and sociability 3 would characterise small dense poplar clones for instance.

A parallel evolution of the soil profile and the plant community being implicit in the ecosystem theory, a close correlation should exist between each natural plant association and its pedogenetic profile. The study then emphasized those properties of the profile which influence and reflect the pedogenetic processes involved: type of humus with its principal chemical properties, thickness of each horizon, variations of texture between horizons, texture, structure and compactness of parent material and its geological origin, intensity of leaching of free iron oxides, presence of seepage and depth to water table, presence of marmorisation, pseudogley or gley. The nomenclature used was that of Kubiëna (1953) and Aubert & Duchaufour (1956) adapted to our conditions by the writer.

Finally all relevant physical factors of the environment were also noted: latitude, altitude, topography, landform, exposure, percent slope, type of bedrock when exposed.

Field procedure

Sampling was distributed throughout the region as evenly as accessibility would permit. The following areas were sampled: Belleterre (11 plots), Kipawa (12 plots), the Dumoine (24 plots), Gatineau, Lièvre and Rouge (109 plots) watersheds and the foothills between Shawinigan and Quebec (18 plots) for a total of 174 plots. Figure 5 shows the location of these areas.

In every area the procedure was to first select a representative block 300 to 600 acres in size from topographic maps (scale: 1:50,000) and aerial photographs (scale: 1:15,840). The main criterion for the choice of a particular block, besides its accessibility, was the degree to which it was representative of the range of habitats of the area. The various cover types were delineated on the photos then further stratified by physiographic sites: combinations of landform, exposure and degree of a slope as they affect drainage and microclimate. Such a stratification was far easier on spring or fall photographs with no leaves on the trees. Transects were then planned to cut through all variations possible. Each tentative ecosystem thus sorted was then checked on the ground for homogeneity. Adjustments in the photo demarcations were made when necessary and a fifth-acre plot established in each homogeneous ecosystem (uniform physiographic site and uniform plant community). Once each block had been thoroughly studied, a check sampling was carried out in adjacent areas to see whether any new combinations might be found.

Each plot was first located as to latitude, longitude, altitude, exposure, degree of slope, position on slope, landform and bedrock type.

A soil pit, three to four feet deep (average maximum depth of C horizon), was dug out and a description of the profile made. Type of humus and color and structure of the various horizons were noted as well as depth of rooting of trees and lesser vegetation. Drainage was evaluated from profile characteristics such as stoniness, texture, compaction, mottling and presence of visible water. Each horizon was sampled for later laboratory analysis. A composite humus sample was also collected from four or five stations within the plot. On most sites, the humus was quite thin and very difficult to sample. The surface leaves were scraped away, then the humus sample collected also by scraping with a knife.

As complete a list as possible of all plant species present, including trees, was made and the abundance-dominance and sociability of each assessed.

Photographs were taken of stands and soil profiles of representative individuals of each typical ecosystem.

Laboratory procedure

a. The vegetation relevés were sorted out into tables and associations, subassociations and variants defined.

b. The following chemical properties of the humus samples were determined: pH, percent organic matter, percent total nitrogen, C/N ratio, cation exchange capacity, exchangeable calcium and percent base saturation.

c. For the mineral horizons, texture, humus and free iron oxide content were determined and the iron-leaching index (indice d'entraînement du fer) calculated.

Methods used in the chemical analyses were those recommended by Amiot and Bernier (1962), except in the determination of free iron oxide where Asami and Kumada's (1959) method was followed.

Particle-size analysis of mineral horizons was done by the hydrometer method (Bouyoucos 1934, 1953). Sodium hexametaphosphate was used as dispersing agent and a reciprocating shaker invented by the writer replaced the standard mixer (Lemieux, in press). Godd dispersion was assured this way without any attrition of soil particles visible even under the microscope. Once the hydrometer readings had been taken, the sandy portion of each sample was retained and washed in a No. 270 sieve then oven-dried. The sand fractions were then separated by dry sieving and the total weight of sand checked against the hydrometer reading.

RESULTS

As stated earlier, the ecosystem is delimited by its biotic community, that is the limits of both coincide. In order then to separate the different ecosystem types, the vegetation relevés or floristic lists were sorted out in tables following the methods of the Zürich-Montpellier school and community types were determined.

Broad groupings related to variations in cover type were evident from the start. One group consisted of mixedwood stands with yellow birch (*Betula lutea* Michx.) while another showed a dominance of black ash (*Fraxinus nigra* Marsh.). The most important group however showed strong dominance of sugar maple (*Acer saccharum* Marsh.). The second most important tree associate in each stand was then used to subdivide these groups. Such a reliance on tree species was justified in the present case where only undisturbed (or very slightly disturbed) stands were sampled and where abundance of regeneration of these same tree species was also considered.

The validity of these first subdivisions was corroborated by a look at the lesser vegetation. Each community separated had its group of indicator species. Some indicator species also made possible a third subdivision.

One thing however was obvious from a comparison of the 174 relevés at the very beginning. That is that the concept of fidelity and exclusiveness would be of little use if adhered to strictly in the separation of associations. The flora of the region as a whole was found to be much poorer than expected and reliance on relative abundance of certain species and ecological indicator value of others such as hydrophytes and eutrophytes was necessary. Besides in view of our present limited phytosociological knowledge of North American vegetation, it was deemed premature to categorise certain species as "characteristics" and "differentials" of given communities in the sense of the Zürich-Montpellier school (Becking 1962). In fact, the scarcity of exclusive species at the level of the association and sub-association is being recognized more and more by phytosociologists (Becking 1957; Richard 1961). The boxed-in species groups in the accompanying tables are to be looked upon as strictly groups of indicator species, not as "characteristics" or "differentials".

On the basis of these indicator groups of trees and lesser vegetation, eight associations were recognized. Some of these were further subdivided into sub-associations and one variant to end up with fifteen ecosystem types as listed in Table 2.

I. Ecosystems dominated by sugar maple

By far the strongest competitor and most abundant species on all sites except the cold or wet is sugar maple (*Acer saccharum* Marsh.) It dominates the upper canopy and its regeneration is most bountiful. The abundance of sugar maple seedlings is a major hindrance to regeneration of all other species except that of beech (*Fagus grandifolia* Ehr.) which holds its own against maple wherever it is present. Five major associations can be recognized in this maize of maple dominated stands. The name of the second most important tree species is used as a prefix to designate the association. These five associations are:

a. *Betulo-Aceretum sacchari* (*B-As*): sugar maple with yellow birch.
b. *Fago-Aceretum sacchari* (*F-As*): sugar maple with beech.
c. *Ostryo-Aceretum sacchari* (*O-As*): sugar maple with ironwood (*Ostrya virginiana* (Mill.) K. Koch.)
d. *Tilio-Aceretum sacchari* (*T-As*): sugar maple with basswood (*Tilia americana* L.)
e. *Ulmo-Aceretum sacchari* (*U-As*): sugar maple with American elm (*Ulmus americana* L.)

It will be noted that the prefix is *Betulo-*, *Fago-*, etc. and not *Betuleto-*, *Fageto*, etc. As pointed out by Richard (1961, p. 12),

Table 2 - Ecosystem types

I Betulo-Aceretum sacchari (B-As): Yellow Birch - Sugar Maple

- a. taxetosum: with Canada yew.
- b. fagetosum: with beech.
- c. fagetosum var. humid: with beech, humid variant.
- d. tiarelletosum: with false mitterwort.

II Fago-Aceretum sacchari (F-As): Beech - Sugar Maple

- a. oxaletosum: with wood sorrel.
- b. tilietosum: with basswood.
- c. polystichetosum: with Christmas fern.

III Ostryo-Aceretum sacchari (O-As): Ironwood - Sugar Maple.

IV Tilio-Aceretum sacchari (T-As): Basswood - Sugar Maple.

- a. typicum: typical.
- b. juglantetosum: with butternut.

V Ulmo-Aceretum sacchari (U-As): Elm - Sugar Maple.

VI Abieti-Betuletum lutese (A-Bl): Balsam Fir - Yellow Birch.

- a. typicum: typical.
- b. tsugetosum: with hemlock.

VII Ulmo-fraxinetum nigrae (U-Fn): Elm - Black Ash.

VIII Betulo-fraxinetum nigrae (B-Fn): Yellow Birch - Black Ash.

the rules of nomenclature specify that the suffix -*etum* be added only to the name of the genus representative of the association while the differential genus name needs only an euphonic connective vowel which is "o" for names of the first and second latin declension and "i" for names of the third declension. From the point of view of latin correction this makes sense. The suffix -*etum* added to the genus name of a tree species indicates a stand of this species: *Aceretum* = stand of sugar maple. The differential genus name which precedes it is used in the dative case (-*ae* of the first declension being replaced by -*o* for euphonic reasons) to qualify further the type of stand. For instance, *Fago*-*Aceretum* *sacchari* means a sugar maple stand with beech (in French: une érablaie *à hêtre*). *Fageto*-*Aceretum* *sacchari* would mean a sugar maple stand with a beech stand (in French: une érablaie *à hêtraie*) which is meaningless.

a. The Yellow Birch-Sugar Maple association:

Betulo-*Aceretum* *sacchari* (*B*-*As*) (Table 3)

Vegetation:

The stand of this association is dominated by sugar maple (*Acer* *saccharum* Marsh.) and yellow birch (*Betula* *lutea* Michx.) (Fig. 7). Balsam fir (*Abies* *balsamea* (L.) Mill.) and white spruce (*Picea* *glauca* (Moench.) Voss) are generally present in the understory, but few trees ever seem to reach the upper canopy. Some typical species of the maple forest in general are present in the lesser vegetation such as *Trillium* *erectum* L., *Smilacina* *racemosa* (L.) Desf., *Polygonatum* *pubescens* (Willd.) Pursh. and in the spring *Erythronium* *americanum* Ker. But they are not abundant. Many species common to the boreal forest still dominate the lesser vegetation. *Lycopodium* *lucidulum* Michx., *Dryopteris* *spinulosa*

Table 3 - The Betulo-Aceretum sacchari association table

ASSOCIATION		BETULO-ACERETUM SACCHARI																											
Sub-association		TAXETOSUM					FAGETOSUM						FAGETOSUM Var.humid							TIARELLETOSUM									
No. of Releve		4001	4002	4007	4008	4009	4043	4037	4032	4026	4029	4030	4040	4041	4044	4038	4035	4033	4031	3002	3000	3008	3016	3007	3033	3046	3044	3076	3074
Altitude (ft)		1200	1150	1190	1160	1100	1300	1275	1250	1100	1050	1000	1335	1300	1275	1250	1250	1225	1025	1600	1300	1150	1100	1150	1000	900	900	1100	700
Aspect		-	SSW	SE	N	W	E	E	ENE	ENE	S	E	-	E	N	-	SW	E	E	NW	NW	W	W	W	N	N	N	S	N
Slope (%)		-	5	15	25	10	8	10	15	15	10	20	-	5	2	-	-	15	-	35	20	5	5	10	5	15	15	5	5
Soil Type		P	P	P	P	P	P	P	P	P	P	P	Pm	Pm	Pm	Pm	Pm	Pm	Pm	Ba	Ba	Ba	Ba	Ba	Ba	Ba	Ba	Ba	Ba
Humus Type		Md	Md	Md	Md	Md	Md	Md	Md	Md	Md	Md	Md	Md	Md	Md	Md	Md	Md	MuMd	MuMd	MuMd	MuMd	MuMd	Md	Md	Md	Md	MuMd
% Cover:																													
Tree layer		90	90	100	60	90	100	80	60	60	80	75	100	90	60	80	50	60	50	30	70	70	80	80	80	90	90	90	90
Shrub layer		90	90	100	100	80	90	80	100	80	80	90	100	10	75	90	90	90	40	80	100	90	60	80	70	10	90	25	80
Herb layer		40	80	5	5	10	5	5	5	60	20	1	5	5	90	80	90	80	40	40	90	90	80	10	20	60	10	20	75
1 TREE LAYER:																													
Acer saccharum	T	5.1	3.1	5.1	2.1	3.1	4.1	3.1	4.1	3.1	4.1	3.1	3.1	2.1	1.1	3.1	+.1	2.1	2.1	+.1	-	3.1	2.1	3.1	3.1	4.1	3.1	3.1	5.1
	r	4.1	3.1	5.5	1.1	4.4	3.2	2.1	4.1	2.1	3.1	3.1	1.1	2.1	+.1	2.1	4.3	4.1	3.1	3.2	4.4	3.3	3.1	3.4	4.3	3.1	3.3	3.1	5.1
Betula lutea	T	2.1	3.1	+.1	2.1	3.1	3.1	2.1	2.1	3.1	3.1	3.1	4.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	+.1	3.1	3.1	2.1	+.1	4.1	3.1	2.1
	r	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	-	+.2	1.1	+.1	+.1	+.1	+.1	+.1	+.1	-	-	+.1	+.1	1.1	+.1	-	-	-	-
Abies balsamea	T	+.1	-	-	-	-	-	+.1	-	-	+.1	-	+.1	-	2.1	+.1	-	+.1	+.1	1.1	1.1	-	+.1	-	1.1	-	-	-	-
	r	+.1	+.1	+.1	-	-	+.1	+.1	+.1	1.1	1.1	1.1	+.1	+.1	1.1	+.1	+.1	+.1	1.1	-	-	+.1	+.1	+.1	-	-	+.1	+.1	-
Picea glauca	T	-	+.1	-	-	-	-	+.1	-	-	-	-	+.1	-	2.1	-	-	+.1	-	-	-	-	-	-	-	-	-	-	-
	r	-	+.1	-	-	1.1	-	+.1	+.1	+.1	+.1	1.1	+.1	-	+.1	+.1	+.1	+.1	+.1	-	-	-	+.1	-	+.1	-	-	-	-
Acer rubrum	T	1.1	+.1	-	-	+.1	-	+.1	-	-	-	-	1.1	+.1	+.1	-	-	+.1	-										
	r	+.1	-	-	-	+.1	+.1	+.1	-	-	-	+.1	1.1	+.1	+.1	+.1	-	+.1	-										
Fagus grandifolia	T						1.1	1.1	-	+.1	+.1	1.1	3.1	1.1	-	1.1	-	-	-										
	r						+.1	+.1	-	+.1	+.1	3.2	2.1	2.1	+.1	+.1	-	-	-										
Fraxinus nigra	T												-	-	-	-	+.1	-	-	+.1	1.1	+.1	2.1	1.1	1.1	+.1	+.1	-	-
	r												-	-	-	-	-	-	+.1	-	-	+.1	1.1	1.1	-	+.1	-	-	-
Ulmus americana	T												-	-	-	-	-	-	-	-	+.1	+.1	1.1	2.1	1.1	+.1	-	-	-
	r												-	-	-	-	-	-	+.1	+.1	-	+.1	+.1	1.1	-	+.1	-	-	-
Tilia americana	T																			-	-	-	-	-	2.1	+.1	+.1	-	-
	r																			-	-	-	-	-	+.1	-	-	-	+.1
11 SHRUB LAYER:																													
Taxus canadensis		1.3	+.1	1.1	5.5	1.2							+.1	+.1	-	-	-	-	-										
Viburnum alnifolium							3.2	4.4	1.2	3.3	2.3	2.2	4.3	3.3	1.2	3.3	+.1	3.2	2.2	-	-	1.1	+.1	3.4	2.3	2.2	1.1	+.1	1.2
Acer pensylvanicum		-	-	+.1	+.1	1.2	+.1	1.1	1.1	-	1.1	1.1	1.1	1.1	1.1	+.1	-	-	-										
Corylus cornuta		+.1	2.2	+.1	+.1	+.2	+.1	+.1	2.3	1.1	1.2	1.1	+.1	-	+.1	2.2	+.1	2.2	+.1	-	1.1	-	-	1.2	2.3	-	2.1	+.1	+.1
Acer spicatum		+.2	+.1	-	4.5	1.2	-	-	-	+.1	+.1	+.1	-	+.1	+.1	+.1	+.1	+.1	+.1	1.2	-	+.1	3.1	+.1	-	-	1.1	-	-
Lonicera canadensis		+.1	+.1	-	+.1	-	+.1	+.1	+.1	+.1	+.1	+.1	-	+.1	+.2	+.1	+.1	1.1	+.1	-	-	-	-	-	+.1	-	-	+.1	1.2
Sambucus pubens		+.1	+.1	+.1	-	-							-	-	-	-	+.1	-	-	-	+.1	+.1	+.1	-	-	+.1	+.1	-	-
Prunus virginiana		-	-	4.3	-	-							-	-	-	-	-	-	+.1	-	+.1	1.2	+.2	+.1	+.1	-	+.1	+.1	-
Viburnum cassinoides													-	+.1	+.1	-	+.2	-	-										
111 HERB LAYER:																													
Lycopodium lucidulum		+.2	+.1	1.3	2.3	2.3	2.3	2.3	3.3	2.3	+.2	-	+.1	1.3	+.2	2.3	2.4	3.3	1.1	-	+.2	+.2	+.2	1.2	+.1	+.1	-	1.3	-
Trillium erectum		-	-	-	-	+.1	+.1	+.1	+.1	+.1	-	-	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	1.1	-	+.1	+.1	+.1	+.1	+.1	+.1	+.1
Smilacina racemosa		+.1	+.1	-	+.1	+.1	+.1	+.1	+.1	+.1	+.1	-	-	-	-	-	-	-	-	-	-	+.1	-	+.1	+.1	-	-	-	-
Polygonatum pubescens		-	+.1	+.1	+.1	1.2	+.1	-	+.1	+.1	+.1	-	-	-	-	+.1	+.1	+.1	+.1	-	+.1	+.1	+.1	+.1	-	-	+.1	-	+.1
Mitchella repens							-	-	1.1	+.1	+.1	+.1	-	+.1	-	-	-	-	+.1										
Medeola virginiana							-	+.1	+.1	+.1	+.1	-	+.1	+.1	-	-	+.1	+.1	+.1										
Dryopteris noveboracensis							1.2	+.2	1.2	-	-	-	-	-	+.1	2.2	+.2	+.1	-										
Tiarella cordifolia																				1.2	2.2	1.2	1.2	1.2	1.1	1.1	+.1	1.1	1.1
Arisaema atrorubens																				+.2	1.1	+.1	+.1	+.1	1.2	+.1	-	-	+.1
Adiantum pedatum																				-	-	1.2	-	-	-	1.3	-	-	1.3
Dentaria diphylla																				-	-	1.2	+.2	+.1	+.1	-	-	-	-
Osmorhiza Claytoni																				-	-	+.1	-	+.1	-	+.1	+.1	-	+.1
Thalictrum polygamum																				+.1	+.1	-	+.1	-	-	-	-	-	-
Ribes sp.																				+.1	+.1	+.1	+.1	+.1	-	+.1	+.1	+.1	-
Carex intumescens																				-	+.2	+.2	+.1	+.1	-	+.1	-	+.1	-
Athyrium thelypteroides																				+.1	-	-	+.1	+.1	-	+.1	-	-	1.2
Cinna latifolia																				-	+.1	+.1	+.1	+.2	-	+.1	+.1	1.1	1.1
Rubus pubescens													-	-	+.1	+.1	+.1	1.2	1.2	+.1	1.1	+.2	+.1	+.1	+.1	+.1	1.2	+.1	-
Dryopteris disjuncta													-	-	-	-	-	+.1	1.1	+.1	+.1	-	+.2	-	+.1	+.1	+.1	-	+.1
Dryopteris phegopteris													-	-	+.1	-	+.2	+.1	1.1	+.2	1.1	-	+.1	-	-	+.1	+.1	-	-
Athyrium Filix-femina													-	-	+.1	-	+.1	1.1	+.1	+.1	1.1	+.2	+.1	+.1	-	+.1	1.1	-	1.2
Osmunda cinnamomea													-	-	+.2	+.1	+.1	-	-										
Coptis groenlandica													-	-	1.1	-	-	+.1	-										
Trientalis borealis		-	-	-	+.1	-	-	+.1	-	-	+.1	+.1	+.1	-	+.1	-	+.1	+.1	+.1	+.1	-	-	-	-	-	-	-	-	-
Pyrola elliptica		-	+.1	-	-	-	-	-	+.1	-	-	-	-	-	-	-	-	-	+.1										
Aralia nudicaulis		+.1	+.1	-	-	+.1	-	+.1	+.1	+.1	1.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1										
Lycopodium obscurum		1.1	+.1	+.1	+.1	+.1	-	+.1	+.1	+.1	1.1	-	-	-	+.1	+.1	+.1	+.1	+.1										
Trillium undulatum		1.1	+.1	-	-	+.1	-	+.1	-	-	-	-	+.1	-	+.1	-	-	-	-										
Maianthemum canadense		1.1	+.1	-	+.1	+.1	+.1	+.1	-	+.1	+.1	+.1	1.1	+.1	+.1	+.1	+.1	+.1	+.1										
Dryopteris spinulosa		+.1	3.3	1.1	1.2	1.1	1.2	+.1	2.1	-	+.1	+.1	+.1	+.1	+.1	1.1	3.3	2.1	+.1	+.2	1.2	1.2	1.2	1.2	1.1	+.1	1.1	1.1	1.1
Galium triflorum		-	+.1	+.1	-	-	-	-	+.1	+.1	-	-	-	-	+.1	-	+.1	+.2	+.1	+.1	+.1	+.1	-	-	+.1	-	-	+.1	+.1
Oxalis montana		-	1.2	-	1.2	-	-	-	-	+.1	+.1	-	+.1	+.1	2.3	-	3.3	3.3	+.1	-	1.2	-	+.1	-	-	+.1	+.1	-	-
Monotropa uniflora		-	-	-	-	-	+.1	-	+.1	+.1	-	-	+.2	+.1	+.1	-	-	-	-	-	r	-	-	-	-	-	+.1	+.1	-
Streptopus roseus		+.1	+.1	-	+.1	+.1	+.1	+.1	+.1	+.1	-	-	+.1	+.1	+.1	+.1	-	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1
Viola incognita		-	1.1	+.1	+.1	-	+.1	+.1	+.1	+.1	-	-	-	-	-	+.1	2.3	2.2	1.2	+.2	+.2	+.2	+.2	+.2	+.2	-	+.2	+.2	-
Clintonia borealis		1.1	1.1	-	+.1	+.1	-	-	+.1	+.1	-	-	+.1	+.1	1.1	+.1	1.1	+.1	+.1	-	+.1	-	+.1	-	+.1	-	-	-	+.1

ADDITIONAL SPECIES:

Actaea pachypoda: 4001 (+.1). Monotropa Hypopithys: 4026 (+.1). Oryzopsis asperifolia: 4037 (+.2). Prenanthes altissima: 4032 (+.1). 3002, 3008, 3076 (+.1). Pinus strobus-r: 4026, 4029 (+.1). Quercus rubra-r: 4029 (+.1). Picea rubens: 3000, 3002, 3076 (+.1). Thuja occidentalis: 3002 (+.1), 4002 (1.1). Prunus serotina: 3076 (+.1) (+.1).

VERNAL ASPECT (Av. values):

Erythronium americanum: AD (1-3), Soc. (2-3). Dicentra Cucullaria (in BAs ti) AD (1-2), Soc. (1-2).

Figure 7 - Stand of Betulo-Aceretum sacchari fagetosum

(O.F. Muell.) Watt., *Streptopus roseus* Michx. and *Clintonia borealis* (Ait.) Raf. are among the most common.

This association can first be subdivided into two broad groups. The first group includes all stands where red maple (*Acer rubrum* L.) is a common associate along with species of the lesser vegetation such as *Trientalis borealis* Raf., *Aralia nudicaulis* L., *Maianthemum canadense* Desf., *Trillium undulatum* Willd. and *Lycopodium obscurum* L.

In the second group the tree associates are black ash (*Fraxinus nigra* Marsh.) and American elm (*Ulmus americana* L.) while in the lesser vegetation is found a host of moisture-loving eutrophic species: *Tiarella cordifolia* L., *Arisaema atrorubens* (Ait.) Blume, *Adiantum pedatum* L., *Dentaria diphylla* Michx., *Osmorhiza Claytoni* (Michx.) C.B. Clarke, *Carex intumescens* Rudge, *Athyrium thelypterioides* (Michx.) Desv. and *Cinna latifolia* (Trev.) Griseb. The latter group is homogeneous and forms the *B-As tiarelletosum* sub-association.

The first group however can be subdivided further into two communities: one without beech (*Fagus grandifolia* Ehrh.) nor *Viburnum alnifolium* Marsh. and with a ground cover of *Taxus canadensis* March., the *B-As taxetosum* sub-association, and the other with beech, *Viburnum alnifolium*, *Mitchella repens* L., *Medeola virginiana* L. and *Dryopteris noveboracensis* (L.) Gray, the *B-As fagetosum* sub-association.

A humid variant of the latter is also recognizable by the presence of *Viburnum cassinoides* L., *Osmunda cinnamomea* L., *Rubus pubescens* Raf., *Dryopteris phegopteris* (L.) Christens. and *Athyrium Filix-femina* (L.) Roth. (See Table 3)

Habitat and Soil:

The first breakdown of this association into two groups corresponds to a major separation of habitats.

Both the *taxetosum* and *fagetosum* sub-associations occupy well-drained, fresh knoll tops and medium slopes of any orientation but at different latitudes, the *taxetosum* sub-association at the border of Halliday's B-7 and L-4 regions (in the Belleterre area), the *fagetosum* sub-association to the south about half way down the Dumoine River.

The parent material in both cases is a stony till of sand to sandy loam texture at least 25 inches thick over bedrock. Rooting depth remains within this limit even if loose soil is deeper.

The soil profile developed under both associations on these sites is a podzolic soil (P)[1] (sol podzolique of Duchaufour, minimal podzol of NSSC) (Fig. 8). This is the most common type of soil profile found on the well-drained fresh sites under hardwoods throughout the region investigated. The intensity of podzolisation varies from one association to the other but is always much weaker than in a typical podzol. All horizons are weakly developed and thin. This seems due mainly to the type of humus found under the hardwoods which is quite different from the mor developed under softwoods. This type of humus is intermediate between the true mor and the mull and Kubiëna (1953) calls it a moder (Md)[1]. The "H" layer of this type of humus is in reality more an "A"$_1$. It is black and consists strictly of a mechanical mixing of mineral and organic particles. There is no clay-organic matter complex as in the true mull. The mixing is mostly the work of insects and other

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[1] = Abbreviations used in the association tables.

Figure 8 - Well-drained podzolic soil.

Figure 9 - Marmorised podzolic soil
on compact basal till.

arthropods; there is no earthworm activity. The lesser intensity of podzolization is indicated in part by the "iron-leaching index", that is the ratio between free iron oxide in the B and the A_2 horizons. This index is about 5 to 10 in podzolic soils while it varies from 10 to 20 but can go up to 90 in true podzols. The "$A"_1$ layer is always thin, varying from traces to 1 inch. The "$A"_2$ horizon is a uniform gray to salt-and-pepper and varies in thickness from ½ to 3 inches, exceptionally 4 inches. The "B_1" horizon is either absent or very thin (½ in.) while it is often impossible to separate on a color basis a "B_2" from a "B_3". In any case, the "C" horizon starts between 10 and 20 inches from the surface. On weak slopes and flats over a fragipan or compact basal till, a slight mottling (marmorization) indicates periodically moist conditions but the profile as a whole contains all the typical podzolic horizons (Pm) (Fig. 9). These sites support the humid variant of the B-As fagetosum sub-association.

The second major subdivision of the Betulo-Aceretum sacchari association contains only one type, the B-As tiarelletosum sub-association. This type is restricted to the flat to almost flat foot of slopes of the Gatineau-Lièvre trough and the Mont-Tremblant area. The parent material is a deep loam of alluvial origin with abundant telluric moisture. The profile developed in these moist conditions is an acid brown soil (Ba) with a humus of the moder (Md) or mull-like moder type (MuMd). The "A_2" horizon is absent and the "B" horizon is brown throughout and impossible to subdivide on the basis of color variation alone.

To summarise, the ecosystem characterized by the sub-association B-As tiarelletosum is in a class by itself with better moisture conditions and a richer humus as can be noted in Table 4.

Table 4 - Some soil characteristics of each ecosystem type

Ecosystem type	No. of samples	Soil profile type	Humus type	pH of humus	Loss on ignition of humus	C/N ratio of humus	% base saturation of humus	Exch. calcium in humus (me/100gs.)
A-Bl typ.	7	Podzol	Mor	3.8	74.6	23	17.9	15.8
A-Bl tsug.	5	Podzol	Mor	4.4	62.6	22	32.7	37.9
B-As tax.	5	Podzolic	Moder	4.3	41.4	18	19.7	10.6
B-As fag.	11	Podzolic	Moder	4.1	59.4	22	25.2	16.9
F-As ox.	5	Podzolic	Moder	3.9	47.5	22	21.0	9.7
O-As	8	Podzolic	Moder	4.4	43.0	18	33.2	26.3
F-As til.	4	Brown podzolic	Moder	5.0	54.0	18	46.2	37.3
F-As pol.	5	Acid brown	Mull-Moder	5.1	31.3	18	36.2	26.5
B-As tiar.	7	Acid brown	Mull-Moder	5.2	40.3	19	47.0	30.0
T-As typ.	8	Brown forest	Mull	5.5	36.7	20	54.2	33.2
T-As jug.	4	Brown forest	Mull	5.9	32.2	18	63.3	50.0
U-As	8	Brown gley	Mull	5.6	28.6	17	64.1	45.3
U-Fn	3	Hydromorphic	Calcic hydromor	6.0	72.5	19	77.6	124.8
B-Fn	4	Gley	Hydromor	4.3	70.6	24	36.0	44.0

b. The Beech-Sugar Maple association:

Fago-Aceretum sacchari (F-As) (Table 5)

Vegetation:

The stand of this association is dominated by sugar maple but the second most important species is beech (Fagus grandifolia Ehrh.) (Fig. 10). Yellow birch however is still an important component. In the lesser vegetation, characteristic species of the sugar maple forest are more abundant than in the preceding association. They are Trillium erectum L., Smilacina racemosa (L.) Desf., Polygonatum pubescens (Willd.) Pursh. and in the spring Erythronium americanum Ker., Claytonia caroliniana Michx., Dicentra Cucullaria (L.) Bernh. and Dicentra canadensis (Goldie) Walp. There is still however a great abundance of boreal species such as Lycopodium lucidulum Michx., Streptopus roseus Michx. and Dryopteris spinulosa (O.F. Muell.) Watt. This is particularly true in the case of the sub-association F-As oxaletosum where Oxalis montana Raf., Clintonia borealis (Ait.) Raf., Acer spicatum Lam. and balsam fir are also common. Red spruce (Picea rubens Sarg.) is also a common associate in this sub-association. In the F-As tilietosum sub-association basswood (Tilia americana L.) though not very abundant becomes a regular component of the stand, and acidophilous species such as Acer spicatum Lam. and Oxalis montana Raf. disappear. In the F-As polystichetosum, the most important and unmistakable difference is the presence of Christmas fern (Polystichum acrostichoides (Michx.) Schott) and occasionally of Polystichum Braunii (Spenner) Fée var. Purshii Fern.

Habitat and Soil:

Both sub-associations oxaletosum and tilietosum again constitute geographic equivalents. Both occur in the southern half of L-4 and occupy

Table 5 - The Fago-Aceretum sacchari association table

ASSOCIATION		FAGO-ACERETUM SACCHARI																										
Sub-association		OXALETOSUM													TILIETOSUM							POLYSTICHETOSUM						
No. of Releve		3028	3026	3011	3010	3005	3001	3009	3019	4050	4051	4052	4055	4077	3040	3041	3042	3082	3088	3025	3087	3047	3048	3049	3092	4047	4048	4053
Altitude (ft)		1300	1150	1800	1450	2000	1600	1450	1450	1250	1200	1200	900	1200	900	1000	1000	900	950	1000	900	1050	?	850	1100	1100	1250	700
Aspect		E	SE	N	SW	W	NW	SW	SW	E	E	NE	E	W	NW	NW	E	NE	NW	SSW	NW	E	N	E	SE	E	E	E
Slope (%)		40	15	-	15	10	10	15	30	25	25	30	25	30	25	5	5	15	15	10	5	25	20	25	25	45	50	50
Soil Type		BP	BP	Pm	Pf	Baf	Baf	Pf	Pf	Pm	Pm	Pm	Pm	P	BP	BP	BP	BP	BPm	P	BPm	Bam	Bam	Bam	Ba	Ba	Ba	Ba
Humus Type		Md	Md	Md	Md	MuMd	MuMd	Md	Md	Md	Md	Md	Md	Md	Md	Md	Md	Md	Md	Md	Md	MuMd	MuMd	MuMd	MuMd	MuMd	MuMd	MuMd
% Cover:																												
Tree layer		80	90	70	90	80	80	80	90	90	80	80	90	70	100	100	100	100	90	90	90	100	80	90	100	90	100	90
Shrub layer		90	80	100	60	60	80	80	90	100	60	25	20	10	90	80	75	80	90	60	75	30	80	60	5	40	20	100
Herb layer		10	70	70	40	50	50	10	10	60	80	80	80	50	5	5	5	1	5	10	5	20	25	5	5	50	10	10
1 TREE LAYER:																												
Acer saccharum	T	4.1	4.1	3.1	4.1	4.1	4.1	3.1	2.1	3.1	4.1	4.1	4.1	3.1	2.1	4.1	5.1	3.1	3.1	5.1	4.1	5.1	4.1	3.1	4.1	2.1	3.1	4.1
	r	3.2	4.1	4.4	4.2	4.4	5.5	3.3	4.4	4.3	2.1	3.1	1.1	1.1	3.1	5.5	4.4	2.1	4.1	4.4	4.1	5.3	3.3	3.4	3.1	1.1	4.4	5.5
Fagus grandifolia	T	1.1	1.1	3.1	3.1	2.1	1.1	2.1	+.1	+.1	2.1	2.1	3.1	1.1	3.1	2.1	1.1	3.1	4.1	+.1	+.1	2.1	2.1	3.1	2.1	2.1	+.1	3.1
	r	+.1	+.1	2.3	+.1	+.1	+.1	1.1	+.1	+.1	1.1	+.1	+.1	5.5	1.1	1.1	+.1	2.1	+.1	-	+.1	+.1	1.1	+.1	+.1	1.1	+.1	+.1
Betula lutea	T	-	2.1	+.1	1.1	+.1	+.1	2.1	3.1	3.1	2.1	3.1	2.1	1.1	1.3	-	+.1	2.1	+.1	+.1	2.1	+.1	+.1	3.1	+.1	3.1	2.1	+.1
	r	+.1	-	+.1	+.1	-	-	+.1	+.1	+.1	1.2	2.1	+.1	+.1	-	-	-	-	-	-	+.1	+.1	-	-	-	+.1	+.1	+.1
Abies balsamea	T	-	-	-	-	+.1	-	+.1	+.1	-	+.1	-	-	+.1								-	-	-	-	-	-	-
	r	+.1	+.1	-	+.1	-	-	-	-	+.1	+.1	-	-	-								-	+.1	+.1	-	+.1	-	-
Picea rubens	T	-	-	+.1	-	+.1	-	-	-	-	-	-	-	1.1								-	-	-	-	-	-	-
	r	-	-	+.1	+.1	-	+.1	+.1	+.1	-	+.1	-	-	-								-	-	-	-	1.1	+.1	-
Tilia americana	T														-	+.1	+.1	+.1	1.1	-	-	+.1	+.1	2.1	-	-	-	-
	r														+.1	1.1	+.1	+.1	+.1	1.1	+.1	+.1	-	+.1	-	-	-	-
Tsuga canadensis	T														3.3	-	+.1	-	2.1	-	-	-	+.1	-	-	-	-	-
	r														+.1	-	-	-	-	-	-	-	+.1	+.1	-	-	-	-
Ulmus americana	T	+.1	-	-	-	-	-	-	-	-	-	-	-	-	-	+.1	-	-	-	-	-	+.1	-	-	+.1	+.1	-	-
	r	+.1	-	+.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+.1	-	-	-	-
11 SHRUB LAYER:																												
Viburnum alnifolium		2.2	2.2	4.4	1.2	1.2	1.2	2.2	1.2	2.1	2.3	1.1	+.1	-	3.2	+.1	3.2	+.1	1.1	1.1	-	+.2	4.2	+.2	-	-	+.1	+.1
Acer pensylvanicum		1.1	+.1	1.2	1.1	+.1	+.1	+.1	+.1	1.1	1.1	+.1	+.1	-	3.1	+.1	2.1	2.1	+.1	+.1	-	+.1	2.1	+.1	-	+.1	+.1	+.1
Corylus cornuta		-	1.2	-	-	-	-	+.1	+.1	-	-	-	-	-	-	+.1	-	-	-	+.1	-	+.1	-	-	-	-	-	-
Lonicera canadensis		+.1	+.1	+.1	+.1	+.1	-	-	+.2	-	+.1	+.1	-	-	+.1	+.1	+.1	-	+.1	+.1	-	+.1	+.1	+.1	-	-	-	-
Sambucus pubens		+.1	+.1	-	+.1	+.1	+.1	-	+.1	+.1	+.1	+.1	+.1	-	-	+.1	-	-	+.1	+.1	+.1	-	-	-	-	-	-	-
Prunus virginiana		+.1	+.1	-	-	+.1	1.2	-	-	-	-	-	-	-	-	-	-	-	-	+.1	-	-	-	-	-	-	-	-
Acer spicatum		+.1	+.1	1.2	-	+.1	1.1	-	1.2	+.1	1.2	1.1	+.1	-														
Taxus canadensis		-	-	-	+.1	-	-	+.1	-	-	3.4	+.2	+.1	-														
11 HERB LAYER:																												
Trillium erectum		+.1	+.1	+.1	+.1	+.1	1.1	+.1	-	+.1	1.1	1.1	1.1	1.1	+.1	-	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	1.1	1.1
Smilacina racemosa		+.1	+.1	1.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	-	-	+.1	+.1	+.1	-	-	+.1	+.1	-	-	-	+.1	-	1.1	+.1
Polygonatum pubescens		+.1	-	-	-	-	-	+.1	+.1	+.1	-	+.1	-	-	+.1	+.1	-	+.1	+.1	+.2	+.1	+.1	-	-	+.1	-	+.1	+.1
Lycopodium lucidulum		+.2	+.2	3.4	1.2	2.3	+.1	1.2	+.2	+.1	3.4	2.3	1.3	-	+.1	1.3	+.2	-	-	+.1	+.2	1.2	2.4	-	-	-	+.1	+.1
Tiarella cordifolia		+.1	+.1	-	+.2	+.1	+.1	+.1	+.1	-	-	-	-	-	-	-	-	-	-	+.1	+.1	+.1	+.1	+.1	+.1	1.1	1.2	-
Arisaema atrorubens		+.1	+.1	-	+.1	-	-	+.1	-	-	-	-	-	-	-	-	-	-	-	+.1	-	+.1	-	+.1	+.1	+.1	-	-
Athyrium thelypteroides		+.1	+.1	-	-	-	1.1	-	+.1	-	-	-	-	-	-	-	-	-	-	+.1	-	-	-	-	-	+.1	-	+.1
Dentaria diphylla		-	+.2	-	-	-	1.1	-	-	-	-	-	-	-	-	-	-	-	-	+.2	-	+.1	-	-	-	-	-	-
Carex intumescens		-	+.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+.1	-	-	-	+.1	-	-
Cinna latifolia		+.1	+.2	-	-	-	+.1	+.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Botrychium virginianum															-	+.1	-	-	+.1	+.1	+.1	+.1	-	+.1	+.1	-	-	-
Osmorhiza Claytoni															-	+.1	-	-	-	-	-	+.1	-	+.1	-	-	-	-
Aralia racemosa															-	+.1	-	-	-	-	+.1	-	-	-	-	-	-	-
Polystichum acrostichoides																						1.2	+.1	1.1	1.1	1.2	2.2	1.1
Polystichum Braunii																						-	-	-	-	+.1	-	+.1
Dirca palustris																						+.2	-	-	-	-	-	-
Rubus pubescens		-	+.1	-	-	+.1	-	-	-	-	+.1	-	+.1	-								-	-	-	-	+.1	+.1	-
Dryopteris Phegopteris		+.1	-	-	-	-	-	-	+.1	+.1	+.1	-	-	1.1								1.1	1.1	+.1	-	-	-	-
Oxalis montana		-	+.2	+.1	+.1	+.1	+.1	+.2	+.1	+.2	+.2	1.2	1.3	-								-	-	-	-	-	-	-
Clintonia borealis		-	+.1	+.1	-	+.1	+.1	+.1	+.1	+.1	+.1	+.1	-	-	-	-	-	-	-	-	-	-	-	-	-	+.1	-	-
Dryopteris spinulosa		1.1	1.1	1.2	1.1	1.1	1.2	1.1	+.1	3.2	2.1	3.2	3.4	1.1	+.1	+.1	+.1	-	1.1	1.1	1.1	1.2	1.1	-	+.1	1.1	1.1	2.1
Aralia nudicaulis		-	+.1	+.1	-	-	-	+.1	+.1	+.1	-	-	-	-	+.1	-	+.1	-	-	+.1	-	-	-	-	-	-	-	-
Trientalis borealis		-	-	-	+.1	-	-	-	+.1	+.1	-	-	-	-	+.1	-	-	-	-	-	-	-	-	-	-	-	-	-
Streptopus roseus		+.1	+.1	+.1	+.1	+.1	1.1	+.1	+.1	+.1	+.1	+.1	1.1	+.1	+.1	-	-	-	+.1	+.1	+.1	-	+.1	+.1	-	+.1	+.1	+.1
Galium triflorum		+.1	-	-	-	-	-	-	-	-	-	-	-	-	+.1	+.1	-	-	+.1	+.1	+.1	-	-	-	-	+.1	-	-
Athyrium Filix-femina		+.1	-	-	-	-	-	-	-	-	-	-	-	+.1	+.1	-	+.1	-	-	+.1	+.1	-	-	-	-	-	-	-
Medeola virginiana		-	-	-	-	-	-	+.1	-	-	-	-	-	-	+.1	-	+.1	-	-	-	-	+.1	-	-	-	-	-	-
Viola incognita		+.1	+.1	+.1	+.2	-	+.1	+.2	-	+.1	+.2	+.1	+.2	+.1	-	-	-	-	+.1	+.1	+.1	-	-	+.1	-	+.1	-	-
Maianthemum canadense		-	-	-	-	-	-	+.1	1.2	+.1	-	+.1	-	-	-	-	-	+.1	-	-	-	-	-	-	-	-	+.1	-
Dryopteris noveboracencis		-	-	-	-	+.1	-	-	-	-	-	+.1	-	-	-	-	-	-	-	+.1	-	-	-	-	-	-	-	-
Aster acuminatus		-	-	-	+.1	-	-	-	+.1	-	-	-	-	-	+.1	-	-	-	-	-	+.1	-	-	-	-	-	+.1	+.1
Dryopteris disjuncta		-	-	-	-	-	-	-	-	-	-	-	-	-	+.2	-	-	-	+.1	+.1	-	-	-	-	-	-	-	+.1

ADDITIONAL SPECIES:

Fraxinus nigra: 3009 (+.1). **Acer rubrum:** 3011 (+.1), 3014 (+.1). **Habenaria viridis, var. bracteata:** 3026 (r). **Corallorhiza maculata:** 3040 (r). **Cornus stolonifera:** 3042 (+.1). **Trillium undulatum:** 3042 (+.1). **Viola pensylvanica:** 3025 (+.1). **Dirca palustris:** 3047 (+.2). **Impatiens capensis:** 4047, 4048 (+.1).

VERNAL ASPECT: (Av. values):

Erythronium americanum: AD (1-3), Soc. (2-3). Claytonia caroliniana: AD (1-2), Soc. (1-2). Dicentra Cucullaria: AD (1), Soc. (1-2). Dicentra canadensis: AD (1), Soc. (1-2).

Figure 10 - Stand of Fago-Aceretum sacchari tilietosum.

the till covered slopes on all exposures except the steep (> 25%) slopes exposed to the north or northeast. The oxaletosum sub-association occurs above 1100 feet while it is replaced by the tilietosum sub-association below that elevation. This lower elevation coincides with an area of frequent limestone outcrops, but it is impossible at this point to state definitely which of elevation or limestone is the determining factor of the presence of basswood. In any case, the 1100-foot mark seems to form the proper demarcation between areas of occurrence of the two sub-associations.

The till is more than three feet deep and its texture varies from a sandy loam to a silt loam in both types. Stoniness is moderate and rooting depth seldom exceeds 24 inches. The profile developed under the F-As oxaletosum community is a podzolic soil very similar to the one developed under the B-As fagetosum sub-association. The humus is a moder (Md), very close to a mor (pH - 3.9)with a C/N ratio of 22, low exchangeable calcium and low base saturation (Table 4). With three exceptions all profiles displayed a slight marmorization (Pm) and the exceptions had seepage water at 14 to 25 inches from the surface. Such a moist site comes as a surprise for it has been generally taken for granted that beech is more abundant than yellow birch on upper slopes because these are drier. The retarded drainage is due to a compact basal till and in some cases to a fragipan (Pf) about two feet from the surface. It was not possible in the present investigation to determine which came first of the beech or the fragipan, in other words the cause and effect relationship between the two.

Under the F-As tilietosum the soil is a fresh brown podzolic (BP) (Fig. 11) with sometimes a slight marmorization. The humus is a moder (Md) with a pH of 5.0, an average C/N ratio of 18 and a good base saturation due mainly to the calcium content (Table 4).

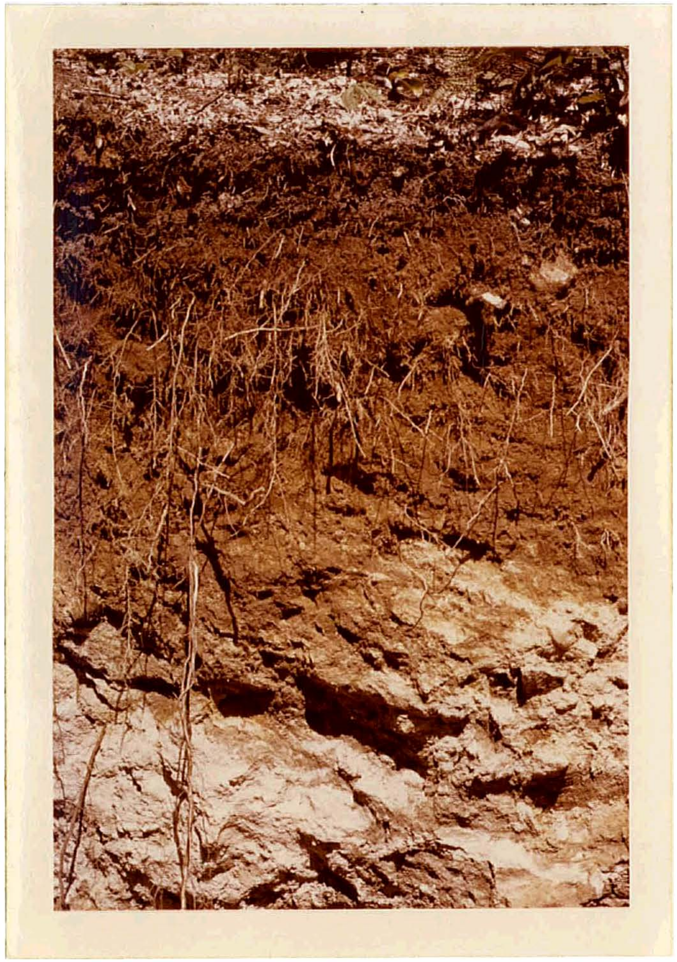


Figure 11 - Well-drained brown podzolic.

Figure 12 - Well-drained acid brown soil.

The F-As polystichetosum sub-association is found throughout the range of the preceding two types on steep cool slopes (25 to 50%) on deep colluvial silt loams with 50 to 60 per cent silt and good water retention capacity. It is restricted in distribution being confined mostly to the sides of deep gullies. The soil profile is an acid brown soil (Ba) with a mull-like (mullartig) moder humus. This humus is very close to a mull: it is well decomposed with a C/N ratio of 18 and low organic matter content (Table 4). It is brown in color, but there is no crumb structure, no clay-humus complex which would evidence earthworm activity characteristic of a true mull. The whole profile itself is brown with very little color differentiation of horizons (Fig. 12).

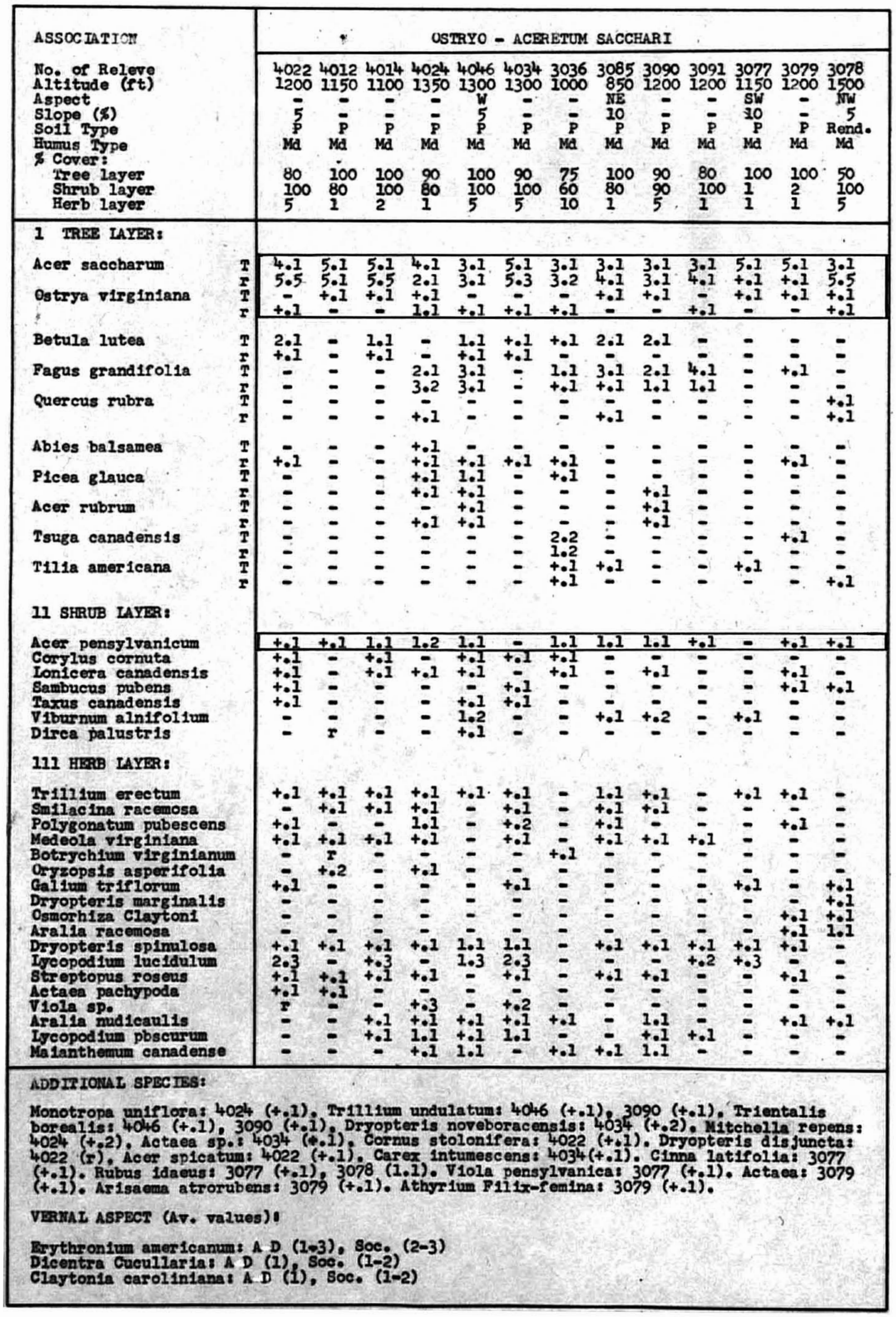
c. The Ironwood-Sugar Maple Association:

Ostrya-Aceretum sacchari (O-As) (Table 6)

Vegetation:

The stand of this association varies from almost pure sugar maple (Fig. 13) to a mixture of sugar maple and beech with a minor component of yellow birch and the odd red oak (Quercus rubra L.). A light fire can sponsor a vigorous regeneration of the latter (Fig. 14). In the intermediate and lower tree layer, ironwood (Ostrya virginiana (Mill.) K.) is a constant component of the association and is very characteristic. Some individuals of this species were found with a diameter of eight inches. The shrub stratum is made up mostly of sugar maple and ironwood seedlings with some beech. Striped maple (Acer pensylvanicum L.) is also regularly present as well as honeysuckle (Lonicera canadensis Bartr.). Mountain maple (Acer spicatum Lam.) is conspicuously absent and moosewood (Viburnum alnifolium Marsh.) is weakly developed. Most of the stands sampled had a very dense canopy

Table 6 - The Ostryo-Aceretum sacchari association table



ASSOCIATION		OSTRYO - ACERETUM SACCHARI												
No. of Releve		4022	4012	4014	4024	4046	4034	3036	3085	3090	3091	3077	3079	3078
Altitude (ft)		1200	1150	1100	1350	1300	1300	1000	850	1200	1200	1150	1200	1500
Aspect		-	-	-	-	W	-	-	NE	-	-	SW	-	NW
Slope (%)		5	-	-	-	5	-	-	10	-	-	10	-	5
Soil Type		P	P	P	P	P	P	P	P	P	P	P	P	Rend.
Humus Type		Md	Md	Md	Md	Md	Md	Md	Md	Md	Md	Md	Md	Md
% Cover:														
Tree layer		80	100	100	90	100	90	75	100	90	80	100	100	50
Shrub layer		100	80	100	80	100	100	60	80	90	100	1	2	100
Herb layer		5	1	2	1	5	5	10	1	5	1	1	1	5
1 TREE LAYER:														
Acer saccharum	T	4.1	5.1	5.1	4.1	3.1	5.1	3.1	3.1	3.1	3.1	5.1	5.1	3.1
	r	5.5	5.1	5.5	2.1	3.1	5.3	3.2	4.1	3.1	4.1	+.1	+.1	5.5
Ostrya virginiana	T	-	+.1	+.1	+.1	-	-	-	+.1	+.1	-	+.1	+.1	+.1
	r	+.1	-	-	1.1	+.1	+.1	+.1	-	-	+.1	-	-	+.1
Betula lutea	T	2.1	-	1.1	-	1.1	+.1	+.1	2.1	2.1	-	-	-	-
	r	+.1	-	+.1	-	+.1	+.1	-	-	-	-	-	-	-
Fagus grandifolia	T	-	-	-	2.1	3.1	-	1.1	3.1	2.1	4.1	-	+.1	-
	r	-	-	-	3.2	3.1	-	+.1	+.1	1.1	1.1	-	-	-
Quercus rubra	T	-	-	-	-	-	-	-	-	-	-	-	-	+.1
	r	-	-	-	+.1	-	-	-	+.1	-	-	-	-	+.1
Abies balsamea	T	-	-	-	+.1	-	-	-	-	-	-	-	-	-
	r	+.1	-	-	+.1	+.1	+.1	+.1	-	-	-	-	+.1	-
Picea glauca	T	-	-	-	+.1	1.1	-	+.1	-	-	-	-	-	-
	r	-	-	-	+.1	+.1	-	-	-	+.1	-	-	-	-
Acer rubrum	T	-	-	-	-	+.1	-	-	-	+.1	-	-	-	-
	r	-	-	-	+.1	+.1	-	-	-	+.1	-	-	-	-
Tsuga canadensis	T	-	-	-	-	-	-	2.2	-	-	-	-	+.1	-
	r	-	-	-	-	-	-	1.2	-	-	-	-	-	-
Tilia americana	T	-	-	-	-	-	-	+.1	+.1	-	-	+.1	-	-
	r	-	-	-	-	-	-	+.1	-	-	-	-	-	+.1
11 SHRUB LAYER:														
Acer pensylvanicum		+.1	+.1	1.1	1.2	1.1	-	1.1	1.1	1.1	+.1	-	+.1	+.1
Corylus cornuta		+.1	-	+.1	-	+.1	+.1	+.1	-	-	-	-	-	-
Lonicera canadensis		+.1	-	+.1	+.1	+.1	-	+.1	-	+.1	-	-	+.1	-
Sambucus pubens		+.1	-	-	-	-	+.1	-	-	-	-	-	+.1	+.1
Taxus canadensis		+.1	-	-	-	+.1	+.1	-	-	-	-	-	-	-
Viburnum alnifolium		-	-	-	-	1.2	-	-	+.1	+.2	-	+.1	-	-
Dirca palustris		-	r	-	-	+.1	-	-	-	-	-	-	-	-
111 HERB LAYER:														
Trillium erectum		+.1	+.1	+.1	+.1	+.1	+.1	-	1.1	+.1	-	+.1	+.1	-
Smilacina racemosa		-	+.1	+.1	+.1	-	+.1	-	+.1	+.1	-	-	-	-
Polygonatum pubescens		+.1	-	-	1.1	-	+.2	-	+.1	-	-	-	+.1	-
Medeola virginiana		+.1	+.1	+.1	+.1	-	+.1	-	+.1	+.1	+.1	-	-	-
Botrychium virginianum		-	r	-	-	-	-	+.1	-	-	-	-	-	-
Oryzopsis asperifolia		-	+.2	-	+.1	-	-	-	-	-	-	-	-	-
Galium triflorum		+.1	-	-	-	-	+.1	-	-	-	-	+.1	-	+.1
Dryopteris marginalis		-	-	-	-	-	-	-	-	-	-	-	-	+.1
Osmorhiza Claytoni		-	-	-	-	-	-	-	-	-	-	-	+.1	+.1
Aralia racemosa		-	-	-	-	-	-	-	-	-	-	-	+.1	1.1
Dryopteris spinulosa		+.1	+.1	+.1	+.1	1.1	1.1	-	+.1	+.1	+.1	+.1	+.1	-
Lycopodium lucidulum		2.3	-	+.3	-	1.3	2.3	-	-	-	+.2	+.3	-	-
Streptopus roseus		+.1	+.1	+.1	+.1	-	+.1	-	+.1	+.1	-	-	+.1	-
Actaea pachypoda		+.1	+.1	-	-	-	-	-	-	-	-	-	-	-
Viola sp.		r	-	-	+.3	-	+.2	-	-	-	-	-	-	-
Aralia nudicaulis		-	-	+.1	+.1	+.1	+.1	+.1	-	1.1	-	-	+.1	+.1
Lycopodium pbscurum		-	-	+.1	1.1	+.1	1.1	-	-	+.1	+.1	-	-	-
Maianthemum canadense		-	-	-	+.1	1.1	-	+.1	+.1	1.1	-	-	-	-

ADDITIONAL SPECIES:

Monotropa uniflora: 4024 (+.1). Trillium undulatum: 4046 (+.1), 3090 (+.1). Trientalis borealis: 4046 (+.1), 3090 (+.1). Dryopteris noveboracensis: 4034 (+.2). Mitchella repens: 4024 (+.2). Actaea sp.: 4034 (+.1). Cornus stolonifera: 4022 (+.1). Dryopteris disjuncta: 4022 (r). Acer spicatum: 4022 (+.1). Carex intumescens: 4034(+.1). Cinna latifolia: 3077 (+.1). Rubus idaeus: 3077 (+.1), 3078 (1.1). Viola pensylvanica: 3077 (+.1). Actaea: 3079 (+.1). Arisaema atrorubens: 3079 (+.1). Athyrium Filix-femina: 3079 (+.1).

VERNAL ASPECT (Av. values):

Erythronium americanum: A D (1-3), Soc. (2-3)
Dicentra Cucullaria: A D (1), Soc. (1-2)
Claytonia caroliniana: A D (1), Soc. (1-2)

Figure 13 - Stand of Ostryo-Acerutum sacchari

Figure 14 - Red Oak clump after fire on
Ostryo-Aceretum sacchari site.

and the sparse summer ground cover reflects the low light conditions. Trillium erectum L., Smilarina racemosa (L.) Desf., Polygonatum pubescens (Willd.) Pursh. and Medeola virginiana L. are generally present but not numerous. The boreal species are equally weakly represented: only Dryopteris spinulosa (O.F. Muell.) Watt, Lycopodium lucidulum Michx. and Streptopus roseus Michx. show any regularity of occurrence. In the spring, however, Erythronium americanum Ker., Claytonia caroliniana Michx. and Dicentra Cucullaria (L.) Bern. are very conspicuous.

Habitat and Soil:

This association occupies the dry hill tops with a thin till cap in the southern half of the L-4 region. Depth of the till cap is less than three feet and texture varies from a sandy loam to a loam. This soil is very permeable and excessively drained. Profile development is very weak. It is still a podzolic soil but the "A_2" layer is very thin, generally of patchy occurrence, while the yellowish brown "B" is very little differentiated and seldom exceeds ten to twelve inches in thickness (Fig. 15). The humus is of the moder type with properties close to those of the Fago-Aceretum association (Table 4).

d. The Basswood-Sugar Maple Association:

Tilio-Aceretum sacchari (T-As) (Table 7)

Vegetation:

In this association, basswood (Tilia americana L.) becomes the most abundant species after sugar maple (Fig. 17). White ash (Fraxinus americana L.) and red oak (Quercus rubra L.) are also regular associates and black cherry (Prunus serotina Ehrh.) is present in some stands.

Table 7 - The Tilio-Aceretum sacchari and Ulmo-Aceretum sacchari association table.

ASSOCIATION		TILIO-ACERETUM SACCHARI														ULMO—ACERETUM SACCHARI								
Sub-association		JUGLANTETOSUM					TYPICUM																	
No. of Releve		3057	3060	3067	3071	3073	3053	3054	3055	3061	3069	3068	4065	4056	4066	3062	3081	3038	3056	3017	3063	4069	4068	3034
Altitude (ft)		700	750	700	>700	750	550	550	550	600	700	800	700	650	600	450	800	800	500	1100	400	?	?	?
Aspect		E	E	E	N	S	SE	W	NW	E	S	E	E	ENE	E	E	NE	E	-	W	N	-	S	-
Slope (%)		25	30	20	25	10	10	5	5	15	40	30	45	20	10	5	-	5	-	5	10	-	15	-
Soil Type		Ra	BF	BF	BF	BF	BFc	BFc	BFc	BFg	BFm	BF	BF	BF	BF	BG	BP	BG	BG	BG	BG	BG	BF	BG
Humus Type		MoCa	Mu	Mu	Mu	Mu	Mu	Mu	Mu	Mu	Mu	Mu	Mu	Mu	Mu	Mu	MuMd	Mu	Mu	Mu	Mu	Mu	Mu	Mu
% Cover:																								
Tree layer		60	100	70	60	90	80	90	100	100	80	100	80	100	90	75	100	90	75	70	90	60	90	75
Shrub layer		80	60	60	30	90	90	10	50	60	70	50	50	-	50	60	50	40	75	80	50	50	90	50
Herb layer		80	50	20	80	5	100	40	20	40	80	15	30	80	30	100	30	90	100	100	100	100	90	100
1 TREE LAYER:																								
Acer Saccharum	T	1.1	3.1	3.1	3.1	3.1	3.1	3.1	4.1	4.1	1.1	4.1	3.1	4.1	3.1	2.1	5.1	5.1	2.1	2.1	-	3.1	3.1	+.1
	r	1.1	3.2	3.1	1.1	2.1	4.4	4.1	2.1	2.3	3.1	3.1	4.1	+.1	2.1	3.1	1.1	+.1	3.1	2.1	2.1	4.1	4.4	1.1
Tilia americana	T	4.3	4.3	3.2	2.2	2.1	3.2	2.1	3.2	-	+.1	2.1	1.2	-	2.1	-	2.1	-	3.2	-	3.2	-	2.1	1.1
	r	+.1	+.1	+.1	+.1	+.1	+.1	-	+.1	1.1	+.1	+.1	-	-	+.1	+.1	1.1	+.1	+.1	-	+.1	-	+.1	+.1
Prunus serotina	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+.1	-	-	-	-	-	-	-	-
	r	+.1	-	-	-	+.1	-	+.1	-	-	+.1	-	-	-	-	-	+.1	-	-	-	-	-	-	-
Fraxinus americana	T	-	+.1	+.1	+.1	-	-	-	-	-	+.1	+.1	-	+.1	+.1									
	r	1.1	+.1	+.1	1.1	1.1	-	-	-	1.1	+.1	+.1	-	-	+.1									
Quercus rubra	T	+.1	-	-	-	4.1	+.1	-	-	-	2.1	-	-	+.1	3.1									
	r	+.1	+.1	-	+.1	+.1	-	-	-	+.1	+.1	-	-	-	+.1									
Ostrya virginiana	T	-	-	-	+.1	-	+.1	+.1	-	1.1	2.1	1.1	-	-	+.1									
	r	-	-	-	-	+.1	-	-	-	-	-	-	-	-	1.1									
Juglans cinerea	T	3.2	1.2	+.1	+.1	+.1										-	-	-	-	-	-	-	r	-
	r	-	+.1	-	-	-										-	-	-	-	-	-	-	-	-
Fagus grandifolia	T	-	-	-	+.1	-	-	-	1.1	2.2	2.1	-	1.1	+.1	-	-	-	+.1	-	-	-	+.1	1.1	-
	r	-	-	-	+.1	-	+.1	+.1	-	+.1	+.1	+.1	2.1	+.1	-	-	-	-	-	-	-	+.1	+.1	-
Betula lutea	T	+.1	+.1	+.1	-	-	+.1	1.1	3.1	-	2.1	-	1.1	+.1	-	-	+.1	1.1	1.1	2.1	1.1	+.1	+.1	+.1
	r	-	-	-	-	-	-	-	-	-	-	-	-	+.1	-	-	-	-	-	+.1	-	1.1	+.1	+.1
Tsuga canadensis	T						-	2.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	r						+.1	-	-	-	-	-	+.1	-	-	-	+.1	-	+.1	-	+.1	-	-	-
Abies balsamea	r						+.1	-	-	+.1	-	-	-	-	-	-	+.1	-	+.1	+.1	-	-	-	+.1
Ulmus americana	T						-	-	+.1	-	-	-	-	+.1	-	3.2	2.1	+.1	3.1	2.1	2.1	3.1	1.1	3.1
	r						-	+.1	-	-	-	-	-	-	-	-	2.3	-	-	1.1	-	+.1	-	-
Fraxinus nigra	T						-	-	+.1	--	-	-	-	-	-	+.1	+.1	-	3.1	2.1	+.1	-	1.1	2.1
	r						-	-	+.1	-	-	-	-	-	-	-	+.1	+.1	-	1.1	+.1	-	+.1	1.1
11 SHRUB LAYER:																								
Acer spicatum		3.2	3.3	+.1	+.1	-	-	-	-	-	+.1	-	-	+.2	-	+.1	-	-	-	2.2	+.1	+.1	-	+.1
Corylus cornuta		2.2	1.2	-	+.1	-	-	-	-	+.2	+.2	+.1	-	-	-	-	1.3	-	+.1	-	-	-	-	-
Sambucus pubens		+.1	-	-	+.1	-	+.1	+.1	+.1	+.1	-	+.1	-	+.1	-	-	+.1	+.1	-	+.1	-	-	+.1	-
Acer pensylvanicum		-	-	-	+.1	-	+.1	+.1	-	+.1	-	+.1	1.2	+.1	-	-	-	-	-	-	-	-	-	-
Lonicera canadensis		-	-	-	-	-	-	-	-	+.1	+.1	+.1	+.1	+.1	1.1	-	-	-	-	-	-	-	-	-
Viburnum alnifolium		-	-	-	-	-	-	+.1	+.1	+.1	-	-	1.1	-	-	-	+.2	-	r	+.1	-	+.1	-	-
Cornus alternifolia		2.2	-	-	+.1	+.1	+.1	+.1	-	+.1	-	-	-	-	-	+.1	-	-	-	-	-	-	-	-
Prunus virginiana		-	+.2	-	+.1	-	-	-	-	-	-	-	-	-	1.2	+.2	-	-	-	1.2	-	-	+.1	-
Ribes triste		+.1	-	-	-	-	-	-	-	-	+.1	-	-	-	-	-	+.1	+.1	-	-	-	-	-	-
Dirca palustris		+.1	-	-	-	+.1	+.1	-	-	-	+.1	+.1	-	-	-	-	+.1	-	-	-	-	-	-	-
111 HERB LAYER:																								
Polystichum acrostichoides		1.1	1.1	1.1	+.1	-	1.1	-	-	+.1	1.2	1.1	2.2	-	-	-	-	-	+.2	-	-	-	-	-
Uvularia grandiflora		+.1	+.1	+.1	+.1	+.1	1.2	-	+.1	+.1	+.1	+.1	+.1	+.2	+.1	+.1	-	-	+.1	-	1.1	+.1	+.1	-
Caulophyllum thalictroides		+.1	+.1	+.1	-	-	1.1	+.1	+.1	+.1	-	-	-	1.2	1.1	-	-	-	1.2	-	+.2	1.2	2.2	-
Botrychium Virginianum		+.1	1.1	+.1	+.1	+.1	1.1	+.1	+.1	+.1	-	-	+.1	-	+.1	+.1	+.1	+.1	-	-	-	+.1	+.1	-
Viola canadensis		-	-	+.1	-	-	-	-	+.1	+.1	-	-	-	-	-	+.1	-	-	+.1	-	+.1	+.1	1.1	-
Tiarella cordifolia		1.1	-	-	2.3	-	-	-	-	-	1.2	-	-	-	-	2.1	1.1	+.1	-	4.1	+.1	+.1	-	+.1
Dentaria diphylla		+.1	-	-	-	-	-	-	-	-	-	-	-	+.1	-	-	-	-	-	1.2	-	-	-	-
Sanicula marilandica		+.1	-	-	-	-	-	-	-	+.1	-	-	-	-	+.1	+.1	-	-	+.1	-	1.1	+.1	+.1	-
Dryopteris marginalis		-	-	-	1.1	-	-	-	-	+.1	-	+.1	+.1	-	-									
Aralia racemosa		+.1	-	+.1	-	-	+.1	-	-	+.1	-	-	-	-	-									
Rubus odoratus		+.1	-	-	-	-	-	+.1	-	-	+.1	-	-	-	-									
Actaea sp.		-	1.1	+.1	+.1	-	+.1	+.1	+.1	-	+.1	-	+.1	-	-									
Adiantum pedatum		+.1	-	-	-	-	+.1	+.1	+.1	+.1	-	+.1	-	+.2	-	-	-	1.3	+.2	-	-	2.2	1.2	1.2
Asarum canadense		-	-	-	-	-	+.1	-	+.2	-	-	-	-	1.2	1.2	-	-	-	1.3	-	+.1	1.2	1.2	-
Osmorhiza Claytoni		-	-	+.1	+.1	+.1	1.1	2.1	2.3	+.1	-	-	-	-	-	1.1	1.1	1.1	+.1	1.1	+.1	1.1	1.1	+.1
Arisaema atrorubens		+.1	+.1	-	+.1	-	+.1	1.1	+.1	+.1	-	+.1	+.1	+.1	-	+.1	+.1	-	+.1	+.1	-	1.1	-	+.1
Veronica americana		+.1	+.1	-	-	+.3	-	-	-	-	-	-	-	-	-	+.1	-	-	-	-	+.1	-	-	-
Viola pensylvanica							+.1	+.1	-	+.1	-	-	-	-	-	-	+.1	-	-	-	-	-	-	-
Mitella diphylla							-	-	-	-	-	-	-	-	+.1	-	-	+.1	-	-	-	+.1	+.1	-
Carex intumescens							-	+.1	-	-	-	-	-	-	-	-	-	+.1	-	+.1	-	-	-	1.2
Cinna latifolia		-	+.2	-	+.1	-	-	+.1	-	-	+.1	-	-	-	-	-	-	+.2	-	+.2	+.1	-	-	1.2
Athyrium thelypteroides		1.1	-	-	+.1	-	-	+.1	+.1	-	-	-	-	+.1	-	-	+.1	+.1	2.3	1.2	+.1	+.1	-	-
Carex plantaginea																-	-	-	1.2	-	-	-	+.1	-
Laportea canadensis							-	-	+.1	+.1	-	-	-	-	-	+.3	+.1	4.3	5.5	1.1	+.1	4.3	1.1	-
Urtica procera																-	-	-	-	-	-	-	-	+.1
Thalictrum polygamum							-	-	-	-	-	-	-	-	1.1	+.1	-	-	-	+.2	-	+.2	-	-
Impatiens capensis																+.1	-	-	1.1	+.1	+.1	-	-	+.1
Onoclea sensibilis																+.1	-	-	+.1	-	-	1.1	-	1.2
Pteretis pensylvanica																-	+.1	-	+.1	-	-	1.1	+.1	+.2
Circaea alpina																-	+.1	+.2	-	-	-	-	-	-
Chelone glabra																+.1	-	-	-	-	-	-	-	-
Amphicarpea bracteata																-	-	-	-	-	1.1	-	-	-
Parthenoeissus quinquefolia																-	-	-	-	-	-	-	-	1.2
Lycopus uniflorus																-	-	-	-	-	-	-	-	1.3
Smilacina racemosa		+.1	1.1	+.1	+.1	+.1	1.1	+.1	+.1	-	+.1	+.1	-	-	+.1	+.1	-	-	-	+.1	+.1	+.1	+.1	-
Polygonatum pubescens		-	+.1	1.1	+.1	+.1	1.1	+.1	-	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	-	-	+.1	+.1	-
Trillium erectum } Trillium grandiflorum		+.1	-	1.1	+.1	+.1	1.1	1.1	1.1	1.1	+.1	1.1	1.1	1.1	1.1	+.1	1.1	1.1	-	1.1	+.1	1.1	1.1	-
Rubus pubescens																1.1	+.1	+.1	1.1	+.1	-	-	-	1.1
Aster macrophyllus		+.1	1.1	-	1.1	-	-	-	-	+.1	1.2	-	-	-	-									
Aster acuminatus		-	1.1	+.1	+.1	+.2	-	-	-	+.1	+.1	+.1	-	-	-									
Aralia nudicaulis		-	+.1	-	+.1	+.1	+.1	-	-	+.1	+.1	+.1	1.1	-	-									
Dryopteris spinulosa		-	+.1	-	+.1	-	+.1	1.1	+.1	+.1	-	-	1.1	+.1	+.1	1.2	1.1	+.2	-	1.2	-	-	-	1.2
Prenanthes altissima		-	+.1	+.1	+.1	-	+.1	-	-	+.1	+.1	-	-	-	-									
Streptopus roseus		-	+.1	+.1	+.1	-	-	-	+.1	+.1	+.1	-	1.1	+.1	-	-	-	+.1	+.1	+.1	+.1	-	-	-
Galium triflorum		+.1	-	-	+.1	+.1	-	-	-	-	+.1	-	-	-	-	+.1	+.1	+.1	-	+.1	-	-	+.1	-
Maianthemum canadense		-	-	+.1	+.1	+.1	-	-	-	+.1	-	+.1	+.1	-	-									
Trientalis borealis		-	-	-	+.1	-										+.1	-	-	-	-	-	-	-	-
Lycopodium lucidulum		-	-	-	+.1	-	-	-	+.1	+.1	-	-	-	-	-	-	+.2	-	+.1	+.2	-	-	-	+.1
Athyrium Filix-femina		-	-	-	-	-	-	-	-	+.1	+.1	-	+.1	-	-	+.1	+.1	-	-	+.1	+.1	+.1	+.1	-

ADDITIONAL SPECIES:

Sanicula trifoliata: 3057 (r). **Viburnum acerifolium:** 3069 (+.3). **Mitchella repens:** 3069 (+.1). **Dryopteris noveboracensis:** 3063 (2.2). **Dryopteris disjuncta:** 4069 (1.1).

VERNAL ASPECT (Av. values)

Erythronium americanum: AD (1-3), Soc. (2-3). **Allium tricoccum:** AD (1-3), Soc. (2-3). **Claytonia caroliniana:** AD (1-2), Soc. (1-2). **Dicentra Cucullaria:** AD (1), Soc. (1-2). Dicentra canadensis: AD (1), Soc. (1-2). **Hepatica acutiloba:** AD (1), Soc. (1). **Sanguinaria Canadensis:** AD (1-2), Soc. (1-2).

Figure 15 - Dry brown podzolic.

Figure 16 - Gleyed brown forest soil.

Figure 17 - Stand of Tilio-Aceretum sacchari typicum.

The ground layer is unmistakably different from that of the previous sugar maple associations. It is dominated by eutrophic species such as *Polystichum acrostichoides* (Michx.) Schott., *Uvularia grandiflora* Am., *Caulophyllum thalictroides* (L.) Michx., *Viola canadensis* L., *Dryopteris marginalis* (L.) Gray, *Aralia racemosa* L., *Adiantum pedatum* L., *Asarum canadense* L. and many others. In the spring, besides *Erythronium americanum* Ker., *Claytonia caroliniana* Michx., *Dicentra Cucullaria* (L.) Bersh. and *Dicentra canadensis* (Goldie) Walp., one finds *Hepatica acutiloba* DC., *Sanguinaria canadensis* L. and *Trillium grandiflorum* (Michx.) Salisb.

The sub-association *T-As juglantetosum* differs from the typical sub-association by the presence in its tree layer of butternut (*Juglans cinerea* L.) and the absence of fresher site species such as American elm and black ash. In the herb layer, some fresh site species such as *Asarum canadense* L. are also absent.

Habitat and Soil:

The *Tilio Aceretum sacchari* association is the dominant community below 700 feet elevation in the Gatineau-Lièvre trough. A combination of lower elevation, presence of limestone and of fresh and brackish water deposits of the Champlain Sea seem to be the main factors responsible for the drastic change of vegetation. This is an area of low relief and the tops and slopes of the low knolls are all occupied by this sub-association. The texture of the deposits varies from a sandy loam to a loam underlain in most cases by a heavier textured compact horizon at 20 to 25 inches from the surface and the moisture supply is very good.

The soil profile is a brown forest soil (BF). The humus is a mull with good earthworm activity and crumb structure. As can be seen in Table 4, pH and percent base saturation are higher than in the previous soils.

The sub-association *juglantetosum* occupies steep lower slopes and the parent material is a fresh, very stony, loamy till. As in the case of the *F-As polystichetosum* sub-association, the higher silt content might be due to fine colluvium from the upper slope. The soil profile is a brown forest soil with a 3 to 6 inches thick crumb mull and high base saturation (Table 4). In plot 3057, the parent material was strictly calcareous rubble with a calcic mor (*MoCa*) sitting directly on top of the rocks.

e. The Elm-Sugar Maple Association:

Ulmo-Aceretum sacchari (*U-As*) (Table 7)

Vegetation:

The stand is composed of sugar maple, American elm (*Ulmus americana* L.) and black ash (*Fraxinus nigra* Marsh.) (Fig. 18). Basswood is also a regular companion. But the site is too wet for white ash, red oak, ironwood and butternut.

In the lesser vegetation, the mull species of the *Tilio-Aceretum sacchari* association are present. But the most characteristic species are *Laportea canadensis* (L.) Wedd., *Impatiens capensis* Meeb. *Onoclea sensibilis* L. and *Pteretis pensylvanica* (Willd.) Fern.

Habitat and Soil:

This association occupies low-lying areas on alluvial or glacio-marine deposits with a compact layer and retarded drainage at a depth of 10 to 25 inches. The soil profile developed in those conditions is a gleyed brown forest soil (BG) (Fig. 16). The humus is a moderately thick mull (5-6 inches) of low acidity (5.6) and high base saturation (Table 4)

II. *Ecosystems dominated by yellow birch*

The Balsam Fir-Yellow Birch association:

Abieti-Betuletum luteae (A-Bl) (Table 8)

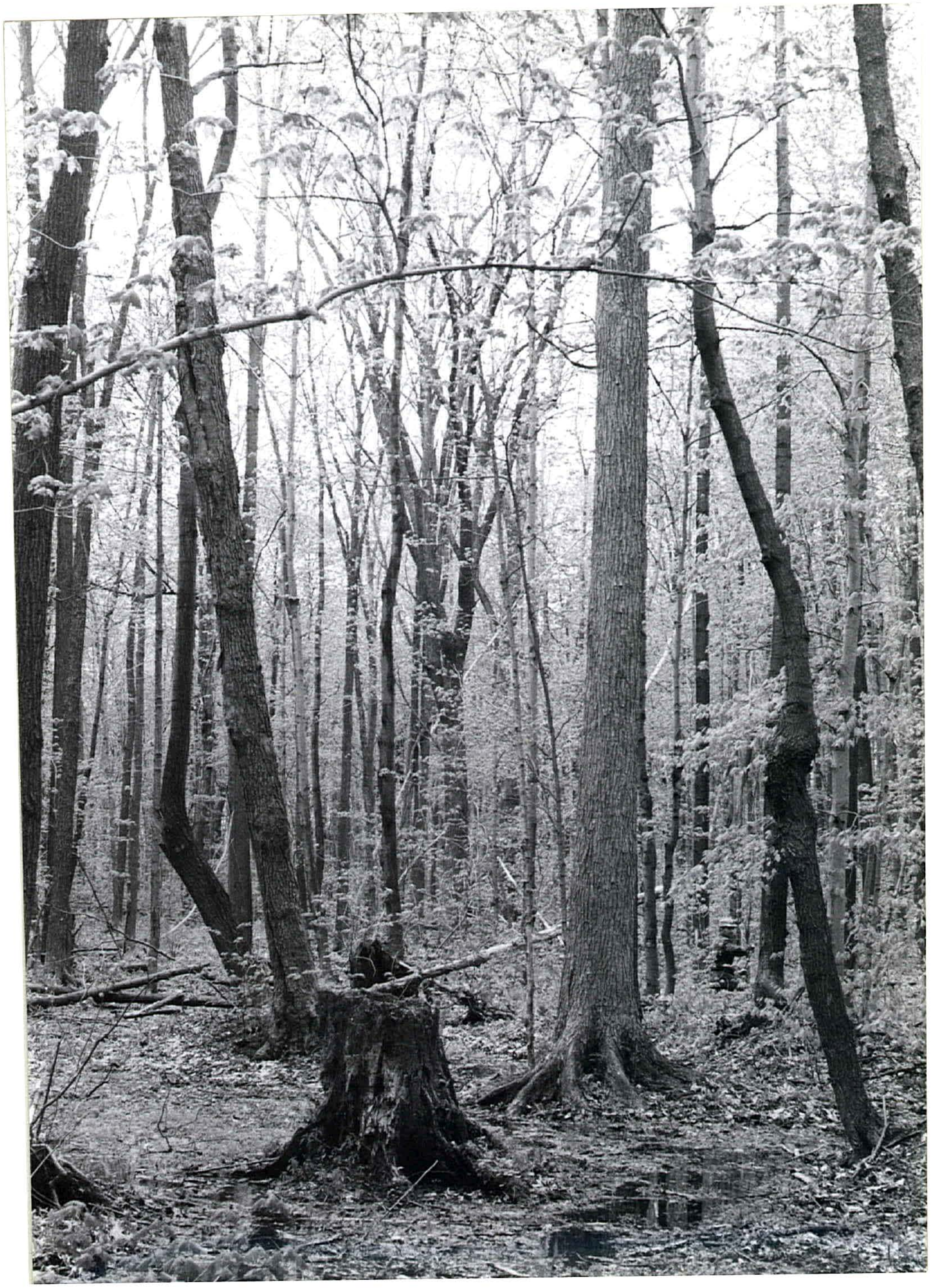


Figure 18 - Stand of Ulmo-Aceretum sacchari.

Table 8 - The Abieti-Betuletum luteae association table.

ASSOCIATION		ABIETI—BETULETUM LUTEAE														
Sub-association		TYPICUM								TSUGETOSUM						
No. of Releve		3019	3022	3023	3027	3018	3096	4006	4010	4019	4015	4013	4011	4018	4017	3086
Altitude (ft)		1150	1200	1200	1200	1250	550	1200	1125	1150	1100	1100	950	950	875	850
Aspect		SW	N	N	E	SE	SE	N	SW	W	N	N	S	N	N	NW
Slope (%)		5	25	30	25	10	10	15	10	15	25	35	35	30	5	5
Soil Type		IHP	IHP	IHP	IHP	IHPm	IHPm	IPm	IHP	IHP	IP	P	P	IHP	Hyd.	IPm
Humus Type		Mo	Mo	Mo	Mo	Mo	Mo	MoMd	MoMd	Mo	Mo	Md	Md	Mo	Md	Mo
% Cover:																
Tree layer		70	40	60	60	90	60	60	50	80	60	80	90	60	75	50
Shrub layer		80	90	75	70	80	80	100	100	90	90	70	70	80	90	70
Herb layer		80	80	80	100	80	90	10	75	5	70	90	2	90	90	30
1 TREE LAYER:																
Betula lutea	T	4.2	2.1	4.2	3.1	4.2	4.1	3.1	3.1	4.1	3.1	3.1	2.1	2.1	4.1	3.1
	r	+.1	+.1	1.1	+.1	1.1	+.1	+.1	+.1	+.1	+.1	+.1	1.1	+.1	+.1	+.1
Acer saccharum	T	+.1	+.1	1.1	+.1	+.1	3.1	+.1	+.1	+.1	+.1	+.1	-	-	-	2.1
	r	1.1	+.1	+.1	+.1	1.1	3.1	+.1	1.2	2.1	2.1	+.1	+.1	+.1	-	+.1
Abies balsamea	T	+.1	1.1	+.1	3.1	+.1	-	+.1	1.1	2.1	-	+.1	1.1	-	+.1	-
	r	+.1	+.1	+.1	+.1	1.2	+.1	+.1	+.1	+.1	+.1	+.1	+.1	-	1.1	-
Acer rubrum	T	-	-	-	1.1	-	+.1	+.1	+.1	-	-	-	-	-	-	-
	r	-	-	1.1	+.1	-	+.1	+.1	1.2	+.1	-	-	-	-	-	-
Picea rubens	T	-	+.1	-	2.1	-	-	-	-	-	-	-	-	-	-	-
	r	-	-	+.2	+.1	1.2	+.1	-	-	-	-	-	-	-	-	-
Picea glauca	T	-	-	-	-	-	-	-	1.1	+.1	-	-	-	-	+.1	-
	r	-	-	-	-	-	-	+.1	+.1	+.1	-	-	-	-	+.1	-
Tsuga canadensis	T									2.1	3.1	3.1	4.1	3.1	1.1	3.1
	r									+.1	+.1	1.1	1.1	1.1	+.1	+.1
Thuja occidentalis	T	-	-	-	+.1	-	-	1.1	-	2.1	-	+.1	+.1	+.1	1.1	+.1
	r	-	-	-	-	+.1	-	+.1	-	2.1	-	+.1	1.1	+.1	1.1	-
11 SHRUB LAYER:																
Acer spicatum		2.3	3.4	2.3	3.1	3.4	1.2	4.5	3.3	3.2	4.3	3.2	4.2	4.2	4.3	3.1
Acer pensylvanicum		-	-	1.1	+.1	+.1	-	+.1	+.1	2.2	-	+.1	+.1	+.1	-	3.2
Corylus cornuta		+.1	+.2	+.1	+.1	1.1	-	+.1	1.1	1.1	+.1	-	+.1	-	+.1	+.1
Viburnum alnifolium		3.2	2.1	2.2	3.3	3.3	3.2	-	-	1.2	3.1	+.1	+.1	1.2	1.2	2.1
Taxus canadensis		-	-	-	-	-	3.3	5.5	1.2	3.3	-	-	+.1	-	-	-
Sambucus pubens		+.1	+.1	+.1	-	-	-	-	-	+.1	+.1	-	-	-	+.1	+.1
Lonicera canadensis		-	-	-	+.1	-	-	+.1	-	-	-	-	1.2	+.1	+.1	-
Cornus alternifolia		1.2	-	-	-	+.1	-	-	-							
Ribes triste		+.1	-	-	-	+.1	-	-	-							
111 HERB LAYER:																
Dryopteris spinulosa		1.1	3.3	2.2	1.2	1.1	3.2	+.1	1.1	+.1	3.2	3.1	+.1	1.1	+.1	2.2
Oxalis montana		+.1	3.3	3.4	3.3	2.3	2.3	-	2.3	-	3.3	3.3	-	3.3	2.3	-
Lycopodium lucidulum		+.2	+.1	+.2	1.2	+.2	2.3	1.1	+.1	-	+.2	3.3	+.2	3.3	-	1.1
Clintonia borealis		-	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	1.1	+.1	+.1
Trientalis borealis		-	+.1	+.1	+.1	+.1	+.1	-	+.1	+.1	-	+.1	-	+.1	+.1	+.1
Aralia nudicaulis		+.1	+.1	+.1	+.1	+.1	-	+.1	1.1	+.1	+.1	+.1	+.1	1.1	1.1	+.1
Streptopus roseus		+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1	1.1
Viola incognita		+.2	+.1	+.1	+.2	+.1	-	-	+.1	-	+.2	-	+.1	+.1	1.1	-
Maianthemum canadense		+.1	+.1	1.3	+.1	1.3	+.1	-	1.1	-	-	+.1	+.1	1.1	+.1	+.1
Lucopodium obscurum		+.1	-	+.1	+.1	-	-	-	+.1	+.1	-	-	-	+.1	-	1.1
Cornus canadensis		-	-	+.1	+.1	+.1	-	-	-	+.1	-	-	-	1.1	1.1	-
Dryopteris Phegopteris		-	+.1	+.1	-	+.1	+.1	-	-	-	1.2	+.1	+.1	+.1	2.3	-
Rubus pubescens		+.2	1.1	+.1	-	+.1	-	-	-	-	+.1	-	-	-	+.1	-
Trillium undulatum		-	+.1	-	+.1	+.1	-	+.1	+.1	-	-	-	-	r	-	-
Trillium erectum		+.1	+.1	-	-	-	+.1	-	-	+.1	+.1	+.1	+.1	+.1	-	+.1
Medeola virginiana		-	-	-	-	-	+.1	-	-	+.1	+.1	-	-	+.1	-	-
Dryopteris disjuncta										-	-	+.1	-	-	1.1	+.1
Actaea pachypoda										-	-	+.1	+.1	-	-	+.1
Galium triflorum		-	-	-	-	+.1	-	-	-	-	+.1	-	-	-	+.1	+.1
Athyrium Filix-femina		-	-	-	-	+.1	-	-	-	-	-	+.1	-	-	-	+.1
Linnaea borealis										-	-	-	1.3	-	+.1	-
Polygonatum pubescens										-	-	-	+.1	-	-	+.1
Smilacina racemosa		+.1	-	-	-	-	-	-	-	+.1	-	-	-	-	-	-
Tiarella cordifolia		+.1	-	-	-	+.1	-	-	-	-	-	-	-	-	-	1.1
Carex intumescens		+.2	-	-	-	+.2	-	-	-	-	-	-	-	-	-	-
Cinna latifolia		+.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dryopteris noveboracensis		+.1	-	-	-	+.1	-	-	-	-	-	-	-	-	-	-

Pm - Boj

ADDITIONAL SPECIES:

Fraxinus nigra: 3022 (+.2) (+.1). Ulmus americana o: (+.1). Fagus grandifolia: 3018 (+.1), 3096 (+.1) (+.1). Prunus virginiana: 3019 (+.1). Mitchella repens: 3096 (+.1). Circaea alpina: 4015 (+.1). Dryopteris marginalis: 4011 (+.1). Oryzopsis asperifolia: 4011 (+.2). Polytrichum juniperinum: 4018 (+.2).

Vegetation:

This association is a mixedwood type. The stand is made up primarily of yellow birch, balsam fir (*Abies balsamea* (L.) Mill.) and spruce: white spruce (*Picea glauca* (Moench.) Voss) west of the Gatineau River and red spruce (*Picea rubens* Sarg.) east. Sugar maple and red maple form only a minor component of the stand. (Fig. 19).

In the shrub layer, *Viburnum alnifolium* Marsh. and *Acer spicatum* Lam. are most abundant and vigorous. The latter shows luxuriant growth in every opening of the stand and becomes a major silvicultural problem after severe cuts where it retards regeneration of valuable species for decades.

The herb layer is dominated by *Dryopteris spinulosa* (O.F. Muell.) Watt, *Lycopodium lucidulum* Michx. and *Oxalis montana* Raf. The latter species occurs in large patches throughout the stand, generally concentrated around acid surface boulders. The overall physiognomy of the vegetation is definitely boreal with much affinity with the white birch-balsam fir community to the north.

The overall physiognomy of the *A-Bl tsugetosum* sub-association is quite similar except for the fact that hemlock (*Tsuga canadensis* (L.) Carr.) and cedar (*Thuja occidentalis* L.) form an important component of the stand.

Habitat and Soil:

This association occupies the stony, cold northern or north-eastern slopes.

In the case of the *tsugetosum* sub-association, two coincidences seem to warrant further investigation. First, all the stands sampled were found along the shores of relatively large lakes hemmed in by steep slopes.

Figure 19 - Stand of Abieti-Betuletum lutese typicum.

The stands generally occupied the steep slopes, but they also occurred on the valley trains or washed tills bordering the lakes. The higher atmospheric humidity of these sites could be an important factor. Another coincidence is that these stands occurred in the vicinity of basic rocks, either Grenville limestone or anorthosite. This might account for the presence of cedar, and perhaps hemlock too.

The parent material in all cases is a bouldery loamy sand till, ablation ~~lateral~~ moraine or in some instances a valley train, all of them well-drained.

The profile is an iron humus podzol (IHP) with a mor humus (Mo) under the typical sub-association. In the *tsugetosum* sub-association, the degree of podzolisation varies. The profile is either a podzol or a podzolic. The humus varies from a mor to a moder, pH is higher as well as calcium content and base saturation (Table 4).

III. Ecosystems dominated by black ash

a. The Yellow Birch-Black Ash Association:

Betulo-Fraxinetum nigrae (*B-Fn*) (Table 9)

Vegetation:

Yellow birch and black ash are the dominant tree species of this association. Crown closure is usually low and the ash trees have tall clean boles. These conditions allow the development of an intermediate tree layer composed of cedar, red maple, balsam fir and white spruce.

The open canopy also permits a luxuriant development of the lesser vegetation. In the shrub layer, *Acer spicatum* Lam. and *Viburnum alnifolium* Marsh. are particularly vigorous. But the most characteristic shrub species are *Viburnum cassinoides* L., *Alnus rugosa* (Du Roi) Spreng. and *Ribes lacustre* (Pers.) Poir.

Table 9 - The Betulo-Fraxinetum nigrae association table.

ASSOCIATION		BETULO-FRAXINETUM NIGRAE					
No. of Releve		4039	4036	4042	4045	4023	3037
Altitude (ft)		1325	1300	1275	1250	1100	900
Aspect		-	-	-	-	-	-
Slope (%)		-	-	-	-	-	-
Soil Type		G	G	G	G	Pg	G
Humus Type		HMo	HMd	HMo	HMo	Mo	HMo
% Cover:							
Tree layer		75	50	75	50	80	90
Shrub layer		80	90	60	80	90	100
Herb layer		100	100	100	100	80	100
Moss layer		25	10	10	60	-	25
1 TREE LAYER:							
Fraxinus nigra	T	3.1	3.1	2.1	3.1	+.1	3.2
	r	1.1	1.1	+.1	1.1	+.1	3.2
Betula lutea	T	3.1	2.1	3.1	2.1	2.1	3.1
	r	1.1	1.1	1.1	+.1	+.1	+.1
Abies balsamea	T	+.1	+.1	1.1	+.1	2.1	1.1
	r	1.1	+.1	1.1	1.1	+.1	+.1
Picea glauca	T	-	+.1	1.1	+.1	+.1	-
	r	+.1	+.1	+.1	1.1	+.1	-
Acer rubrum	T	+.1	+.1	+.1	-	-	-
	r	+.1	+.1	+.1	+.1	-	+.1
Thuja occidentalis	T	2.1	2.1	+.1	-	-	3.2
	r	1.1	+.1	+.1	-	-	+.1
Acer saccharum	T	-	-	+.1	-	-	-
	r	-	+.1	+.1	+.1	-	+.1
11 SHRUB LAYER:							
Viburnum cassinoides		1.1	-	-	1.2	+.1	-
Alnus rugosa		1.1	-	-	1.2	-	-
Ribes lacustre		-	-	+.2	1.2	-	+.1
Viburnum alnifolium		+.1	+.1	1.2	+.1	+.1	-
Lonicera canadensis		1.1	1.1	1.2	+.1	+.1	r
Acer spicatum		+.1	5.4	1.2	+.1	4.4	3.3
Corylus cornuta		-	+.2	1.2	+.1	1.1	-
Acer pensylvanicum		+.1	+.1	+.1	+.1	-	1.1
111 HERB + MOSS LAYER:							
Onoclea sensibilis		2.3	+.1	1.2	3.2	+.1	-
Osmunda cinnamomea		1.2	5.5	-	-	-	+.1
Mitella nuda		-	+.1	+.1	+.1	-	1.1
Equisetum sylvaticum		1.1	+.1	-	1.1	-	-
Coptis groenlandicum		1.2	+.1	+.2	1.1	-	+.1
Lycopodium annotinum		1.1	-	-	+.1	-	-
Circaea alpina		-	+.1	1.2	-	-	+.1
Mnium punctatum		1.2	1.2	+.2	-	-	+.2
Sphagnum sp.		1.3	-	+.3	4.3	-	+.1
Bazzania trilobata		1.2	-	-	-	-	+.2
Hylocomium triquetrum		-	+.1	-	-	-	+.2
Carex intumescens		1.2	1.3	-	-	+.1	-
Athyrium Filix-femina		+.2	2.2	1.2	1.1	+.1	-
Rubus pubescens		2.2	1.1	1.1	1.1	1.1	4.4
Dryopteris spinulosa		1.1	+.1	+.1	+.1	2.1	+.1
Dryopteris disjuncta		-	+.1	1.1	+.1	-	1.1
Dryopteris Phegopteris		-	1.1	1.1	2.2	+.1	+.1
Dryopteris noveboracensis		-	1.2	-	+.1	-	+.1
Clintonia borealis		+.1	+.1	+.1	+.1	+.1	+.1
Maianthemum canadense		+.1	-	+.1	-	+.1	+.1
Trientalis borealis		+.1	+.1	+.1	+.1	+.1	+.1
Aralia nudicaulis		+.1	+.1	+.1	+.1	+.1	+.1
Oxalis montaba		+.1	2.3	1.2	1.2	2.3	3.3
Lycopodium lucidulum		-	1.1	+.1	-	2.2	-
Galium triflorum		-	+.1	+.1	+.1	+.1	+.1
Streptopus roseus		+.1	+.1	+.1	+.1	+.1	+.1
Viola sp.		1.1	1.1	1.1	1.2	1.1	+.1
Cornus canadensis		+.1	+.1	+.1	+.1	+.1	+.1
Carex sp.		1.2	+.1	-	1.2	-	-
Smilacina racemosa		-	-	+.1	-	-	+.1

ADDITIONAL SPECIES:

Picea mariana: 4039 (+.1), 4036 (+.1). Acer saccharinum: 4036 (r). Tsuga canadensis: 3037 (+.1) (1.1). Tilia amerinana o: 3037 (+.1). Fagus grandifolia: 4042 (+.1) (+.1). Betula papyrifera: 4023 (2.1) (+.1). Trichocolea tomentella: 4039 (+.2). Listera cordata: 4036 (+.1). Sanicula marilandica: 4042 (+.1). Impatiens capensis: 4042 (+.1). Osmumda Claytoniana: 4042 (+.2). Thuidium delicatulum: 3037 (+.2). Hylocomium splendens: 3037 (+.2). Mnium hornum: 3037 (+.1). Climacium dendroides: 3037 (+.1).

In the herb layer, species characteristic of rich, wet soils are abundant: *Onoclea sensibilis* L., *Osmunda cinnamomea* L., *Mitella nuda* L., *Equisetum sylvaticum* L., *Coptis groenlandica* (Oeder) Fern. and *Circaea alpina* L. Mosses and hepatics are also common on this site: *Sphagnum* sp., *Mnium punctatum* L., *Bazzania trilobata* (L.) S.F. Gray and *Hylocomium triquetrum* (L.) BGS.

Habitat and Soil:

This type is found in flat hollows with retarded drainage. In the summer, the water table remains at 5 to 10 inches from the surface. The profile is a gley soil with a 5 to 10-inch thick hydromor. Some of the properties of this humus are listed in Table 4.

b. The Elm-Black Ash Association:

Ulmo-Fraxinetum nigrae (*U-Fn*) (Table 10)

Vegetation:

The stand of this association is made up almost entirely of American elm and black ash.

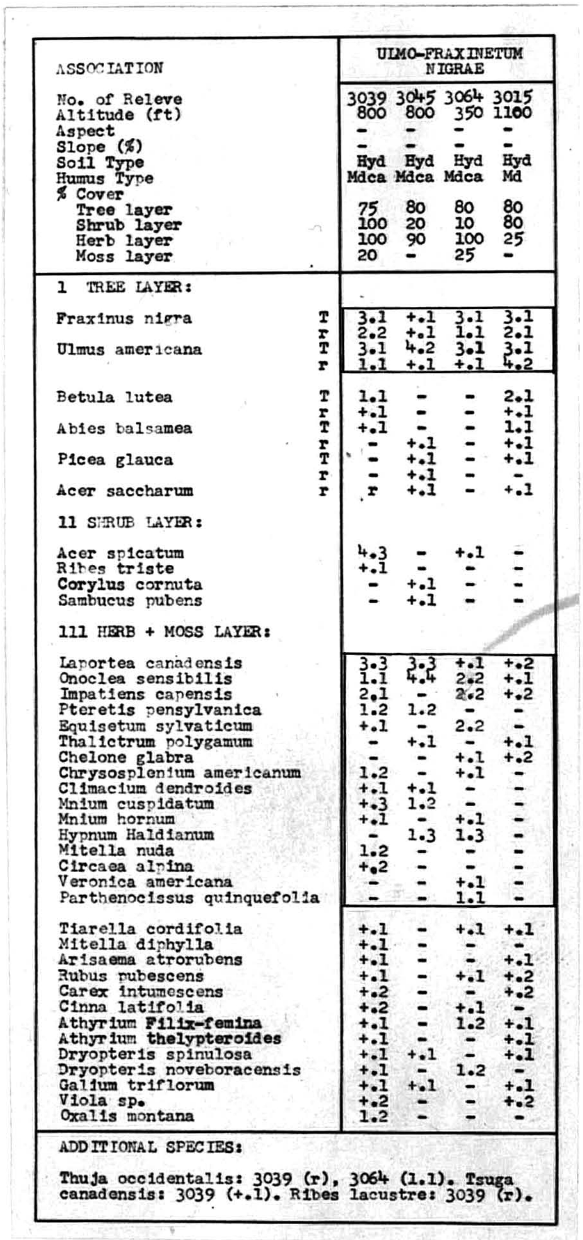
In the lesser vegetation, this association shares some of its species with the *Ulmo-Aceretum sacchari* association. The following species are abundant: *Laportea canadensis*, *Onoclea sensibilis*, *Impatiens capensis*, *Pteretis pensylvanica* and *Equisetum sylvaticum*.

In addition to these, however, a host of hygrophytes are present: *Chrysosplenium americanum* Schwein., *Climacium dendroides* (L.) Web. & Mohr., *Mnium cuspidatum* (L.) Leyrs, *Mnium hornum* L., *Hypnum Haldaniamum* Grev. and *Mitella nuda* L.

Habitat and Soil:

This association occupies wet depressions and lake shores below 1100 feet in the Gatineau-Lièvre trough. It would appear that the presence

Table 10 - The Ulmo-Fraxinetum nigrae association table.



ASSOCIATION		ULMO-FRAXINETUM NIGRAE			
No. of Releve		3039	3045	3064	3015
Altitude (ft)		800	800	350	1100
Aspect		-	-	-	-
Slope (%)		-	-	-	-
Soil Type		Hyd	Hyd	Hyd	Hyd
Humus Type		Mdca	Mdca	Mdca	Md
% Cover					
Tree layer		75	80	80	80
Shrub layer		100	20	10	80
Herb layer		100	90	100	25
Moss layer		20	-	25	-
1 TREE LAYER:					
Fraxinus nigra	T	3.1	+.1	3.1	3.1
	r	2.2	+.1	1.1	2.1
Ulmus americana	T	3.1	4.2	3.1	3.1
	r	1.1	+.1	+.1	4.2
Betula lutea	T	1.1	-	-	2.1
	r	+.1	-	-	+.1
Abies balsamea	T	+.1	-	-	1.1
	r	-	+.1	-	+.1
Picea glauca	T	-	+.1	-	+.1
	r	-	+.1	-	-
Acer saccharum	r	r	+.1	-	+.1
11 SHRUB LAYER:					
Acer spicatum		4.3	-	+.1	-
Ribes triste		+.1	-	-	-
Corylus cornuta		-	+.1	-	-
Sambucus pubens		-	+.1	-	-
111 HERB + MOSS LAYER:					
Laportea canadensis		3.3	3.3	+.1	+.2
Onoclea sensibilis		1.1	4.4	2.2	+.1
Impatiens capensis		2.1	-	2.2	+.2
Pteretis pensylvanica		1.2	1.2	-	-
Equisetum sylvaticum		+.1	-	2.2	-
Thalictrum polygamum		-	+.1	-	+.1
Chelone glabra		-	-	+.1	+.2
Chrysosplenium americanum		1.2	-	+.1	-
Climacium dendroides		+.1	+.1	-	-
Mnium cuspidatum		+.3	1.2	-	-
Mnium hornum		+.1	-	+.1	-
Hypnum Haldianum		-	1.3	1.3	-
Mitella nuda		1.2	-	-	-
Circaea alpina		+.2	-	-	-
Veronica americana		-	-	+.1	-
Parthenocissus quinquefolia		-	-	1.1	-
Tiarella cordifolia		+.1	-	+.1	+.1
Mitella diphylla		+.1	-	-	-
Arisaema atrorubens		+.1	-	-	+.1
Rubus pubescens		+.1	-	+.1	+.2
Carex intumescens		+.2	-	-	+.2
Cinna latifolia		+.2	-	+.1	-
Athyrium Filix-femina		+.1	-	1.2	+.1
Athyrium thelypteroides		+.1	-	-	+.1
Dryopteris spinulosa		+.1	+.1	-	+.1
Dryopteris noveboracensis		+.1	-	1.2	-
Galium triflorum		+.1	+.1	-	+.1
Viola sp.		+.2	-	-	+.2
Oxalis montana		1.2	-	-	-

ADDITIONAL SPECIES:

Thuja occidentalis: 3039 (r), 3064 (1.1). Tsuga canadensis: 3039 (+.1). Ribes lacustre: 3039 (r).

of calcareous parent material is also important if we consider the calcium content of the calcic hydromoder developed on this site. The soil is a hydromorphic soil (Hyd) (not a gley) with a thick ($\geq$ 10 in.), well-decomposed, water-saturated moder rich in calcium (Mdca). Some of its properties are also listed in Table 4.

Ecological Relationships

To understand properly the ecological relationships between the various ecosystems described, it is necessary to first sort them out regionally.

The sub-associations *Betulo-Aceretum saccharí taxetosum*, *Betulo-Aceretum sacchari fagetosum* and *Fago-Aceretum sacchari oxaletosum* represent the north-south community variation on the glaciated uplands. In the Gatineau-Lièvre trough the *Fago-Aceretum sacchari oxaletosum* is replaced by *Fago-Aceretum sacchari tilietosum* between 1100 feet and the 700-feet level which represents the maximum invasion of the Champlain Sea. Below 700 feet the dominant community on mesic sites is *Tilio-Aceretum sacchari*.

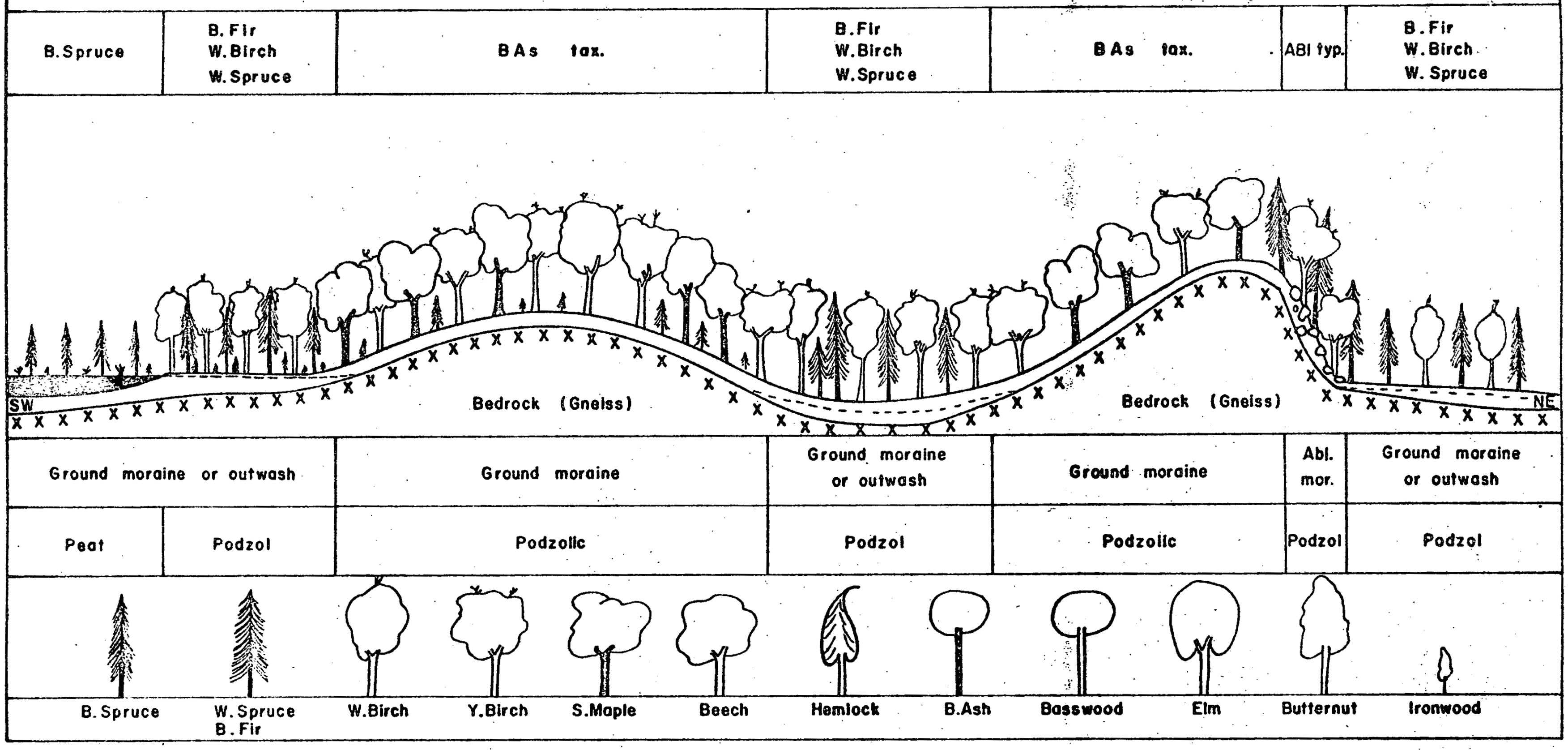
The other communities gravitate around these central communities and the interrelationships can best be shown by regional generalized ecological transects (Figs. 20-24). In the Belleterre area (Fig. 20) which is, as mentioned before, at the borderline of B-7 and L-4, only two tolerant hardwood types were found. The sub-association *Betulo-Aceretum sacchari taxetosum* occupies knoll tops and slopes with a moderately deep till mantle (23 in. +) while the *Abieti-Betuletum luteae typicum* is found on the steep cold rocky slopes with lateral moraines or ablation tills as well as on well-drained valley trains.

FIG. 20

FOREST HABITAT TYPES

(GENERALIZED ECOLOGICAL SERIES)

A) BELLETERRE AREA



In the Kipawa area, these two types occupy the same habitats. On knoll tops, however, with a thin solum (less than 25 in.) and drier, hotter conditions, the *Betulo-Aceretum sacchari taxetosum* is replaced by *Ostryo-Aceretum sacchari*. On slopes facing large lakes, the *Abieti-Betuletum luteae tsugetosum* replaces also the typical sub-association.

In the Dumoine area (Fig. 21) the climax community on fresh sites is *Betulo-Aceretum sacchari fagetosum* while the humid variant occupies weak slopes with retarded drainage. The two sub-associations of the *Abieti-Betuletum luteae* again occupy the steep cold rocky slopes and well-drained valley trains, the sub-association *tsugetosum* again favouring lake side slopes. In the southern portion of this area, the dry knoll tops are also occupied by *Ostryo-Aceretum sacchari*. Finally in small catchment basins, waterlogged soils support stands of the *Betulo-Fraxinetum nigrae* association, but these stands are never extensive.

In the Gatineau-Lièvre-Mont-Tremblant area a threefold subdivision seems warranted, governed both by altitude and geology.

Above 1100 feet (Fig. 22) and apparently above the limit of extension of the Grenville series, the fresh sites are occupied by the *Fago-Aceretum sacchari oxaletosum* type. The *Abieti-Betuletum luteae* again occupies the same sites as in the preceding areas. The same is also true for the *Betulo-Fraxinetum nigrae* and the *Ostryo-Aceretum sacchari*. In addition, alluvial flats and lower slopes with moist soils support the *Betulo-Aceretum sacchari tiarelletosum* while wetter soils of the flats support the *Ulmo-Fraxinetum nigrae* type.

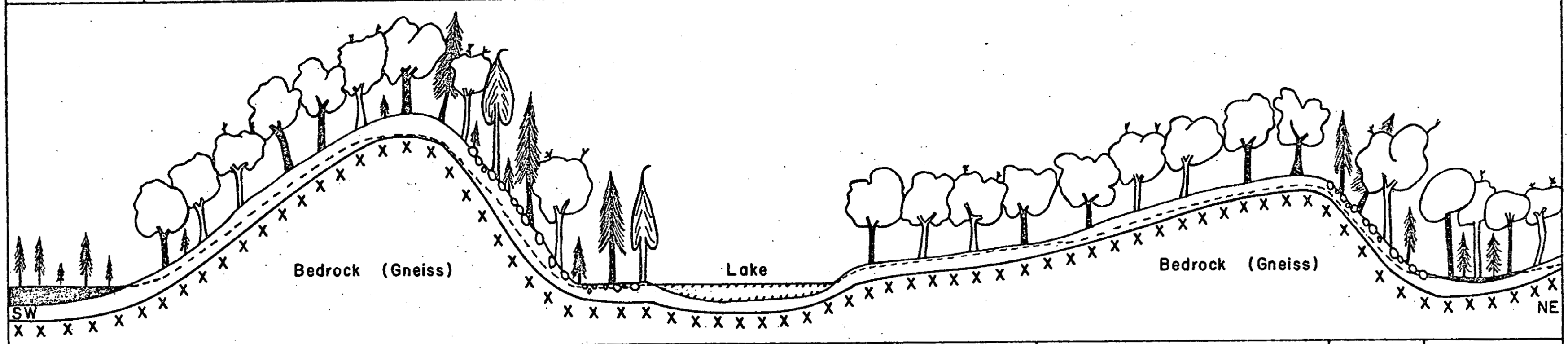
At elevations between 700 and 1100 feet (Fig. 23), that is above the limit of the Champlain Sea invasion but in the area of

FIG. 21

FOREST HABITAT TYPES

(GENERALIZED ECOLOGICAL SERIES)

B) DUMOINE AREA



B.Spruce	BAs fag.	ABl tsu.			BAs fag. var. humid	BAs fag.	ABl typ.	BFn
Ground moraine		Ablation moraine	Valley train		Ground moraine + lacustrine material	Ground moraine	Ablation moraine	Ground moraine
Peat	Podzolic	Podzol	Podzol		Podzolic marmorized	Podzolic	Podzol	Gley

FIG. 22

FOREST HABITAT TYPES

(GENERALIZED ECOLOGICAL SERIES)

C) GATINEAU-LIEVRE-MONT TREMBLANT AREA (>1100')

FAs ox.	ABl tsu.		UFn.	BAs tla.	FAs ox.	ABl typ.	BFn	FAs ox.
Ground moraine	Ablation moraine		Lacustrine deposits		Ground moraine	Ablation moraine	Ground moraine	
Podzolic	Podzol		Hydromorphic	Acid brown	Podzolic	Podzol	Gley	Podzolic

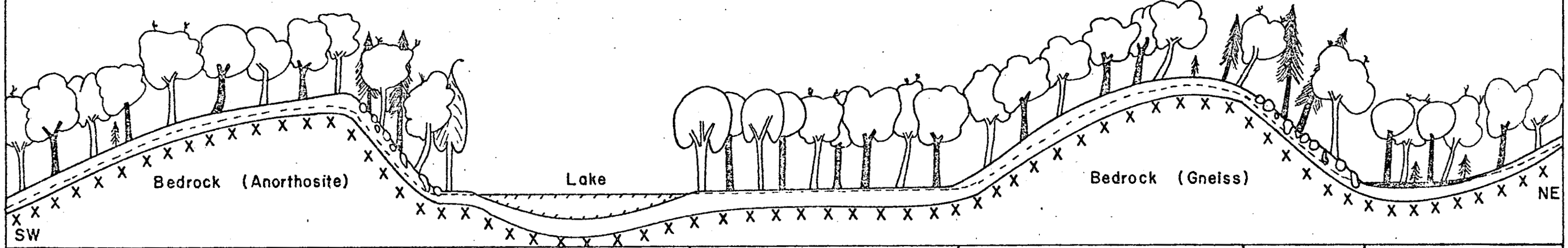
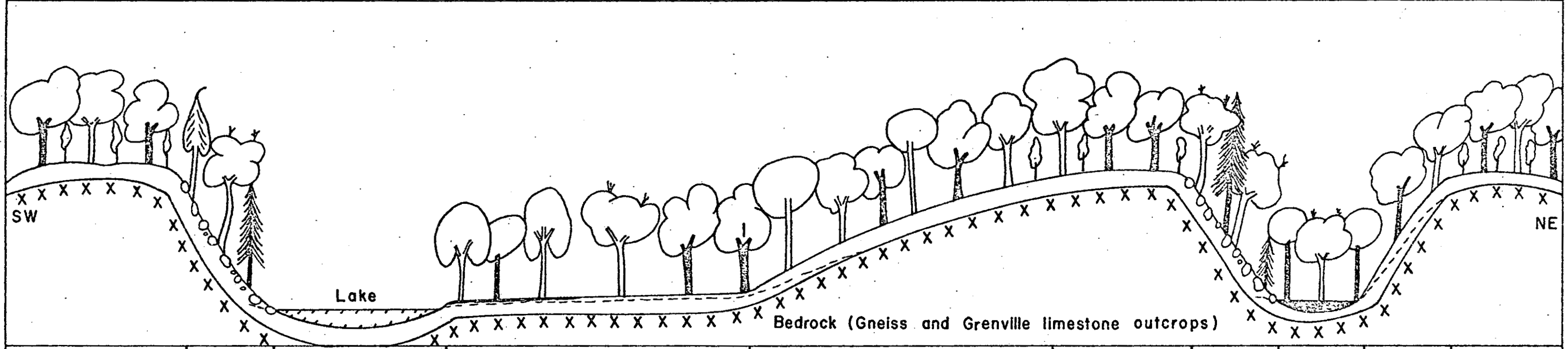


FIG. 23

FOREST HABITAT TYPES

(GENERALIZED ECOLOGICAL SERIES)

D) GATINEAU-LIEVRE-MONT TREMBLANT AREA (700' < X < 1100')



OAs	A Bl tsu.		UFn	BAs tia.	FAs til.	OAs	A Bl typ.	BFn	FAs pol.	OAs
Thin moraine	Ablation moraine		Lacustrine deposits		Ground moraine	Thin moraine	Ablation moraine	Ground moraine	Moraine + colluvium	Thin moraine
Podzolic	Podzol		Hydromorphic	Acid brown	Brown podzolic	Podzolic	Podzol	Gley	Acid brown	Podzolic

abundant limestone outcrops, the same habitats support the same types. Basswood, however, becomes a regular component of the stands, particularly on the fresh sites, where the climax community becomes *Fago-Aceretum sacchari tilietosum*. A few steep slopes of fresh loamy colluvium are also occupied by the sub-association *Fago-Aceretum sacchari polystichetosum*. The latter, incidentally, also occurs sporadically in the same conditions above 1100 feet.

Below the 700-foot level (Fig. 24) on Champlain Sea fresh and brackish water deposits the climax association on fresh sites becomes *Tilio-Aceretum sacchari typicum*. The dry knoll tops are occupied by *Ostryo-Aceretum sacchari*, the steep calcareous stony slopes by the FAS *juglantetosum* sub-association and the flats by *Ulmo-Aceretum sacchari* and *Ulmo-Fraxinetum nigrae* on the very moist and wet soils respectively.

CONCLUSION

The ecological descriptions just presented permit an easy identification of each ecosystem on the ground as well as on aerial photos. They also permit a qualitative estimate of their potential productivity. From north to south, an increase in potential productivity parallel to an increase in total heat accumulation (growing degree-days) is to be expected. Locally, retarded or excessive drainage will also lower the site productivity in comparison to the mesic sites.

Potential productivity of each ecosystem in relation to individual species can also be estimated from the relative abundance and ease of regeneration of these species in each ecosystem. The amount of silviculture necessary to maintain or encourage a given species is also indicated.

For a quantitative estimate of productivity however the use of mensuration methods is necessary. This is the subject of the following chapter.

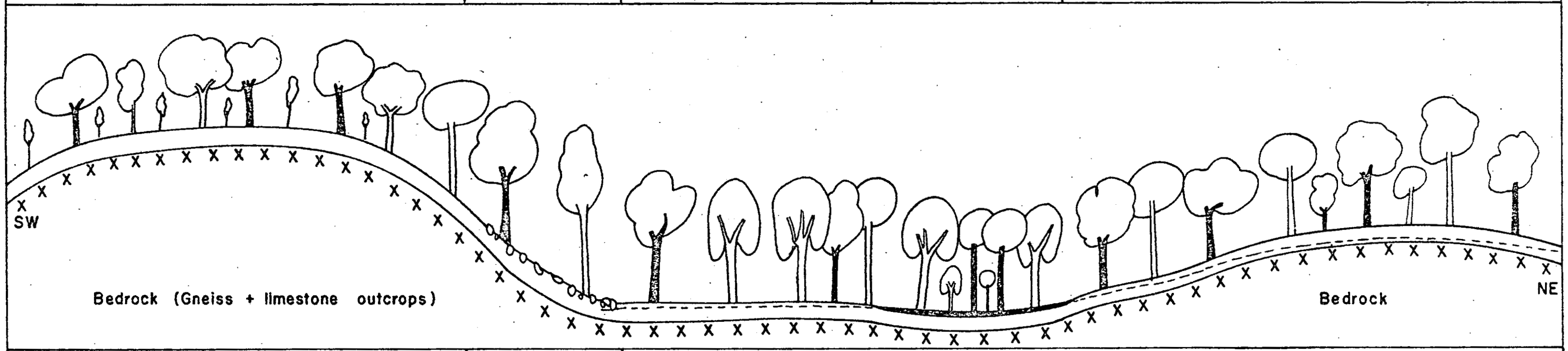
FIG. 24

FOREST HABITAT TYPES

(GENERALIZED ECOLOGICAL SERIES)

E) GATINEAU-LIEVRE AREA (< 700')

OAs	TAs jug.	UAs	UFn	TAs typicum



Thin moraine	Ablation moraine + colluvium	Champlain Sea fresh and brackish water deposits. Beach sands.		
Podzolic	Brown forest	Brown gley	Gley	Brown forest (moist)

PART III

PRODUCTIVITY

INTRODUCTION

The ultimate purpose of any site classification is not just to separate ecosystems for the sake of classification alone. Site classification is also concerned with the determination of the productivity, actual or potential, of a given tract of land. Site classification itself can already be used for a qualitative estimation of productivity but we also need a quantitative evaluation. The terms in which this productivity is to be evaluated depend on the purpose of the investigation. Both quantity and quality and money value of products can be utilized. Money value however is subject to fluctuating market conditions and, consequently, is not a stable criterion of productivity.

Biomass production per unit area (or space) might be the most exact measurement of quantitative productivity of an ecosystem, but at the moment it must remain a theoretical goal of ecology, difficult to realize in practice and of little use anyway in forestry. The same can be said of total production of cellulose or fiber. It is true that twigs and shrubs could be converted to pulp or other products, but the present harvesting and converting techniques and equipment cannot economically handle this small-size material. The obvious goal of forestry evaluation of sites is then to find how much tree-wood each can produce. This productivity is ultimately expressed as volume of tree-wood per unit area per unit time: in North America, as cubic feet per acre per year (Spurr 1952). But volume per acre is dependent not only on the size of trees, but also on their number per acre, in other words dependent also on stand density. What constitutes full-stocking for a given type of forest is highly subjective in practice. Even if, theoretically, a standard of full-stocking can be established (Krajicek et al. 1961) (Vézina 1962), full-stocked stands are still uncommon and what is more, stand density is in most cases unrelated to site.

Growth behaviour of individual trees remains the only reliable mensurational criterion of site quality. But even that must be handled with care. Height growth, for instance, has long been recognized as the parameter least affected by stand density in even-aged stands and average height of dominants and codominants at different ages has been used to prepare height growth curves to be used as indices of site quality. There are however notable cases where height growth has been seriously curtailed by overstocking, in lodgepole pine and balsam fir stands for instance. There are also cases where height growth was held back for some years periodically by insect attacks, v.g. jack pine by the sawfly and balsam fir, by the budworm. In both instances, ecological knowledge of the sites and stem analyses will point out these irregularities which must be dropped or corrected if the evaluation of site productivity is to make sense.

It must be noted again that the trees measured and used to evaluate site productivity in even-aged stands are the dominants and codominants (in some cases only the dominants), that is the best trees in the stand, the trees which have the greatest chance of reaching maturity or have reached it and have been free to grow in height throughout most of their lives, though often more or less restricted in diameter growth by density.

In the case of undisturbed all-aged stands, such trees are the exception. Here, the individual tree is generally submitted throughout most of its youth to entirely different sociological conditions. It is engaged in a constant struggle for growing space, suppressed both from above and from the sides. The species growing in this sort of environment are fierce competitors. When the competition is too strong they abide their time, but as soon as it lets down, they make the most of it. These ups and downs in growing space usually repeat themselves more than once before a tree reaches the upper canopy as can be seen from stem analyses. The trees that manage to survive and reach the upper canopy show a tremendous variation in age (from 50 to 150 years on the average) in the same stand on the same uniform site.

If, as in even-aged stands, the best looking and most healthy trees in each diameter class are studied through stem analysis, the average rate of growth under undisturbed conditions as well as the average maximum rate of growth of free-growing trees can be evaluated.

In the present case, a complete study of height and diameter growth by stem analysis of hundreds of hardwood trees would have been an enormous task. The stem analyses were restricted to diameter growth and the results applied to height growth as explained later on.

METHODS OF STUDY

In each fifth-acre plot established, a complete count was made of all trees 0.6 inch. d.b.h. and over by species, crown classes and one-inch d.b.h. classes. Twenty to twenty-five of the better looking trees, distributed evenly in all diameter classes and including all hardwood species present, were measured for d.b.h. (to the nearest 0.1 inch), bark thickness (to the nearest 0.05 inch), total height and commercial height (height to the first major fork or branch beyond which no log could be cut). Diameters up to 24 inches were measured with a steel caliper, others with a diameter tape. Heights were measured with an Abney level at minimum distances of 80 to 100 feet.

For age counts and diameter growth studies, trees 3 inches or less at breast height were cut and sections collected at stump height and breast height. All others were bored at breast height along the estimated average radius, Sections and increment cores were brought into camp to be studied with hand-lens and microscope. Age counts were made from the back in and each decade marked with a pencil and measured to the nearest .05 inch. Usually back-lighting of moist cores was sufficient for accurate ring counts, but in some instances phloroglucinol was necessary to accentuate separation of growth rings.

Age differences between stump and breast height varied from 2 to 20 years with an average of 10 irrespective of site. Because of the difficulty of getting sound cores at the stump on the larger trees, height and d.b.h. values in this paper are related to age at d.b.h. for all trees.

Growth was measured from the bark in and the cores checked for exceptional growth periods due to climatic conditions or epidemics. Measuring growth by decades lessened the influence of the odd exceptional year of growth due to more favorable climatic conditions. About thirty per cent of the trees sampled, particularly the larger ones, were too rotten at the center to be used directly for age counts. These trees however were retained for the calculation of the height-d.b.h. relationships and comparison of the growth by decades of their sound portion with the basic data from the sound or just discolored trees.

RESULTS

The all-aged structure of the stands seemed quite obvious at first sight. It was nevertheless checked by an analysis of the size and

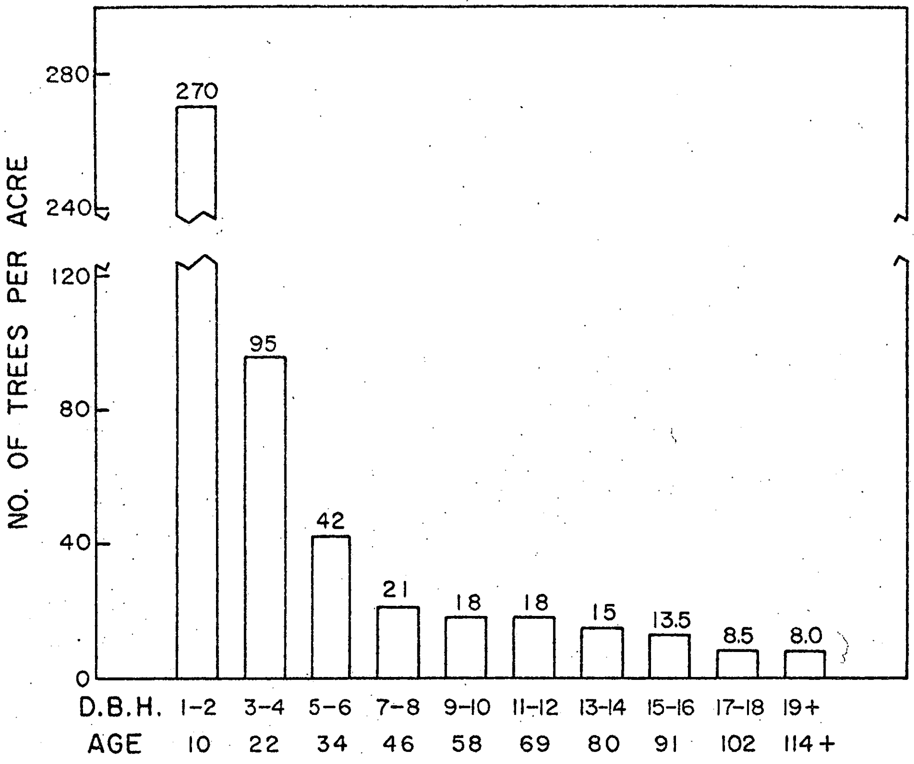


FIG. 26 STRUCTURE OF ONE PLOT OF THE FAGO-ACERETUM SACCHARI OXALETOSUM ECOSYSTEM TYPE.

age distribution of the trees. As an example, Figure 26 shows the results for one typical plot of the Fago-Aceretum saccheri association. All stands showed this typical inverted J-shaped curve. Steepness of the curve varies however from plot to plot.

In the office, once the ecological classification was completed, the data were sorted out by ecosystem types. For each species in each ecosystem type scatter-diagrams were prepared for height over diameter, height over age at breast height and diameter over age at breast height.

The Height-D.B.H. Relationship

The height d.b.h. curve had been suggested by some authors (McLintock and Bickford 1957) as a site index curve for uneven-aged stands.

This suggestion was particularly tempting to test for, of the three series of scatterdiagrams, only those of height over d.b.h. showed a close cropping of points and allowed the tracing of a decent curve. The variation about the curve was about 10 feet both for the individual plots and for the plot groups in each ecosystem type (see Figs. 27 to 48).

When the average curves for the different ecosystems were compared, however, the difference between the highest and the lowest was also about 10 feet (Fig. 49). For the sake of clarity, only five of the curves are represented in the figure. The others overlapped these five. There were two possible explanations for the behaviour of these curves: either the difference in site quality was really small between the ecosystems studied or the height-d.b.h. relationship is a poor indicator of site quality. Though the first possibility could not be excluded altogether, the second possibility seemed more probable for the difference in productivity between two sites resides not so much in the difference between actual tree sizes as in the difference in the time necessary to reach those sizes. So attention was directed to the height-age and diameter-age relationships. In both cases, age was used as the independent variable. In this investigation we were not interested so much in the age variation of a tree of a given size as in the average size of tree to be expected after a certain number of years. This average tree size can be used as an indicator of site productivity and in growth predictions for management.

The Diameter-Age Relationship

As mentioned earlier, decennial diameter growth inside bark was measured by stem analysis on all sample trees that were sound enough.

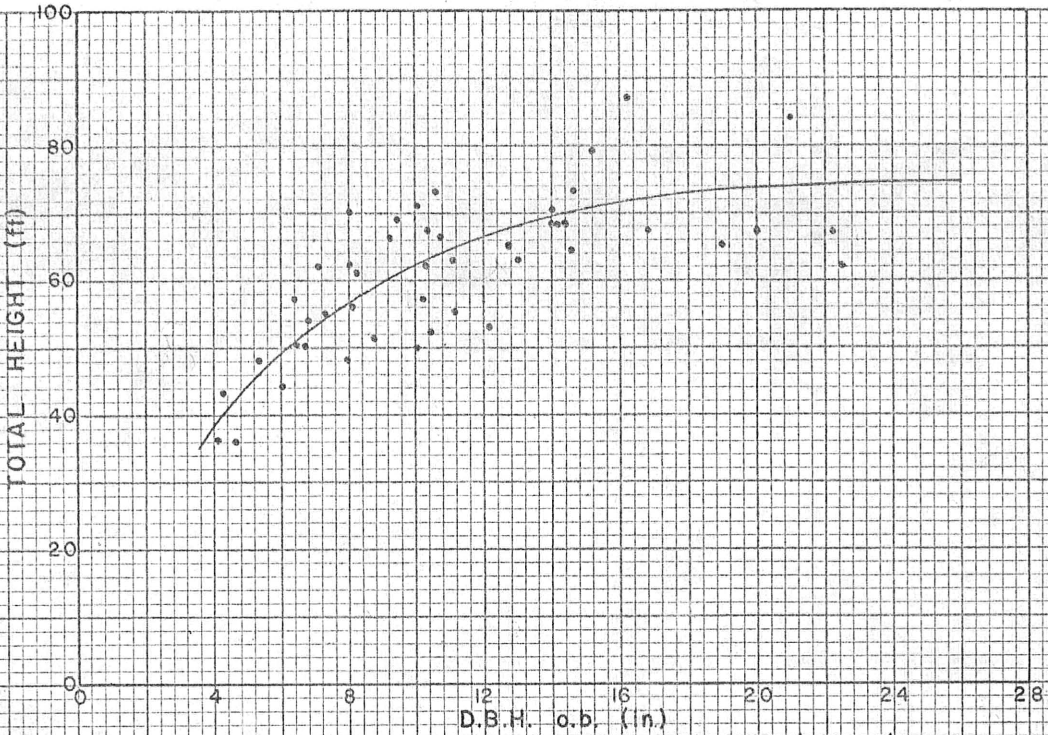


FIG. 27 TOTAL HEIGHT – D.B.H. RELATIONSHIP (s.Maple)
BAs tax. Type

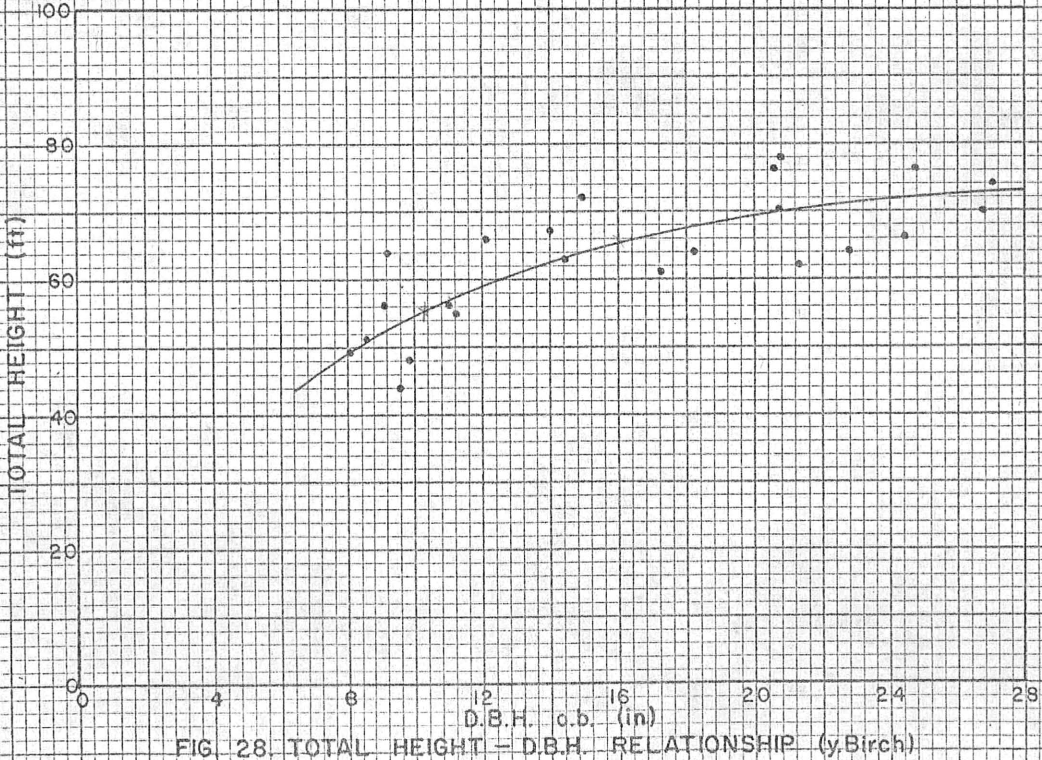


FIG. 28. TOTAL HEIGHT – D.B.H. RELATIONSHIP (y.Birch)
BAs tax. Type

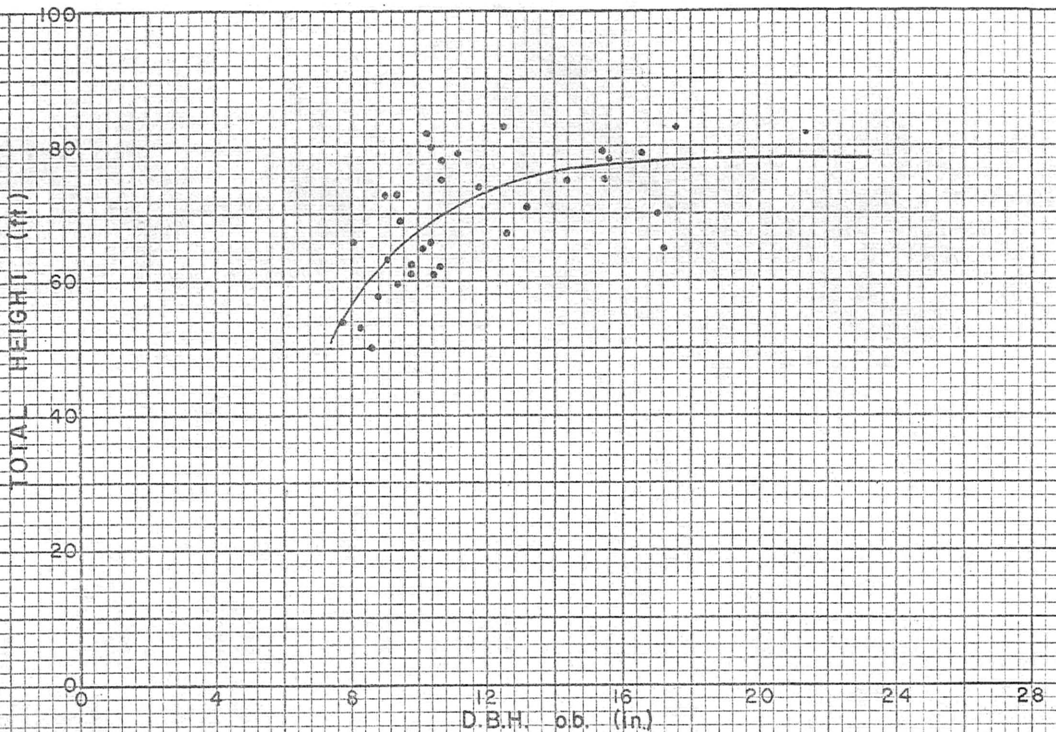


FIG. 29. TOTAL HEIGHT – D.B.H. RELATIONSHIP (s.Maple + Beech)
BAs fag. Type

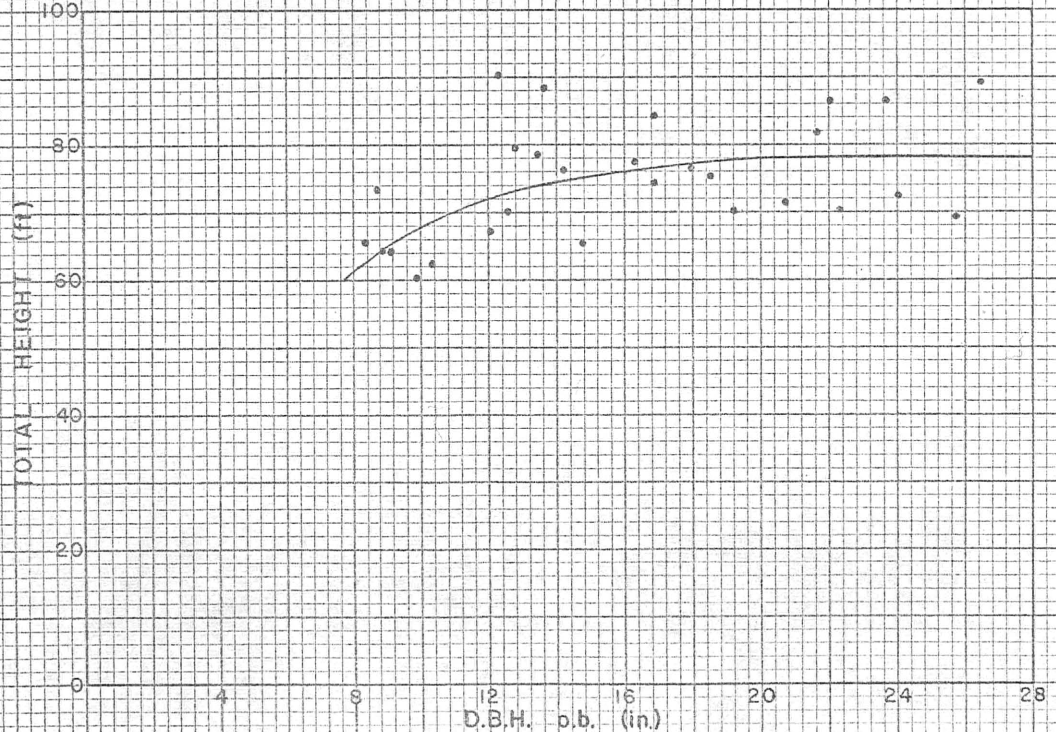


FIG. 30. TOTAL HEIGHT – D.B.H. RELATIONSHIP (y.Birch)
BAs fag. Type

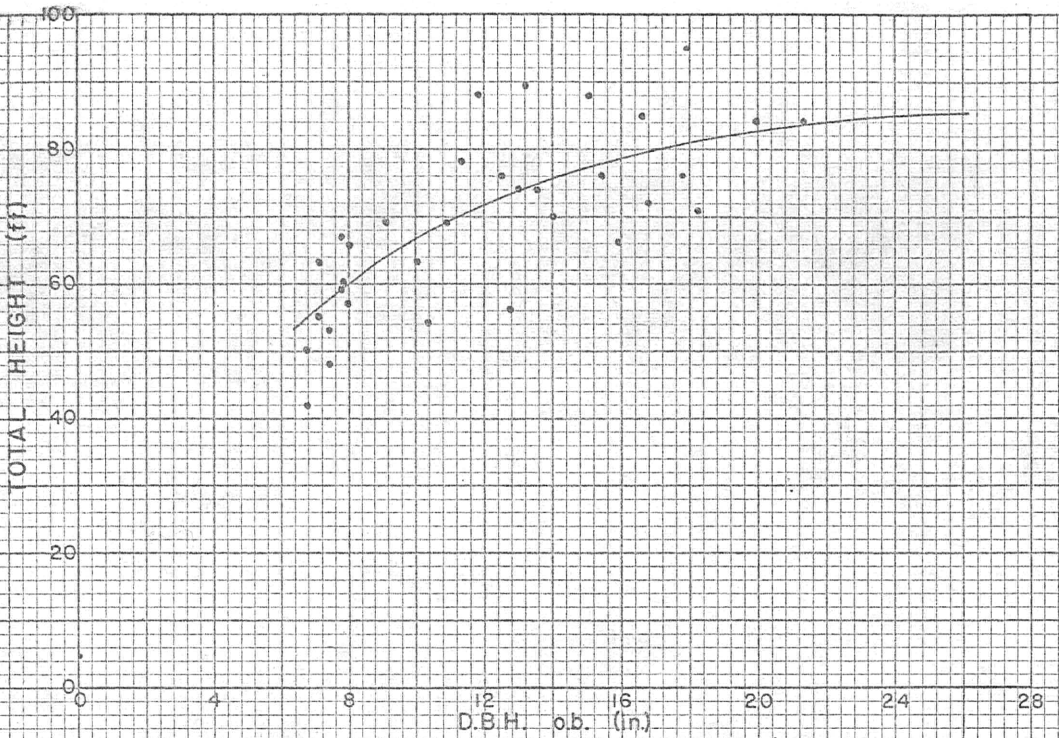


FIG. 31 TOTAL HEIGHT – D.B.H. RELATIONSHIP (s.Maple+Beech)
BAs fag. var. humid. Type

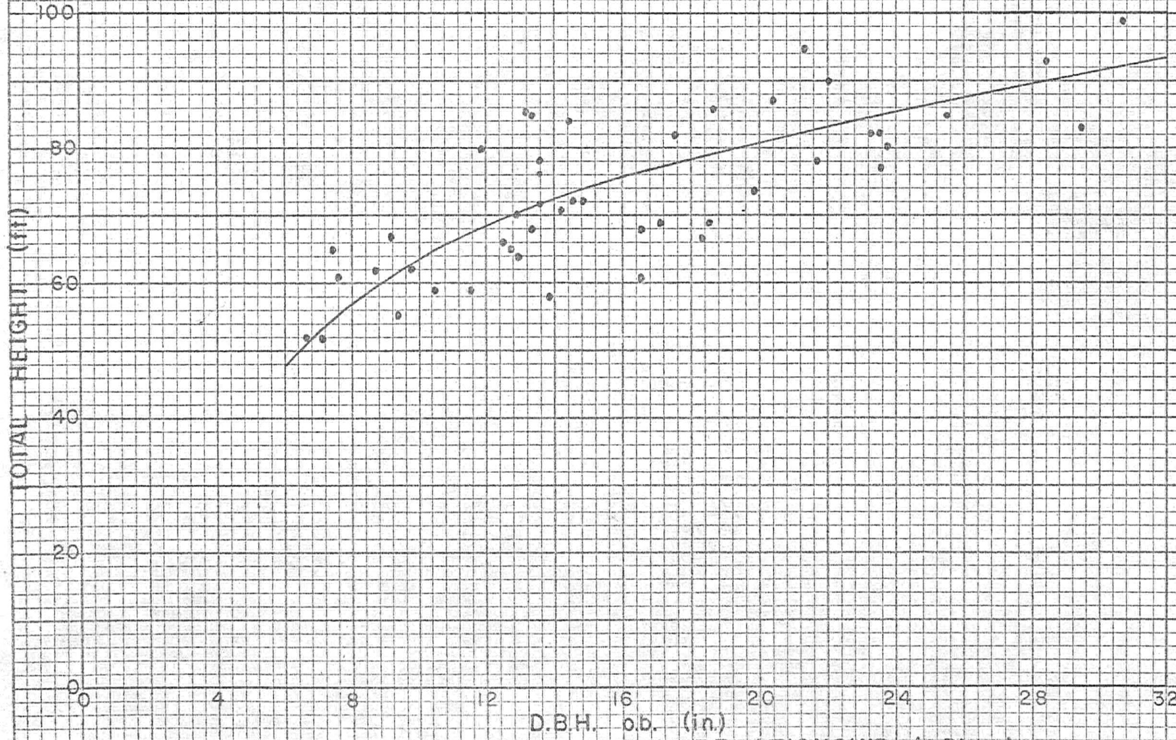


FIG. 32. TOTAL HEIGHT – D.B.H. RELATIONSHIP (y.Birch)
BAs fag. var. humid. Type

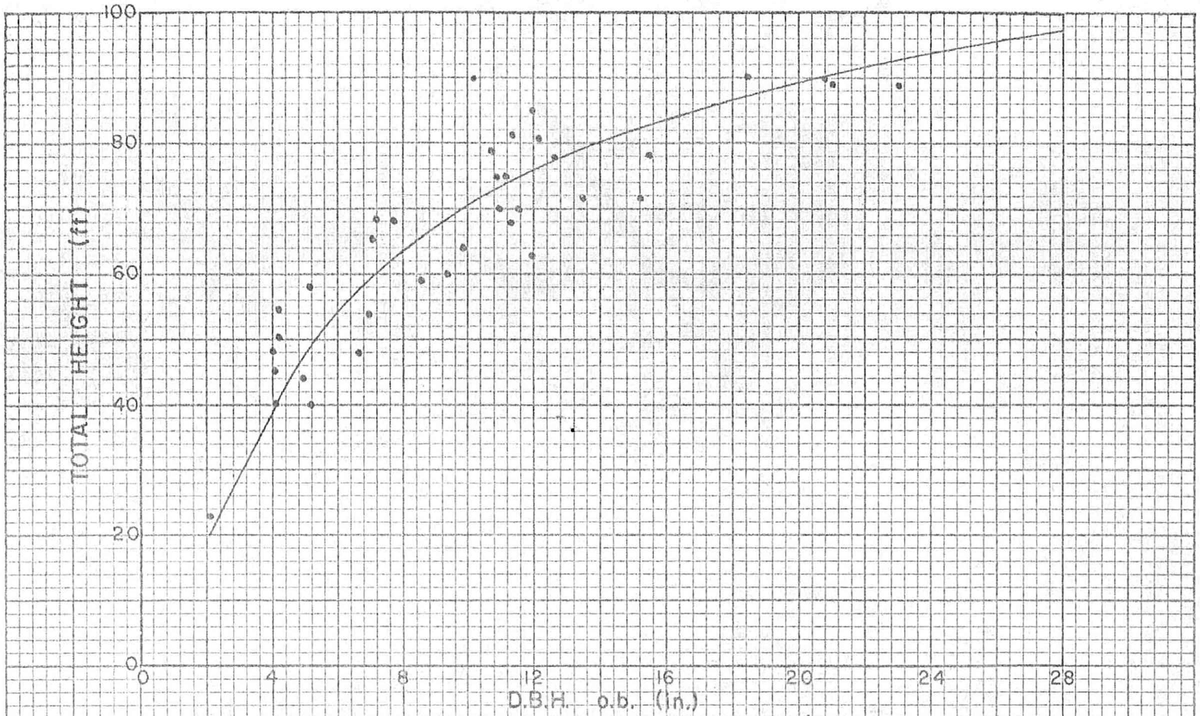


FIG. 33 TOTAL HEIGHT – D.B.H. RELATIONSHIP (s.Maple + b.Ash)
BAs tiar. Type

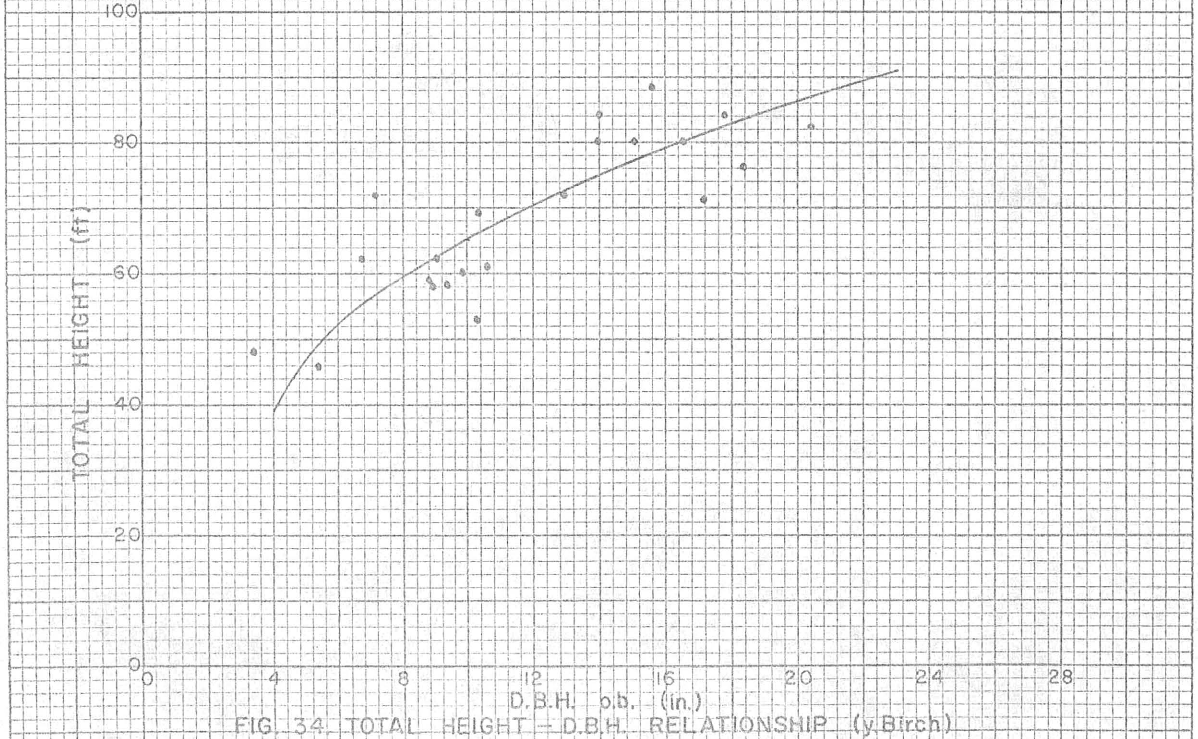


FIG. 34 TOTAL HEIGHT – D.B.H. RELATIONSHIP (y.Birch)
BAs tiar. Type

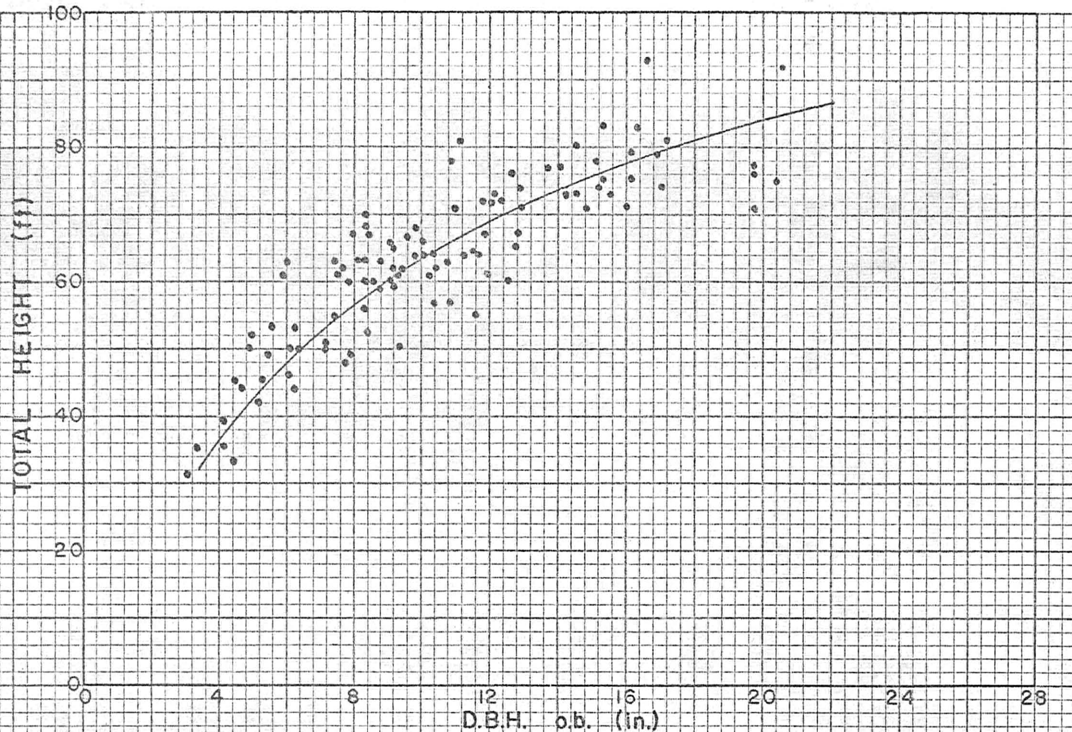


FIG. 35. TOTAL HEIGHT – D.B.H. RELATIONSHIP (s.Maple + Beech)
FAs ox. Type

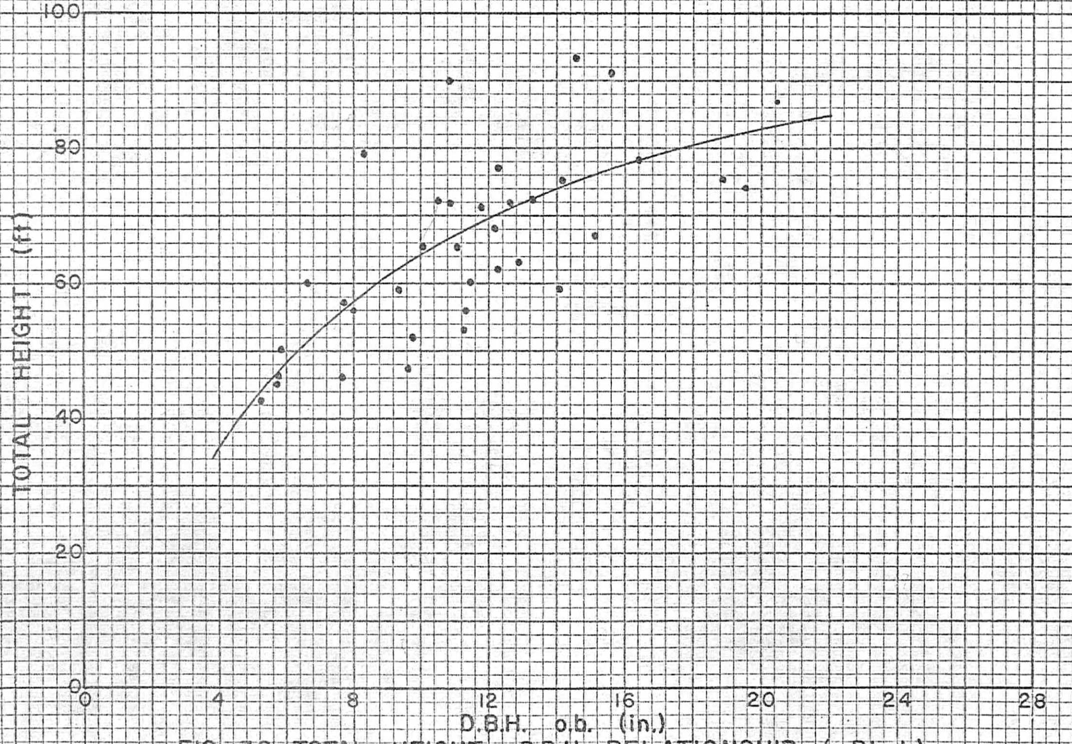


FIG. 36. TOTAL HEIGHT – D.B.H. RELATIONSHIP (y.Birch)
FAs ox. Type

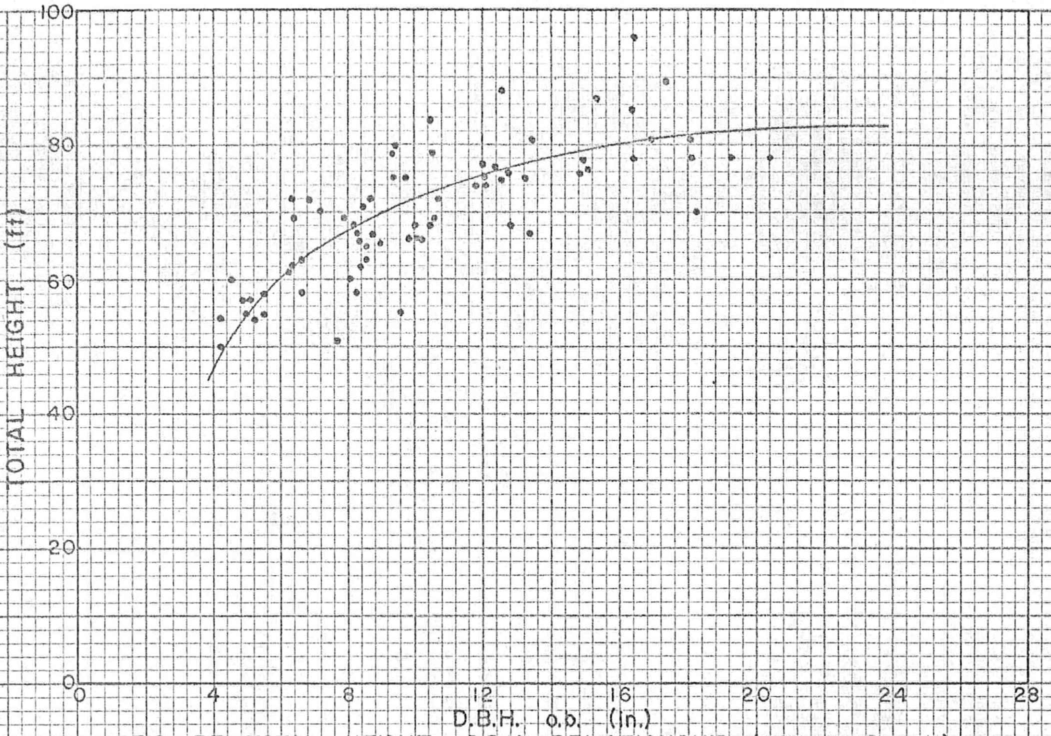


FIG. 37 TOTAL HEIGHT – D.B.H. RELATIONSHIP (s.Maple+Beech)
FAs til. Type

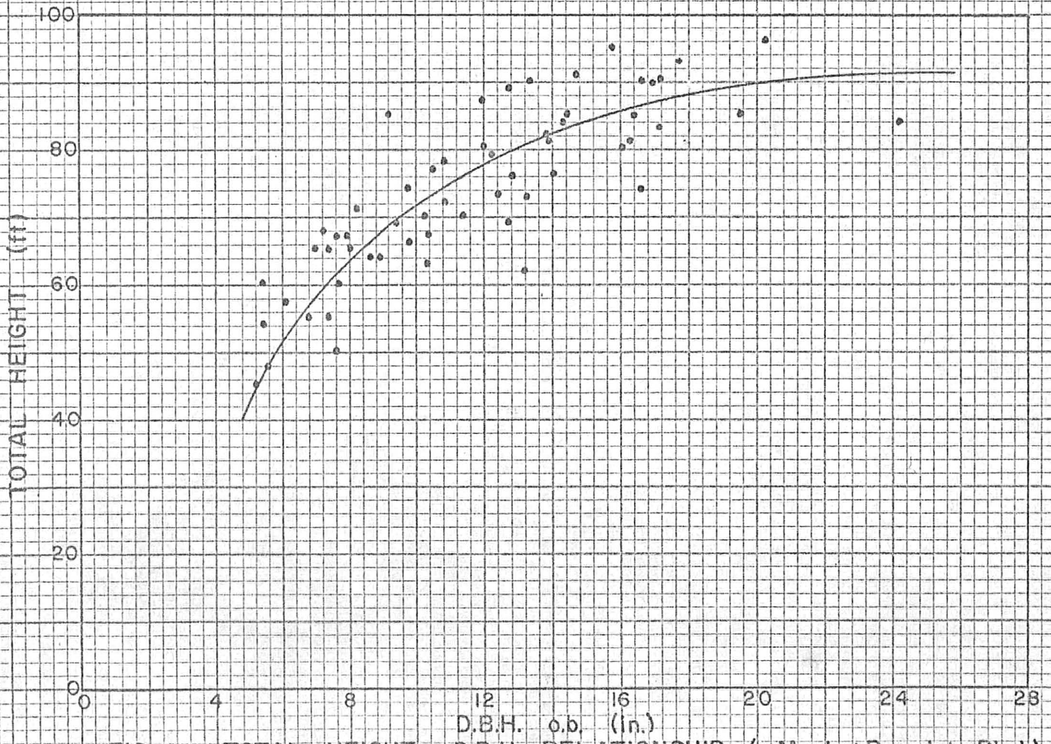


FIG. 38. TOTAL HEIGHT – D.B.H. RELATIONSHIP (s.Maple+Beech+y.Birch)
FAs pol. Type

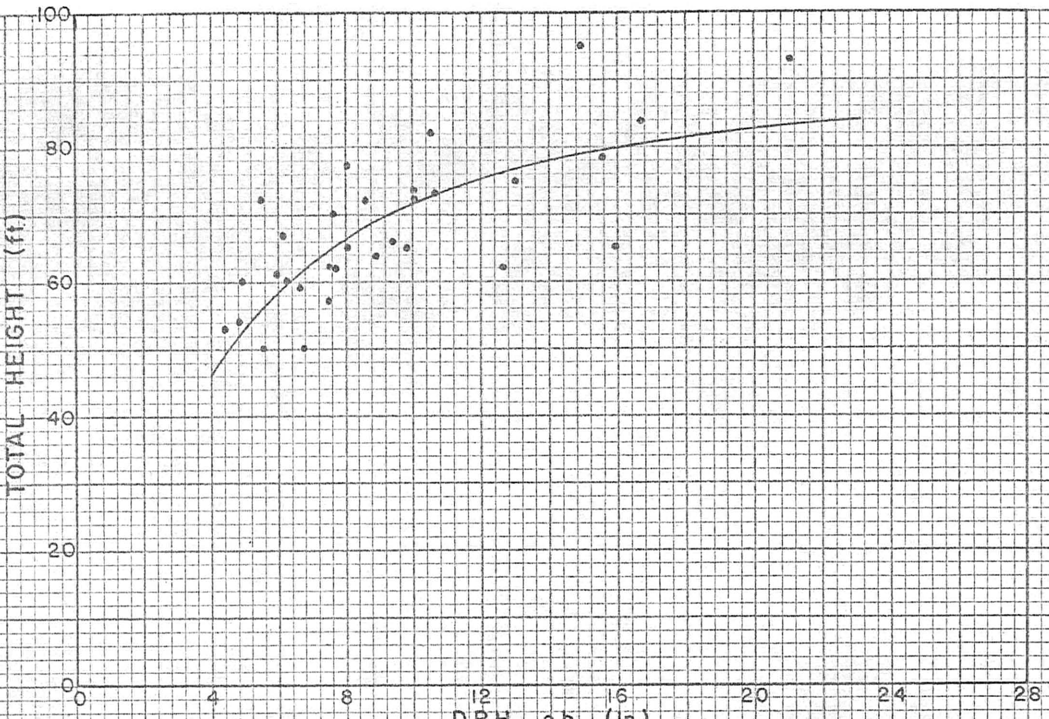


FIG. 39. TOTAL HEIGHT – D.B.H. RELATIONSHIP (s.Maple + Beech)
TAs Type

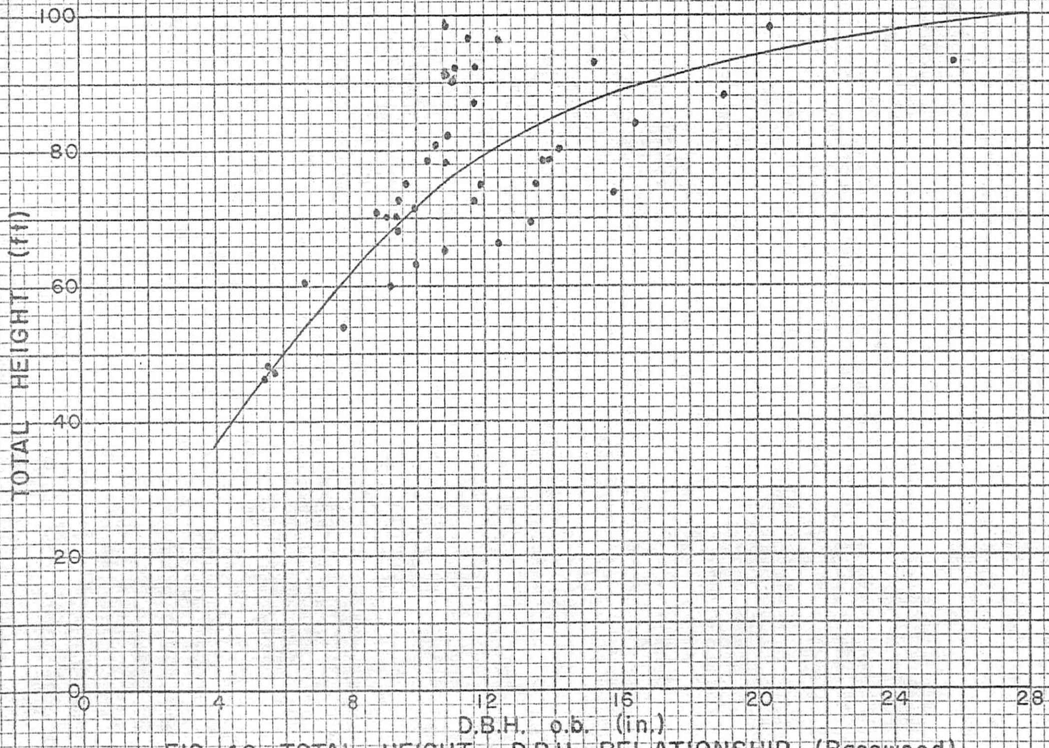


FIG. 40. TOTAL HEIGHT – D.B.H. RELATIONSHIP (Basswood)
TAs Type

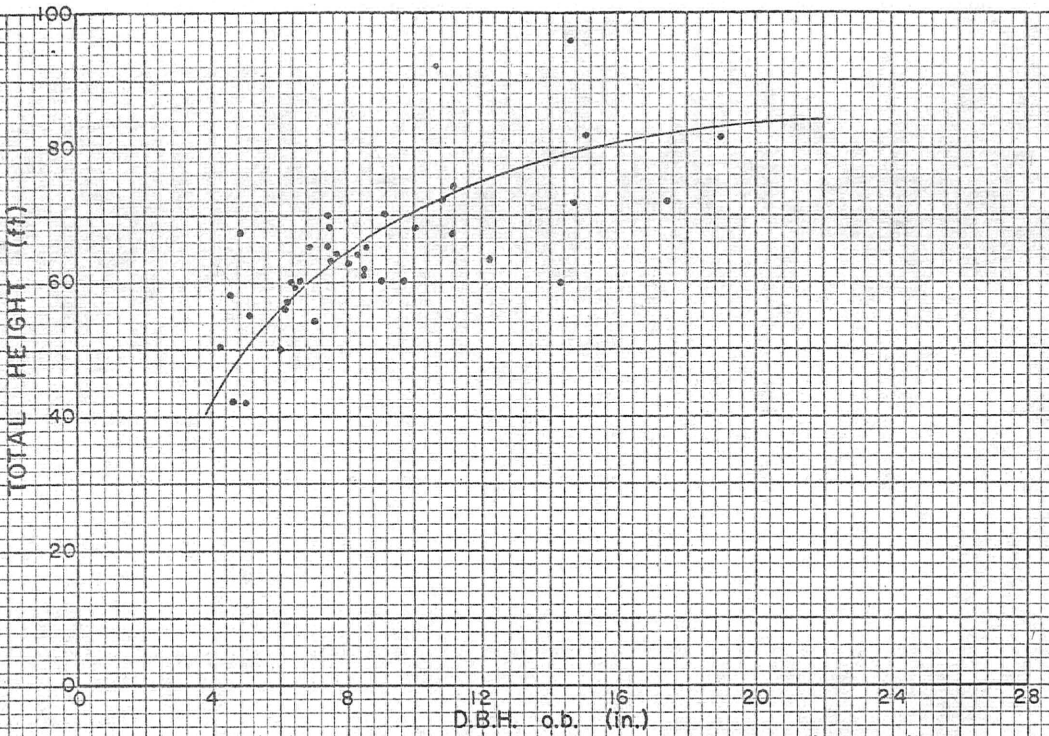


FIG. 41. TOTAL HEIGHT – D.B.H. RELATIONSHIP (s.Maple)
UAs Type

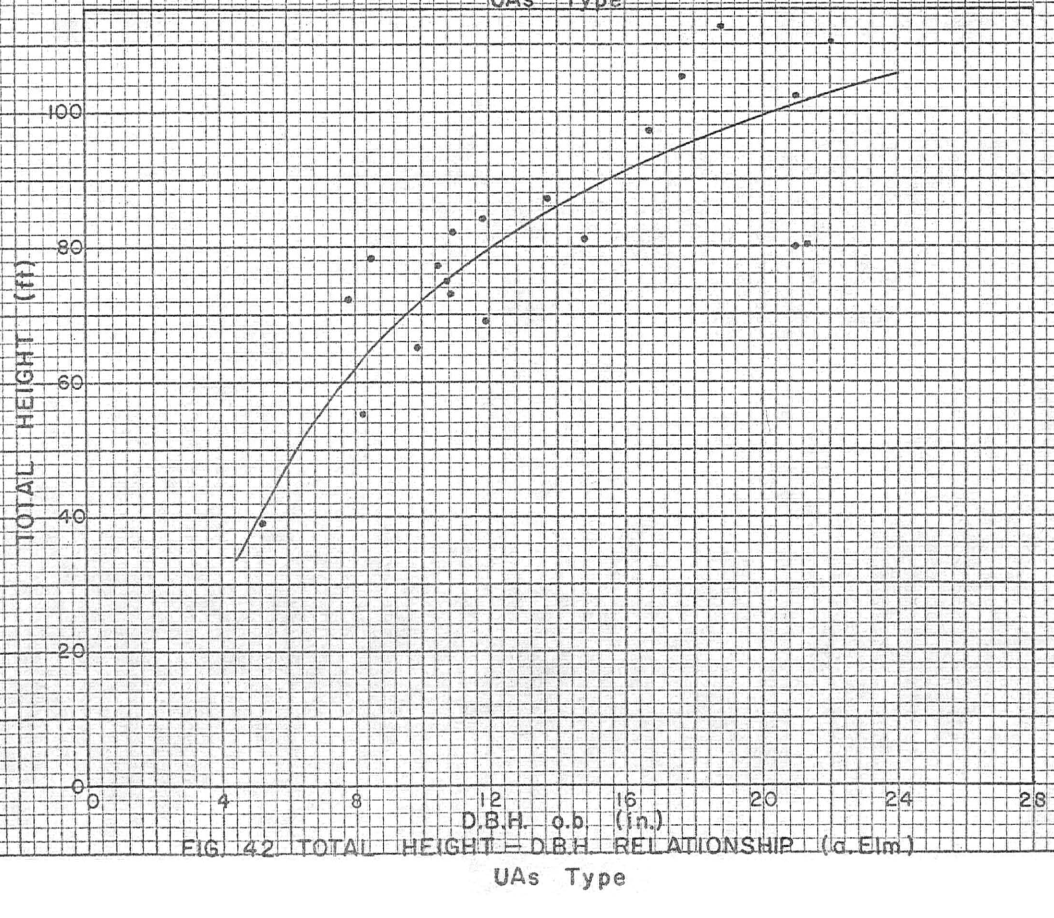


FIG. 42 TOTAL HEIGHT – D.B.H. RELATIONSHIP (a.Elm)
UAs Type

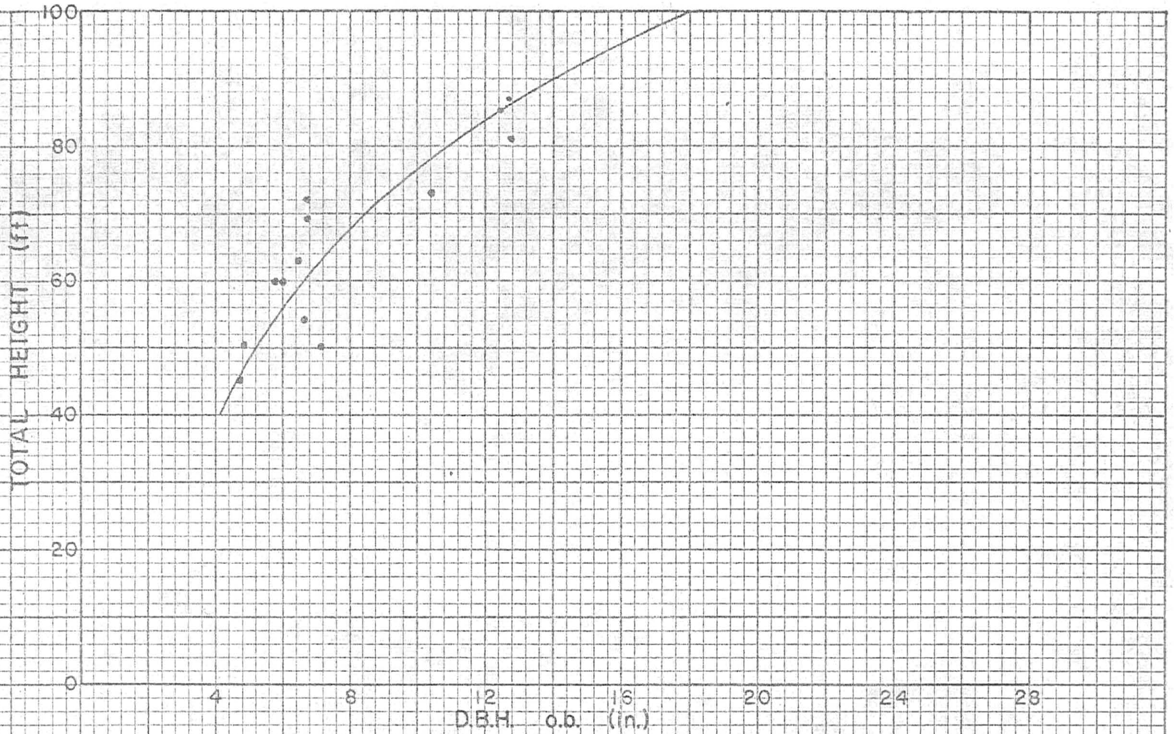


FIG. 43. TOTAL HEIGHT – D.B.H. RELATIONSHIP (b.Ash)
UAs Type

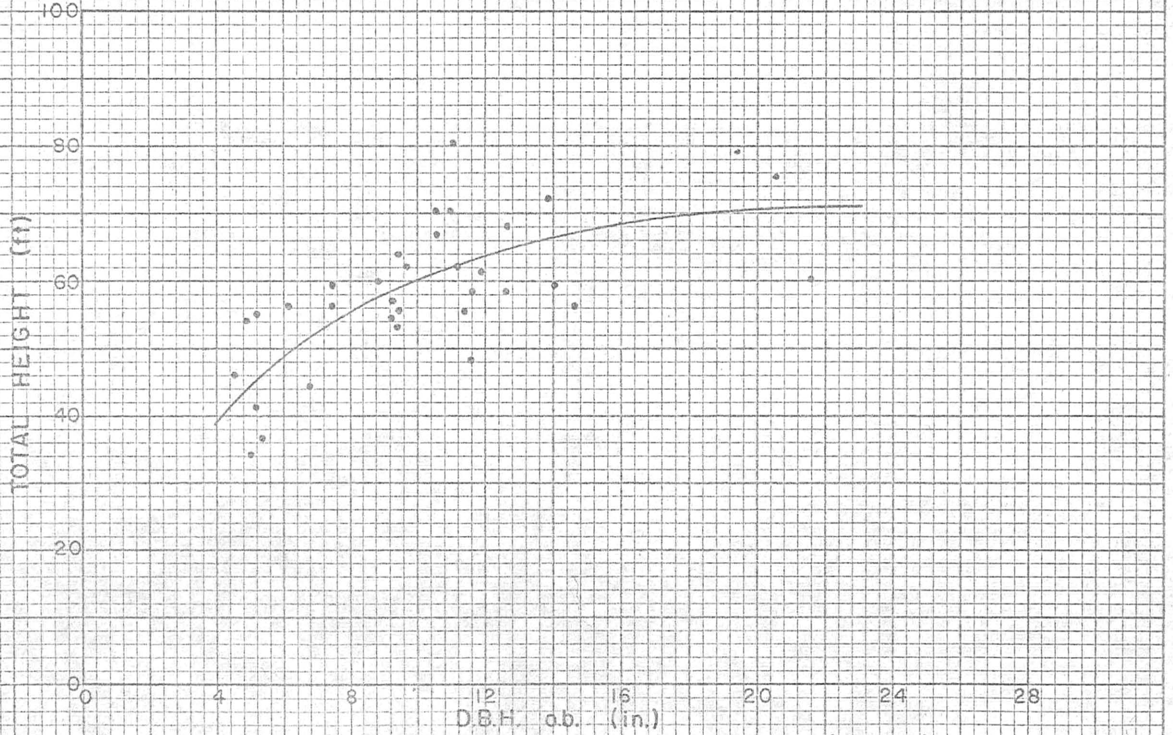


FIG. 44. TOTAL HEIGHT – D.B.H. RELATIONSHIP (y Birch)
ABI typ. Type

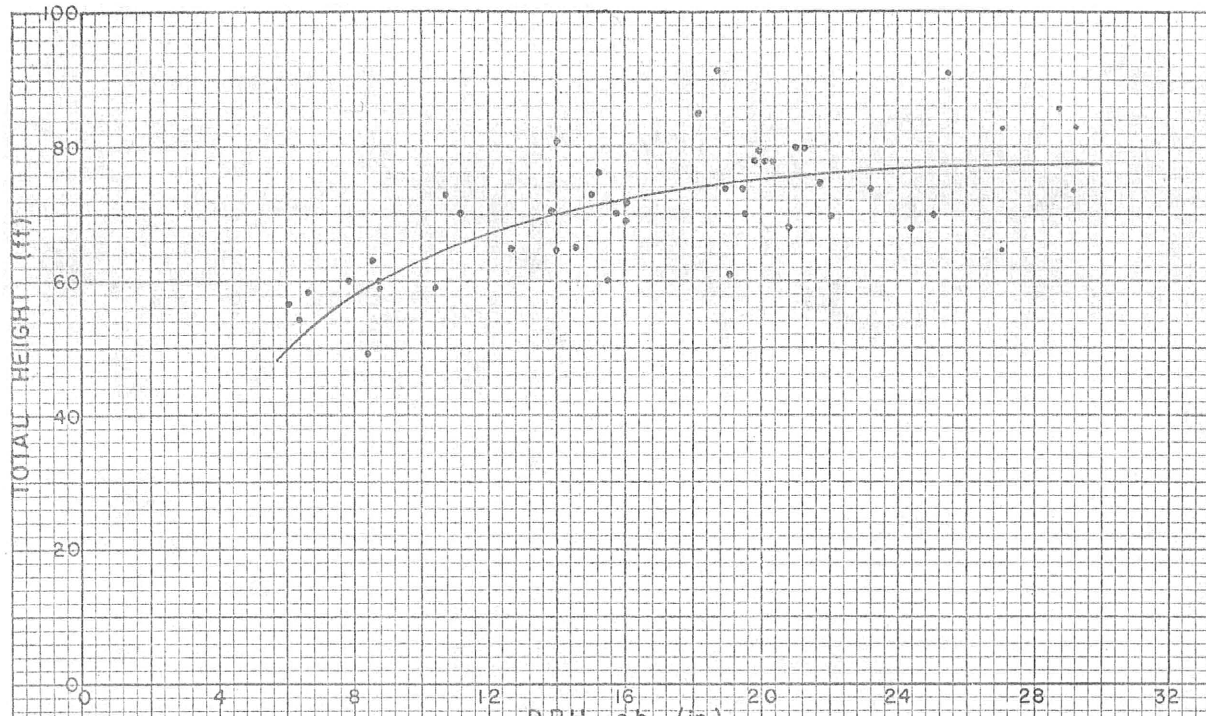


FIG. 45. TOTAL HEIGHT – D.B.H. RELATIONSHIP (y.Birch)
ABI fsu. Type

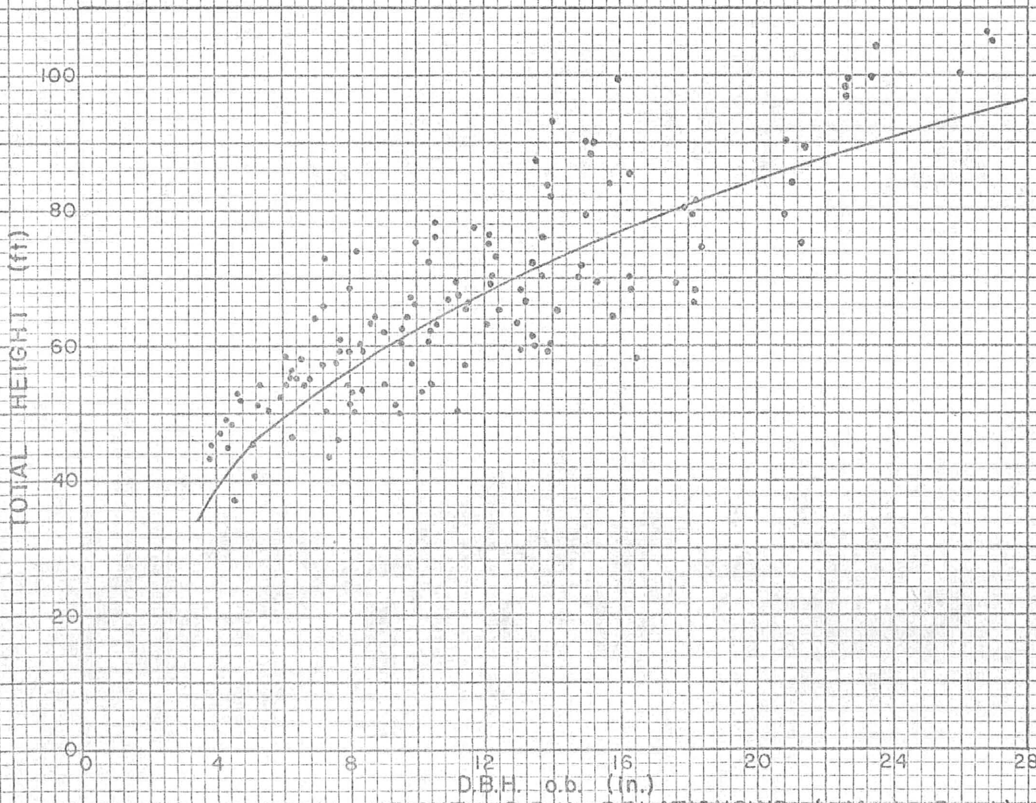


FIG. 46 TOTAL HEIGHT – D.B.H. RELATIONSHIP (s.Maple+Beech)
OAs Type

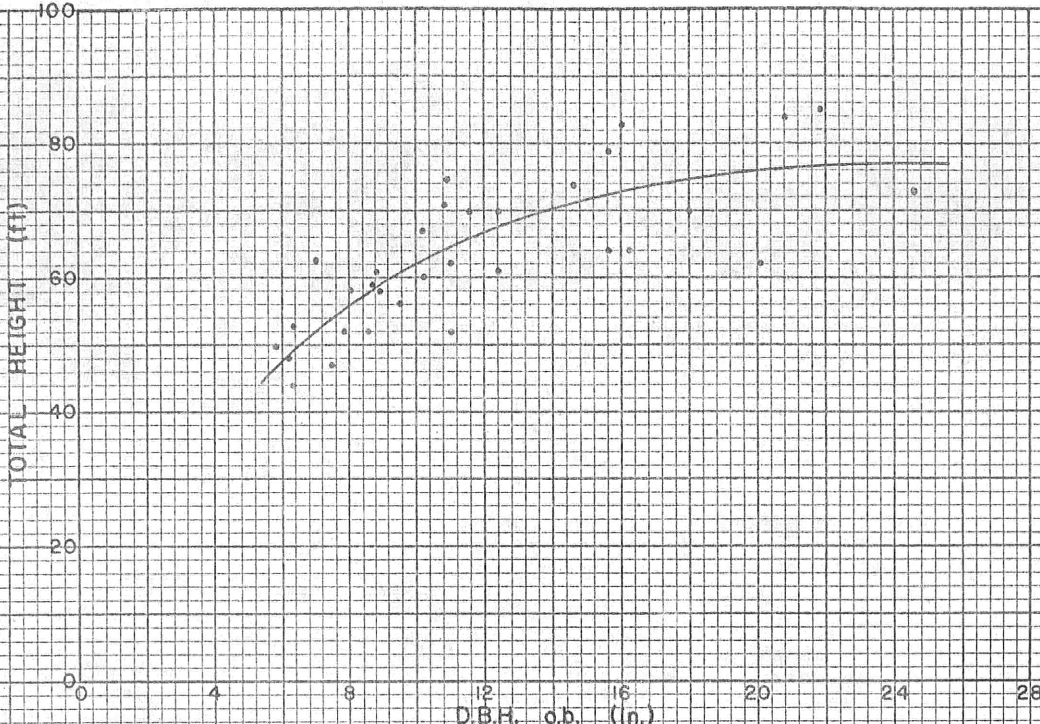


FIG 47 TOTAL HEIGHT – D.B.H. RELATIONSHIP (y.Birch)
BFn Type

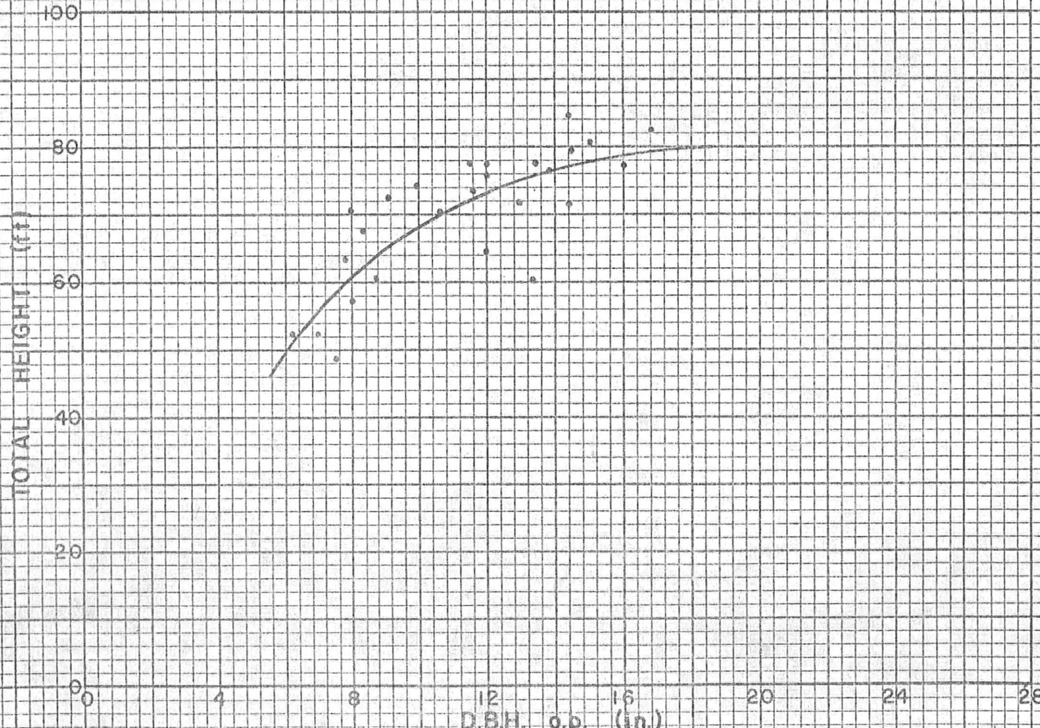


FIG 48 TOTAL HEIGHT – D.B.H. RELATIONSHIP (b.Ash)
BFn Type

The true diameter of each tree after each decade was plotted and the diameter growth curve traced. When all the individual curves of a given species in a given stand were plotted together and compared, no constant growth pattern was discernible (Fig. 50) and the trend in growth could be represented quite adequately by a straight line (Frothingham 1915, Bruce and Schumacher 1950). One tree grew fast for the first thirty years then slowed down considerably. Another grew very slowly for eighty years then put on a spurt of growth. At one or more points the curves of both trees passed through the same coordinates and the same tree at two different points in time could be above and below the average by even more than two standard deviations. Such a behaviour certainly affects the value of any statistics used to measure variation around the average curve as well as the final shape of this curve. In order to minimize the effect of the more excentric trees on the ultimate shape of the average curve, decennial growth was averaged by decades for all trees of a given species then cumulated into one curve giving the average diameter inside bark attained at different ages.

For the tolerant sugar maple and beech this curve came out as a straight line up to 180 years, the average maximum age of trees sampled. This would indicate that on the average the tolerant species do not realize their potential growth in early years under uneven-aged forest conditions but that they manage to survive and realize some growth. As they increase in size, they grow out of the heavy competition zone and finally manage to put on ~~better~~ normal growth.

In the case of semi-tolerant or intolerant species such as yellow birch, basswood, black ash, American elm, etc., the curve rose more quickly for the first four or five decades then straightened out at

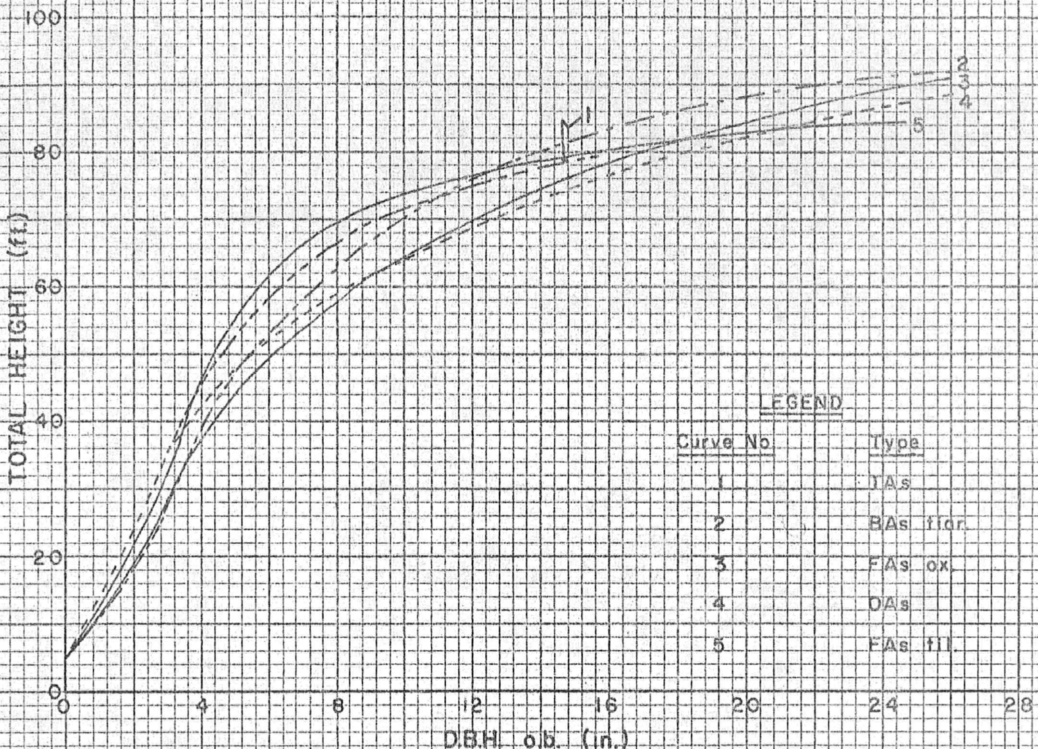


FIG. 49. RELATION BETWEEN HEIGHT AND D.B.H. (SUGAR MAPLE).

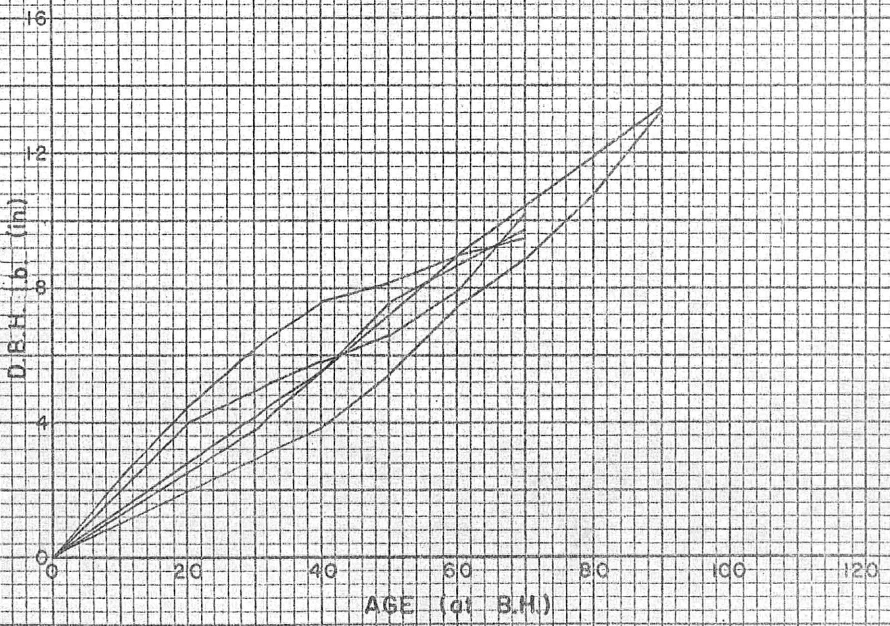


FIG. 50. DIAMETER GROWTH OF SINGLE MAPLES (Plot 4030)

a smaller gradient. Such a behaviour would indicate that, in the case of these species, the only trees that managed to survive and grow to be measured are those which had some free-growing space early in life, a reflection of their semi-tolerance.

The stronger flattening at the upper end of the yellow birch curves could also reflect in part the birch dieback of the last 20 years.

It was also observed for all species that the best decade of growth could occur anytime in the life of a tree, at least up to 200 years. So an average was made by species of the best decade of growth of each tree and a cumulative straight line based on this average was drawn. Such a curve can serve as an indication of the average potential diameter inside bark attainable by free-growing trees with intensive silviculture. These curves were stopped whenever they reached the largest diameter encountered in the investigation for each species or at 180 years, whichever came first.

When double bark thickness was added the sugar maple and beech straight lines became slightly sigmoid curves while the curves for the semi-tolerant species straightened out (Figs. 51-60).

The average diameter of sugar maple trees at 100 years varies with types from 11 to 18 inches. Wherever present, beech behaves the same way. When the relative position of the curves is considered however, there are notable discrepancies with the potential growth as evaluated qualitatively from the ecological properties of the ecosystem types. It seems that the effects of competition could not be eliminated.

For the types which are basically sugar maple-beech-yellow birch stands, the relative position of the curves is as expected and related to latitudinal and altitudinal distribution of types and

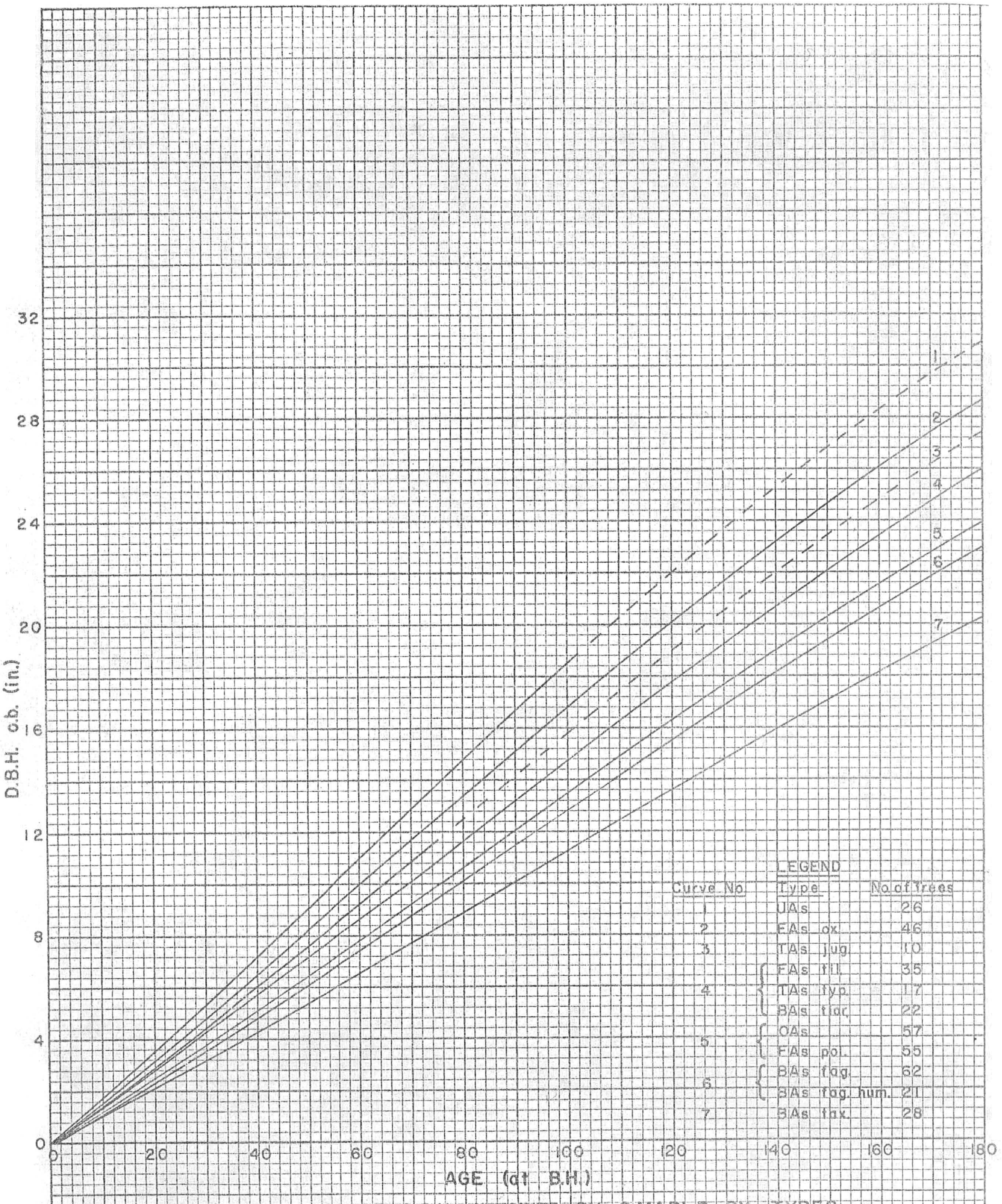


FIG. 51. AVERAGE D.B.H. ATTAINED BY S.MAPLE BY TYPES

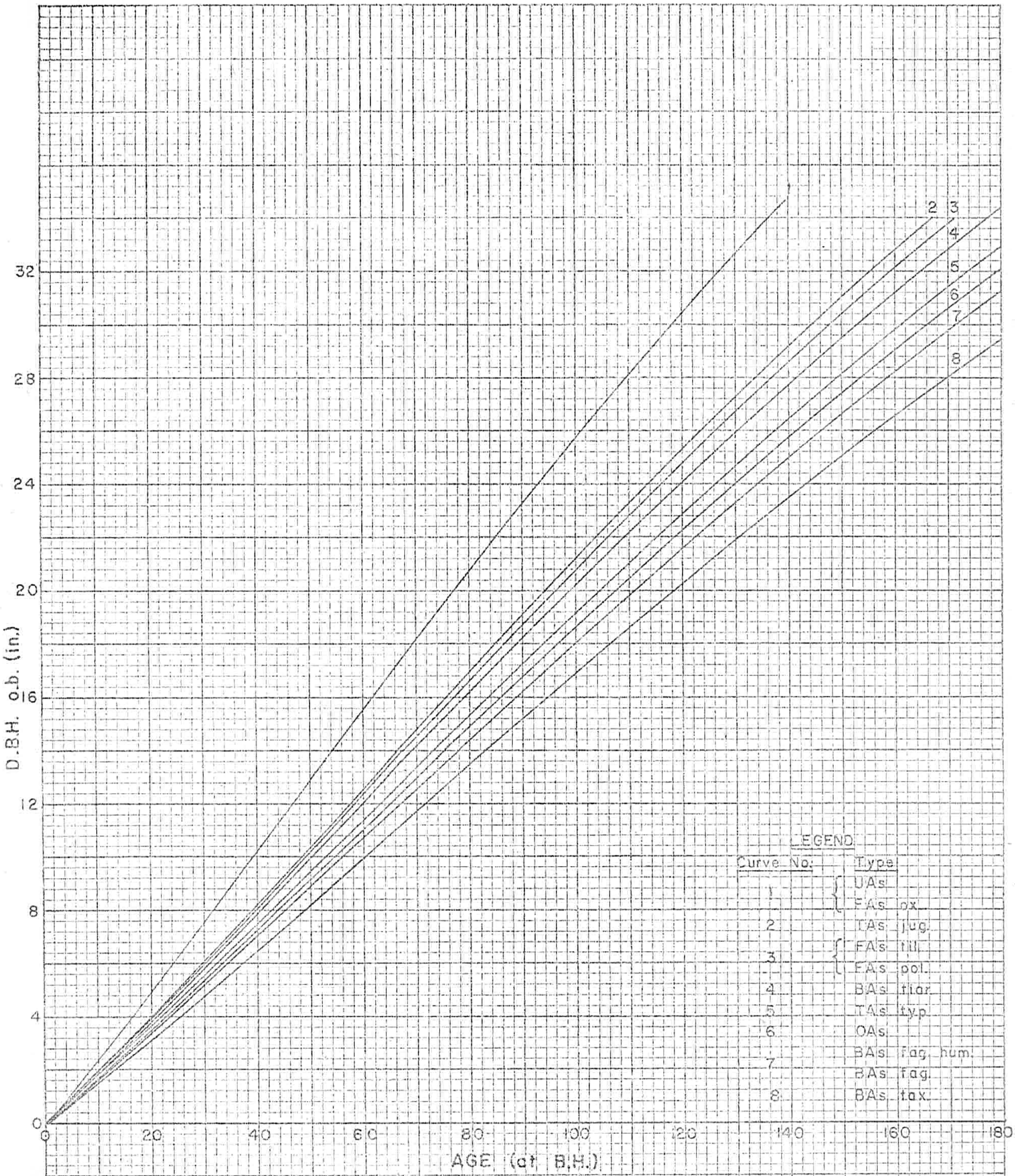


FIG. 52. AVERAGE MAXIMUM D.B.H. ATTAINABLE BY S.MAPLE BY TYPES

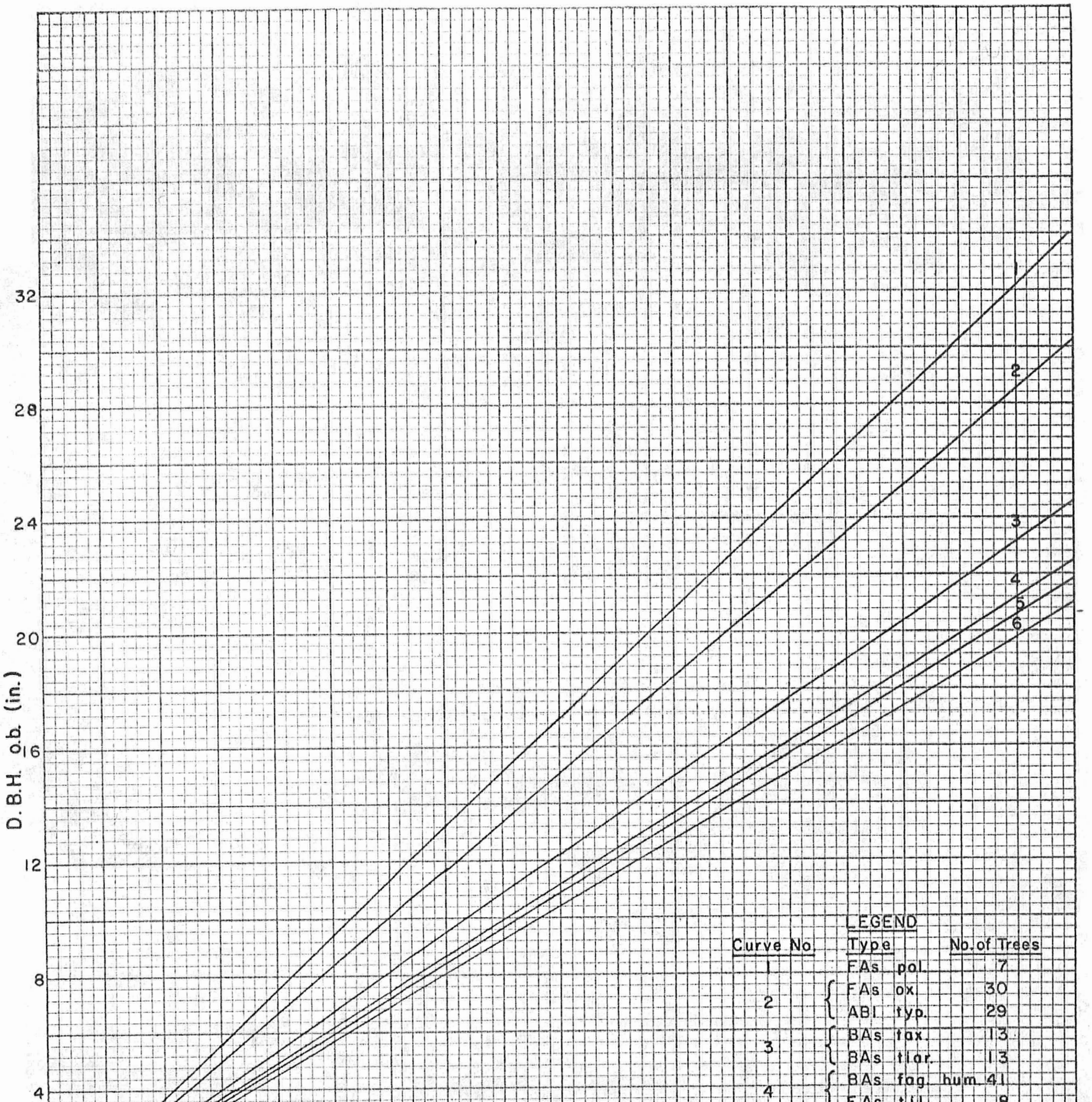


FIG. 53. AVERAGE D.B.H. ATTAINED BY Y. BIRCH BY TYPES

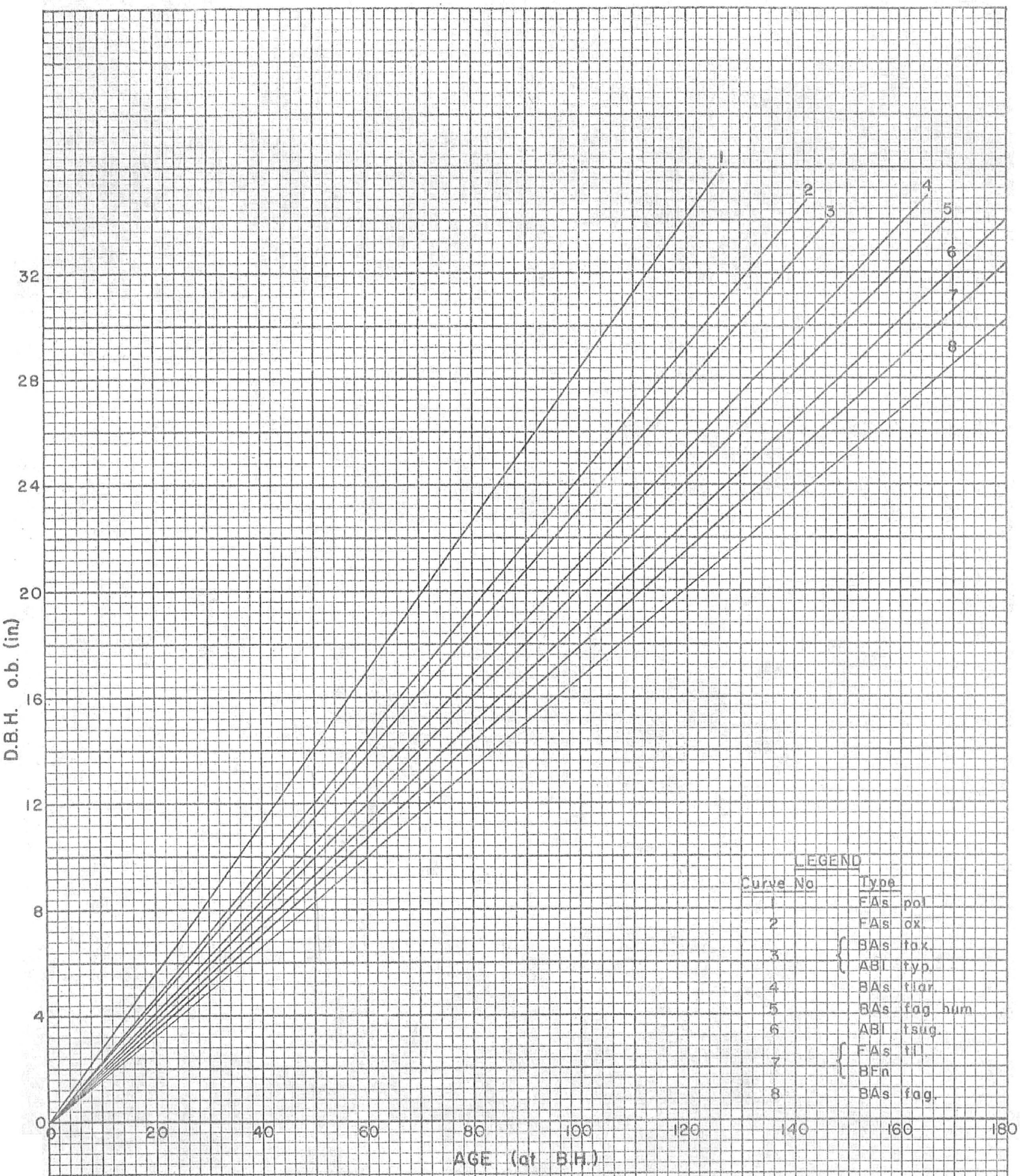


FIG. 54. AVERAGE MAXIMUM D.B.H. ATTAINABLE BY Y.BIRCH BY TYPES

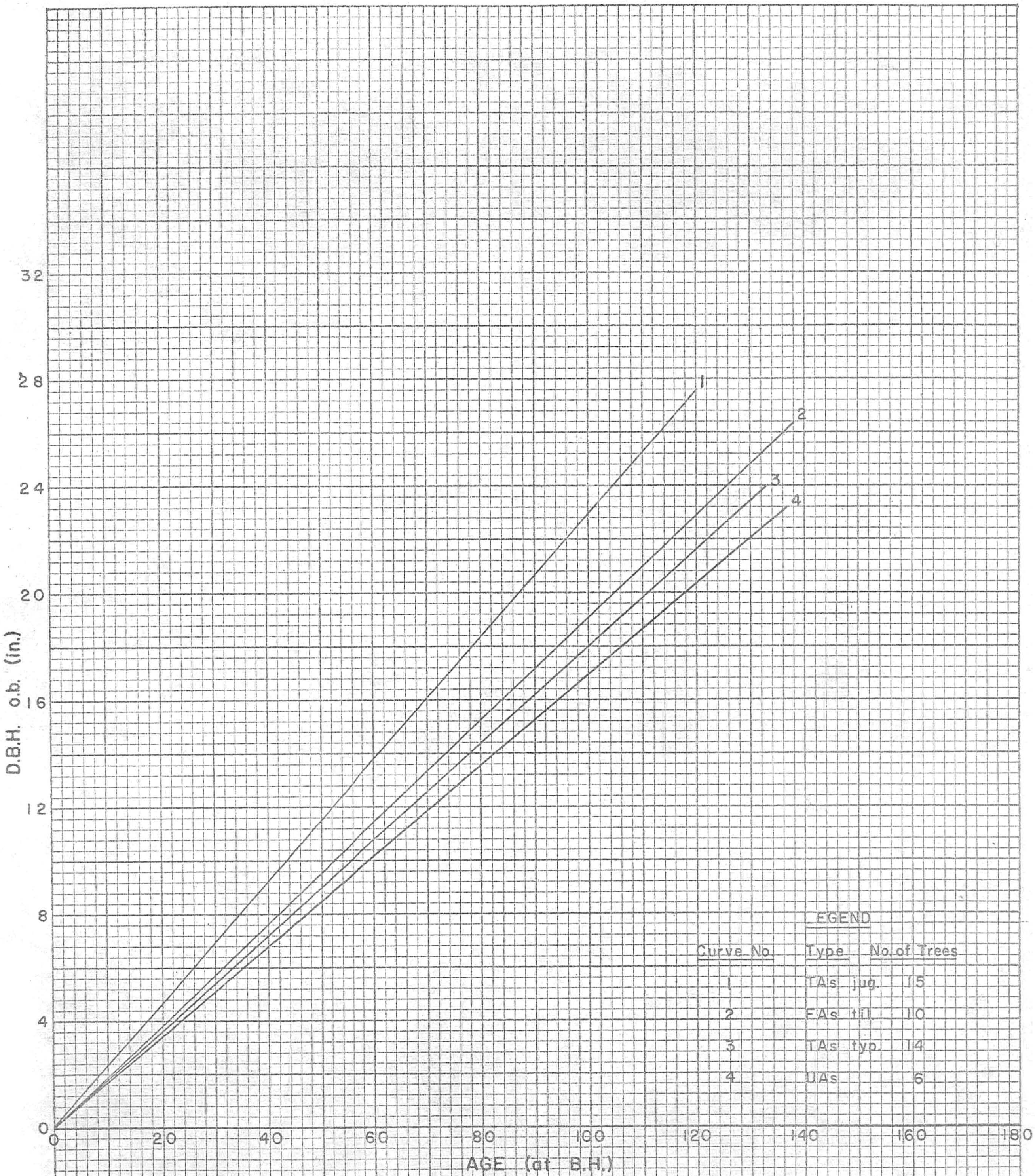


FIG. 55. AVERAGE D.B.H. ATTAINED BY BASSWOOD BY TYPES

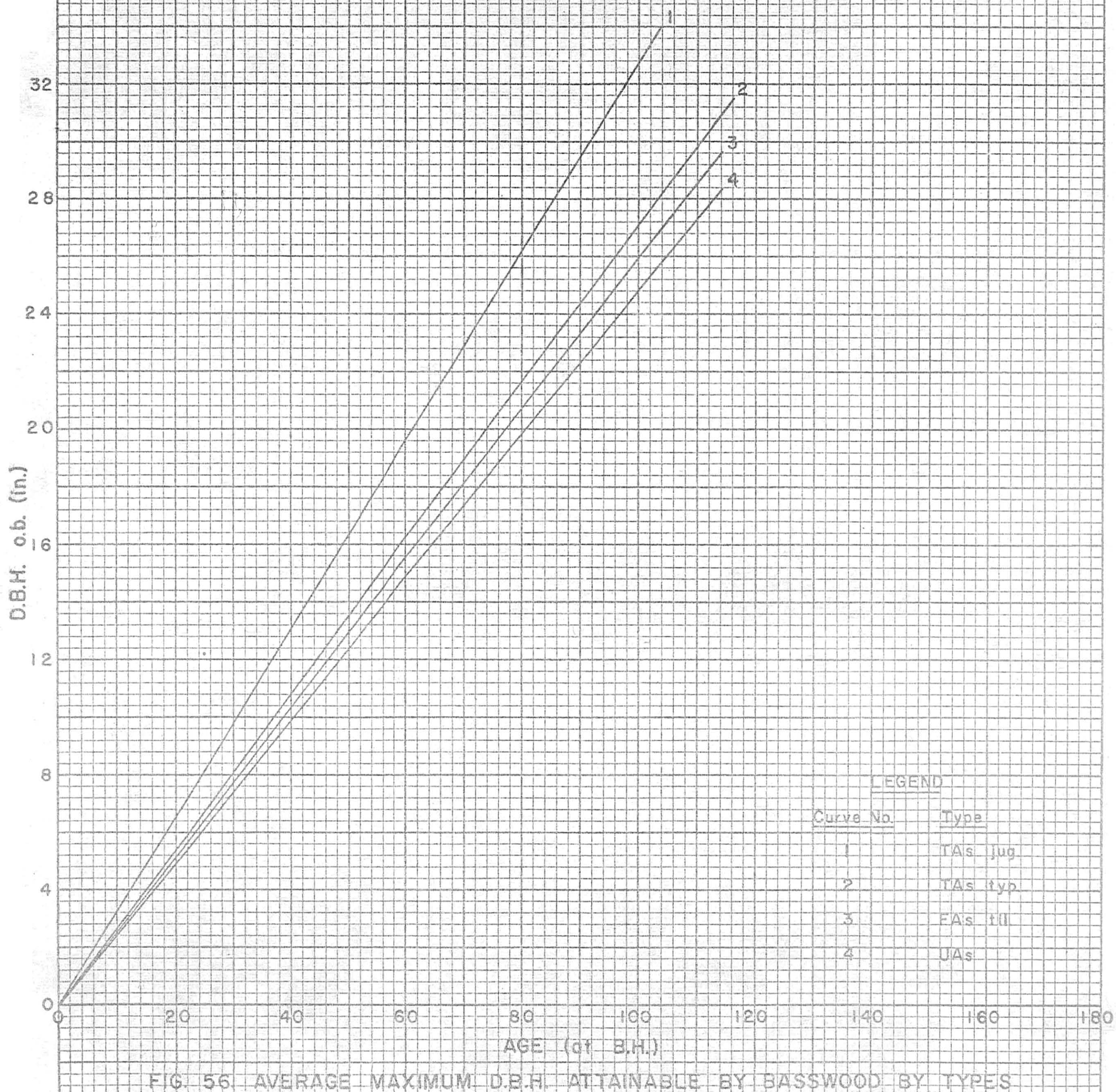


FIG. 56. AVERAGE MAXIMUM D.B.H. ATTAINABLE BY BASSWOOD BY TYPES

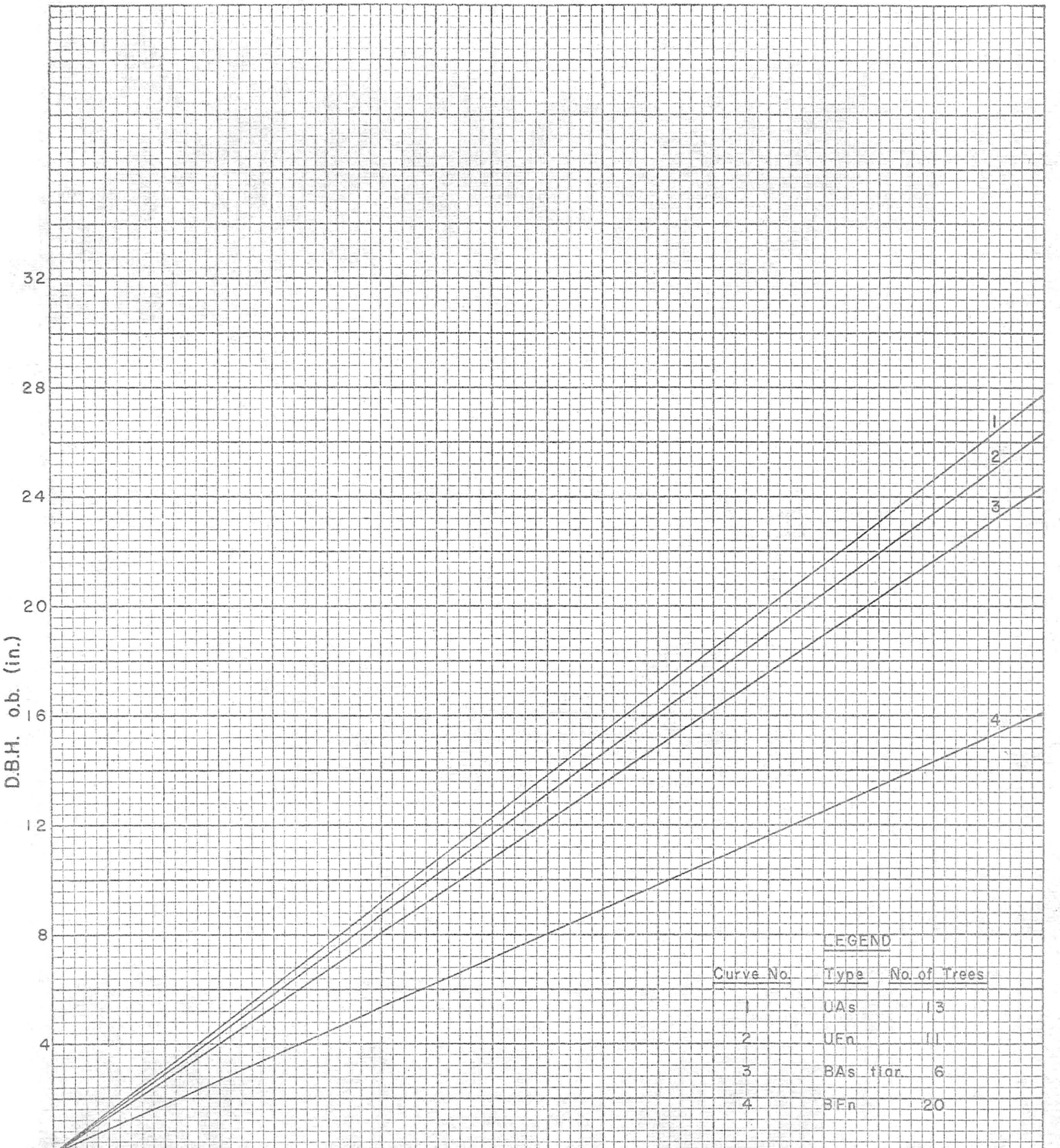


FIG. 57 AVERAGE D.B.H. ATTAINED BY B. ASH BY TYPES

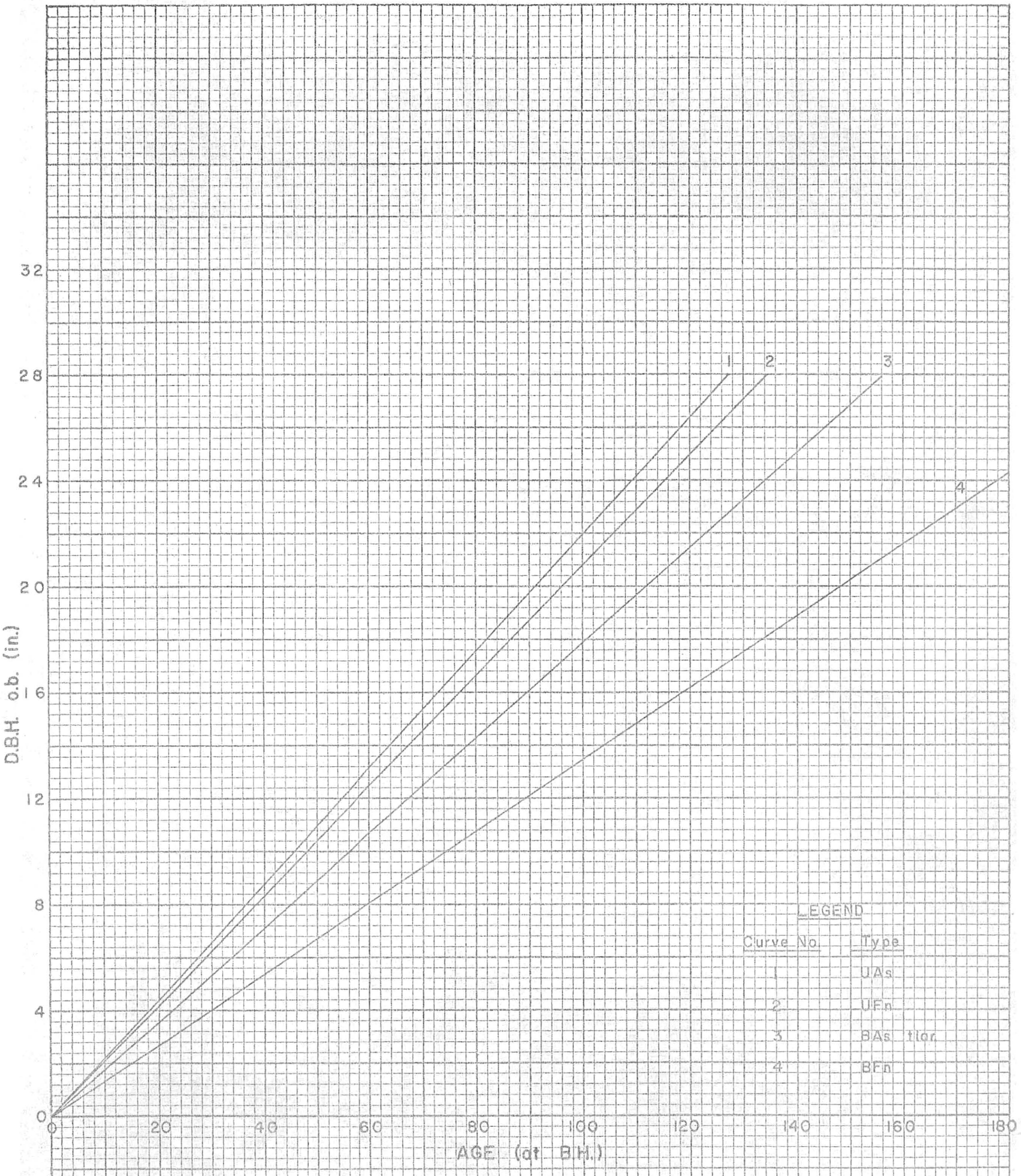


FIG. 58 AVERAGE MAXIMUM D.B.H. ATTAINABLE BY B.ASH BY TYPES

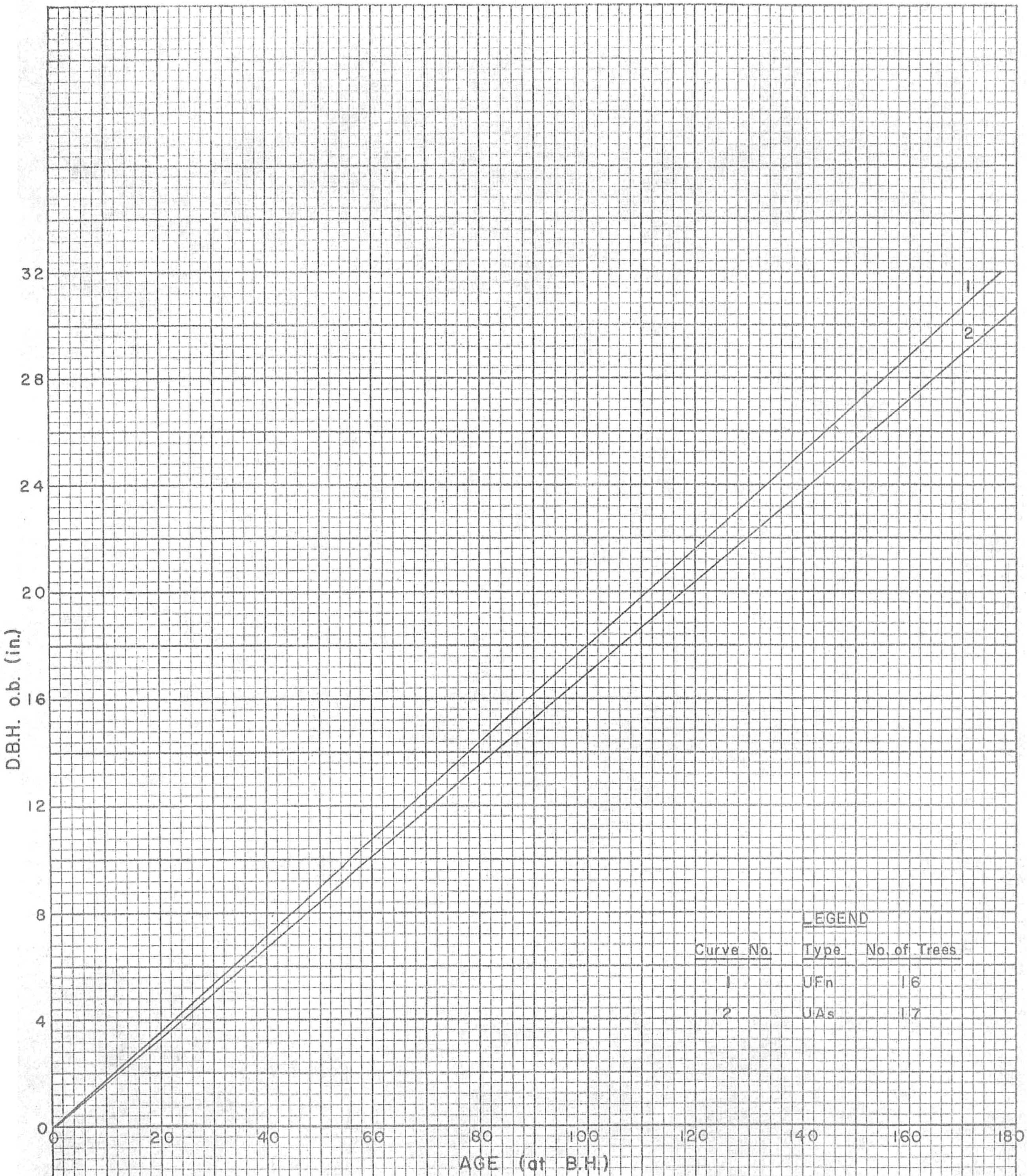


FIG. 59. AVERAGE D.B.H. ATTAINED BY A.ELM BY TYPES

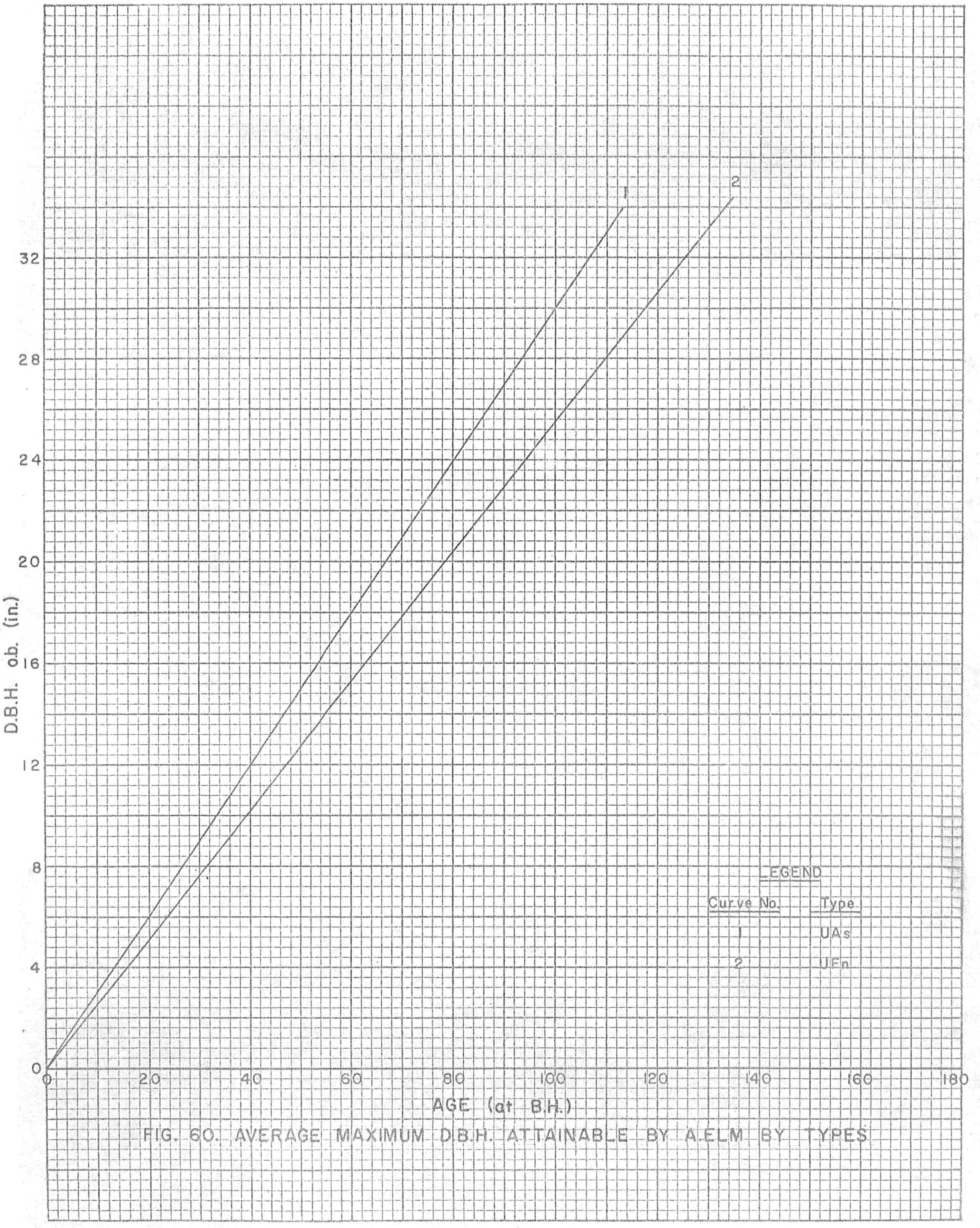


FIG. 60. AVERAGE MAXIMUM D.B.H. ATTAINABLE BY A.ELM BY TYPES

available moisture and nutrients of soils. The only exception is the curve for the F-As polystichetosum type. The low values for sugar maple and beech could be due to the general condition on high density of the few stands investigated (90 to 100% crown closure). As will be seen later, height was less affected.

In types where basswood and elm form an important component of the stand, the curves for sugar maple and beech are much lower than expected. For both climate and soil are much more favourable in these types than in the previous ones. Their growth rate should be superior to that of the Fago-Aceretum sacchari oxaletosum. It seems however that competition from basswood and elm is more difficult to overcome for they outgrow sugar maple easily and are taller and larger than that species at maturity.

The better position of the Ulmo-Aceretum sacchari curve can be explained in part by the lower density of many of the stands sampled (60 to 70% crown closure), resulting in more growing space for maple.

When the curves based on the best decade of growth of each tree were drawn, the relative position of the curves did not improve significantly. The diameter attained at 100 years in the various types increased however by six to eight inches, which is an increase of 40 to 50%.

The same comments apply to the curves of yellow birch. The relative position of these curves does not reflect the potential of the various sites as evaluated from their ecological properties. It does seem that a much larger sampling is needed if the effects of suppression are to be compensated.

Curves for black ash are in line with the ecological evaluation of the sites. As for elm and basswood, the curves of diameter attainable by free-growing trees give a better idea of the relative potential of the sites.

As mentioned before the discrepancies in the relative position of the curves of diameter over age might be corrected in part by a larger sampling. But in the case of stands where sugar maple, beech or yellow birch must compete with basswood or elm, simply a larger sampling would probably not solve the problem altogether. The curves would probably still be too low and would represent the average growth to be expected under extensive silviculture, considering competition from basswood and elm as an important environmental factor.

Of course if only the free-growing trees, as indicated by stem analysis, were selected in each stand, a better evaluation of diameter growth potential might be possible. But then genetics might be important in such a limited sampling and distort the results.

In any case, curves of diameter over age as presented here or improved by larger or more selective sampling, are not recommended as safe indicators of site quality because diameter growth besides being affected by climate and soil, is also most strongly affected by competition, an imponderable which varies tremendously in any single uneven-aged stand.

They are however useful in that they provide a first estimation of the average growth behaviour of the trees in natural undisturbed stands with their actual species composition and of the degree of improvement that could be attained by silviculture. As they are, both sets of curves certainly expose as a myth the belief that northern hardwoods are slower growing species than their softwood companions.

The Height-Age Relationship

As mentioned before, the height-age relationship is considered by most foresters the best indicator of site quality in even-aged forests. The growth behaviour of trees in uneven-aged stands is however very different and the use of height over age to indicate site quality in this case is often questioned. Davis (1954) suggests selecting the "representative-appearing" trees in the upper canopy which have grown evenly and at a moderately rapid rate throughout their lives. Other authors have proposed using the height of the large "mature" trees as an index of site quality (Dagnélie 1952, Meyer 1943, Donahue 1940). The type of tree referred to by Davis (1954) is not only difficult to assess in the field but also difficult to define even with stem analyses. These have revealed very few trees with an even growth. It is also practically impossible to establish a standard by which to determine whether a tree has had a "moderately rapid", a slow or a fast rate of growth. The concept of "maturity" is also misleading. Maturity on a poor site comes later than on a rich site and as mentioned earlier time is an important element in the evaluation of site productivity.

Despite these various shortcomings, scatter-diagrams of height over age were nevertheless prepared and curves balanced. The middle section of the curves balanced fairly well. But shortage of sound trees larger than 12 inches d.b.h. badly affected the trend at the upper end. As a proper balancing of this section of the curves was most important, an attempt was made to improve the shape of the curves.

As in the method of stand table projection the growth in diameter was used to predict height growth through the use of the height-d.b.h. curve (Bruce and Schumacher 1950). As mentioned earlier, the height-d.b.h. curves did balance very well and the diameter-age curves based on stem analyses were most reliable and gave diameter growth based both on average age and "economic free-growing" age. The diameter attained at each ten-year period was transferred to the height-d.b.h. curve and the corresponding height determined. This way two sets of height-age curves were prepared for each species: one of average height attained and one of attainable height. The results are presented in Figures 61-70.

This approach brought a great improvement in the shape and upper trend of the curves and reduced overlapping considerably.

In the sheaf of curves for sugar maple, two groups stand out. One group representing stands of sugar maple, beech and yellow birch alone curves out smoothly without overlapping and the relative position of the curves is consistent with the ecological evaluation of the sites. As expected the more northern _B-As_ _taxetosum_ type has the lowest height, 65 feet at 100 years (Fig. 61). The _O-As_ and _B-As_ _fagetosum_ (including the humid variant) types then follow with an average height of 72 feet at 100 years while the _F-As_ _oxaletosum_ type shows a height of 79 feet at 100 years. Finally, both the _B-As_ _tiarelletosum_ and _F-As_ _polystichetosum_ show an average height of 81 feet at 100 years.

The second group includes the four types where the fast growing species, basswood and elm, form an important component of the stand (_T-As_ stands for both the _typicum_ and the _juglantetosum_ subassociations). In this group, height growth is rapid and superior to that of the other types till the trees reach about 80 feet, which is consistent with the greater richness of the sites. But at this point the curves flatten out. Possibly a larger and more selective sampling could correct this.

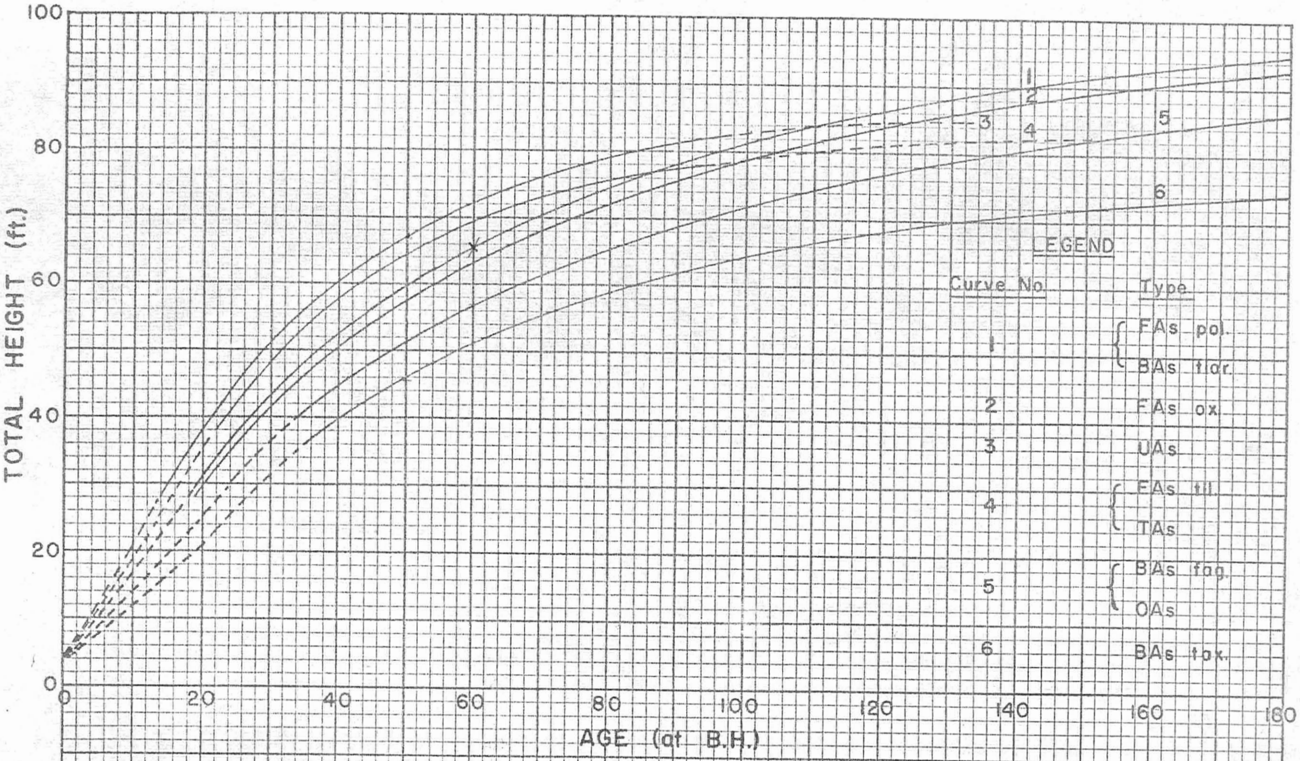


FIG. 61. AVERAGE HEIGHT ATTAINED BY S.MAPLE BY TYPES

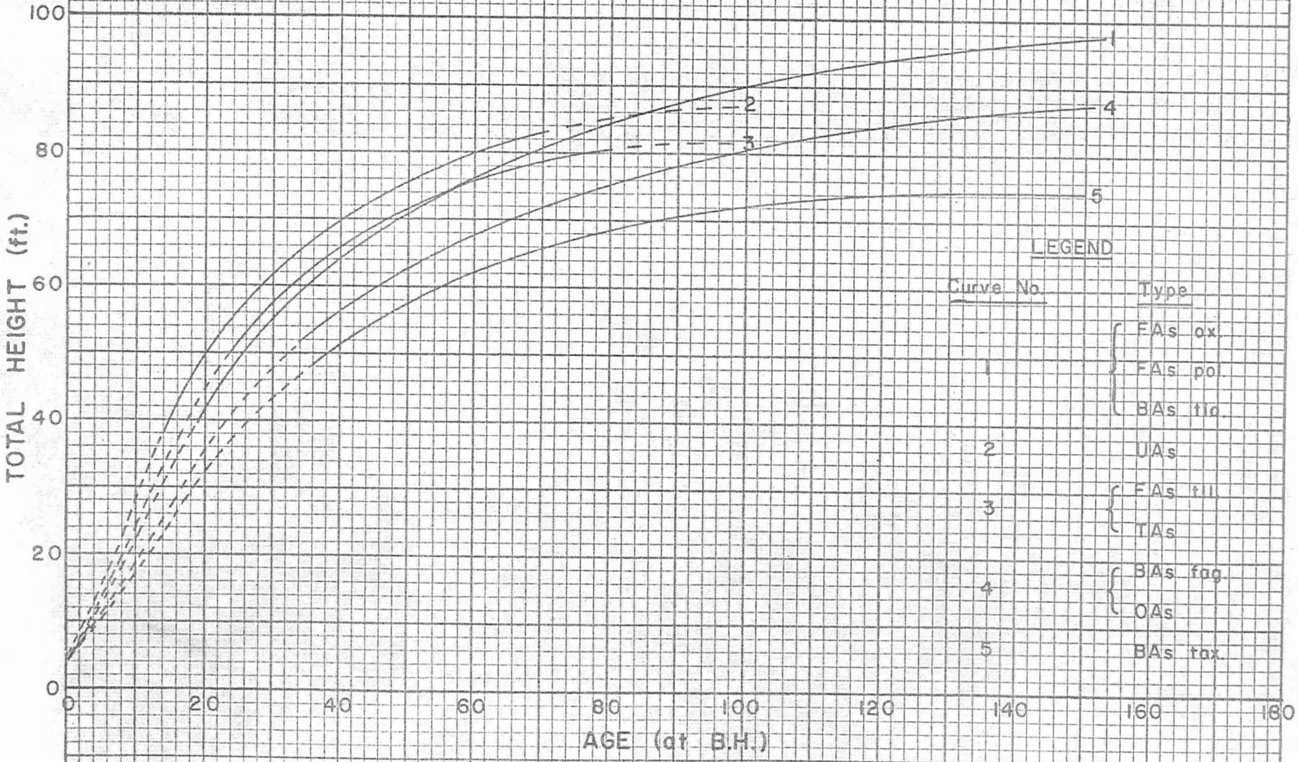


FIG. 62. AVERAGE MAXIMUM HEIGHT ATTAINABLE BY S.MAPLE BY TYPES

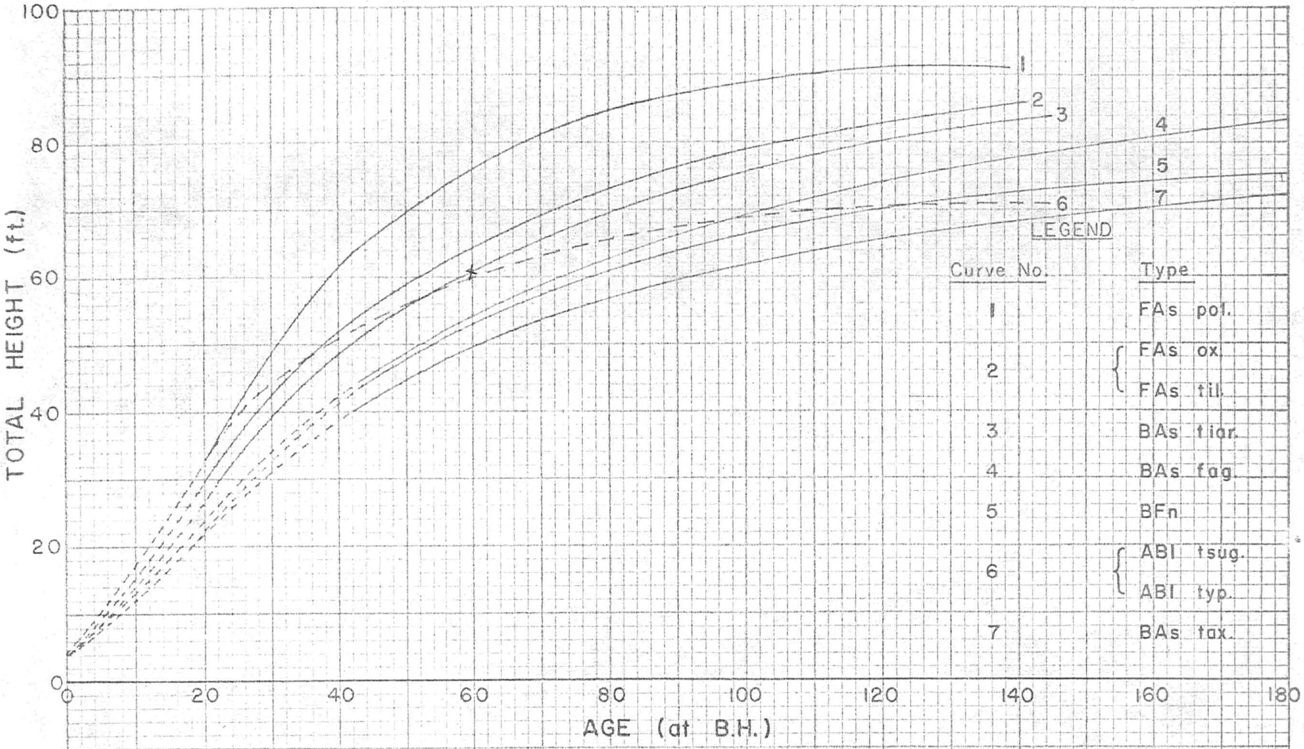


FIG. 63. AVERAGE HEIGHT ATTAINED BY Y. BIRCH BY TYPES

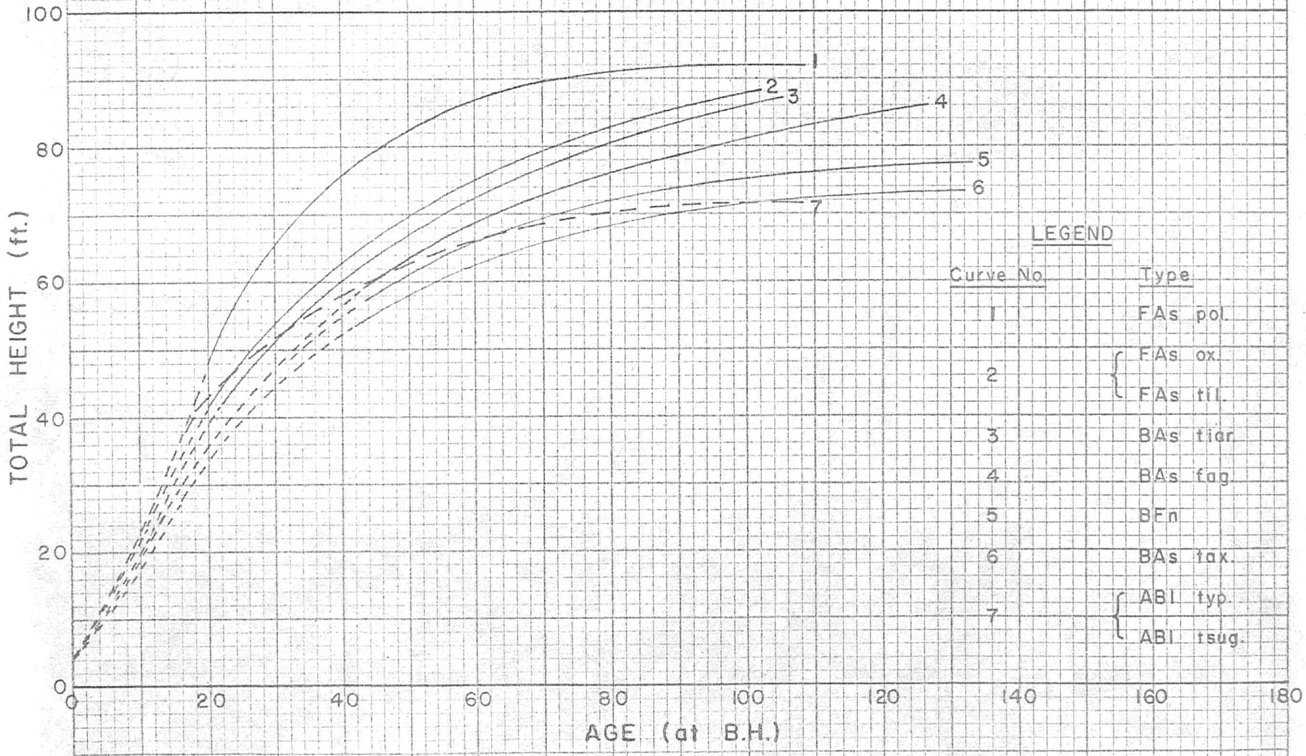


FIG. 64. AVERAGE MAXIMUM HEIGHT ATTAINABLE BY Y. BIRCH BY TYPES

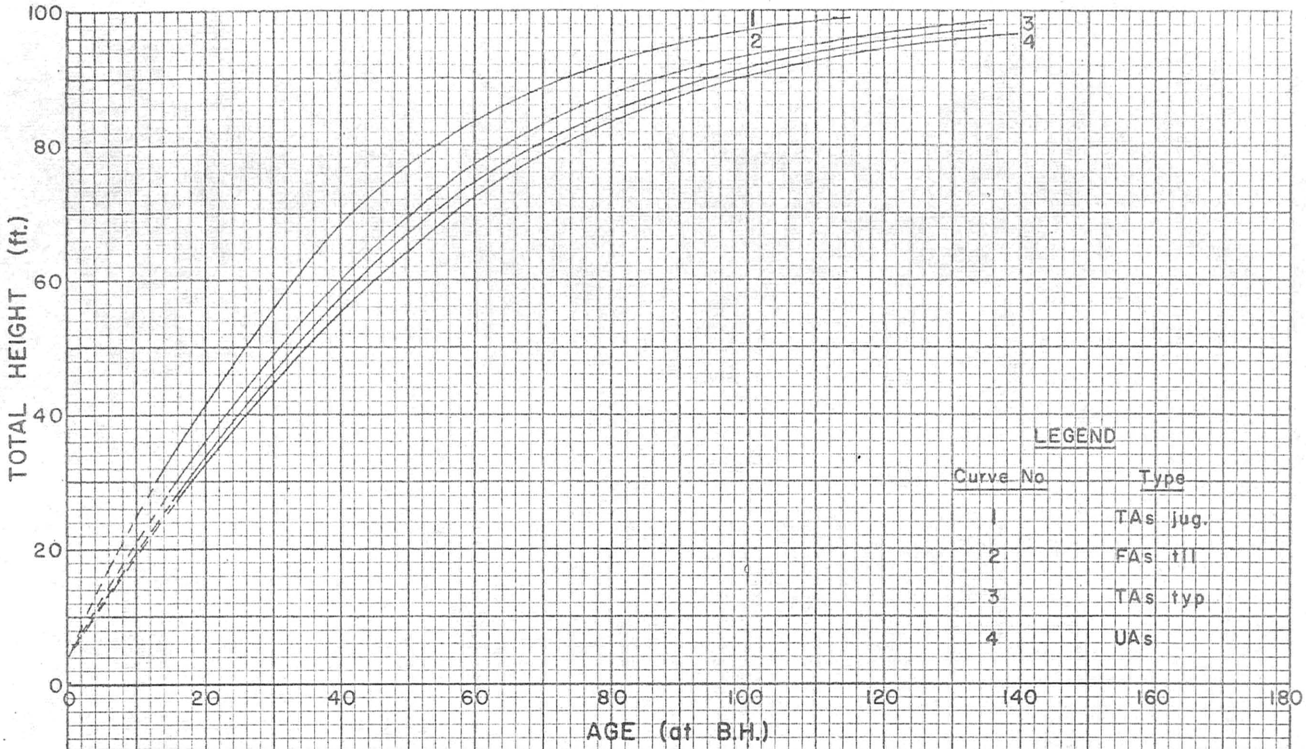


FIG. 65. AVERAGE HEIGHT ATTAINED BY BASSWOOD BY TYPES

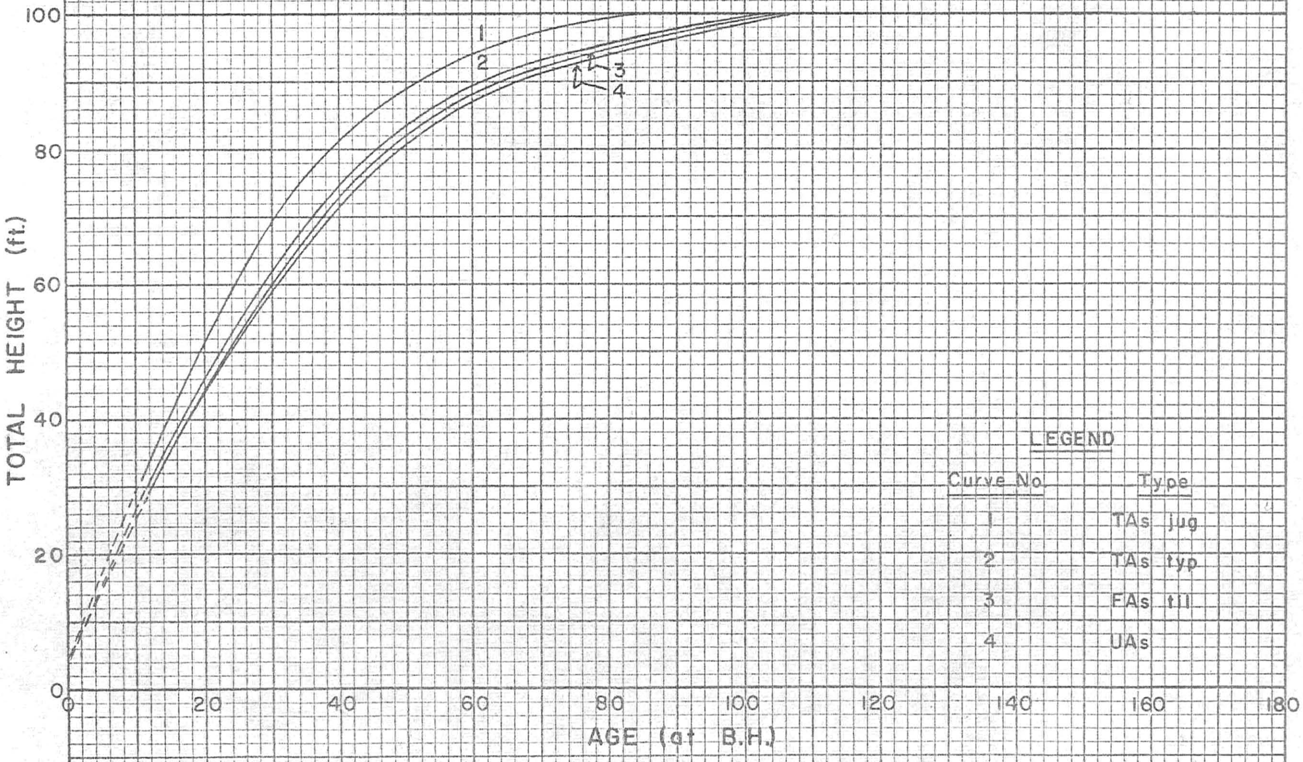


FIG. 66. AVERAGE MAXIMUM HEIGHT ATTAINABLE BY BASSWOOD BY TYPES

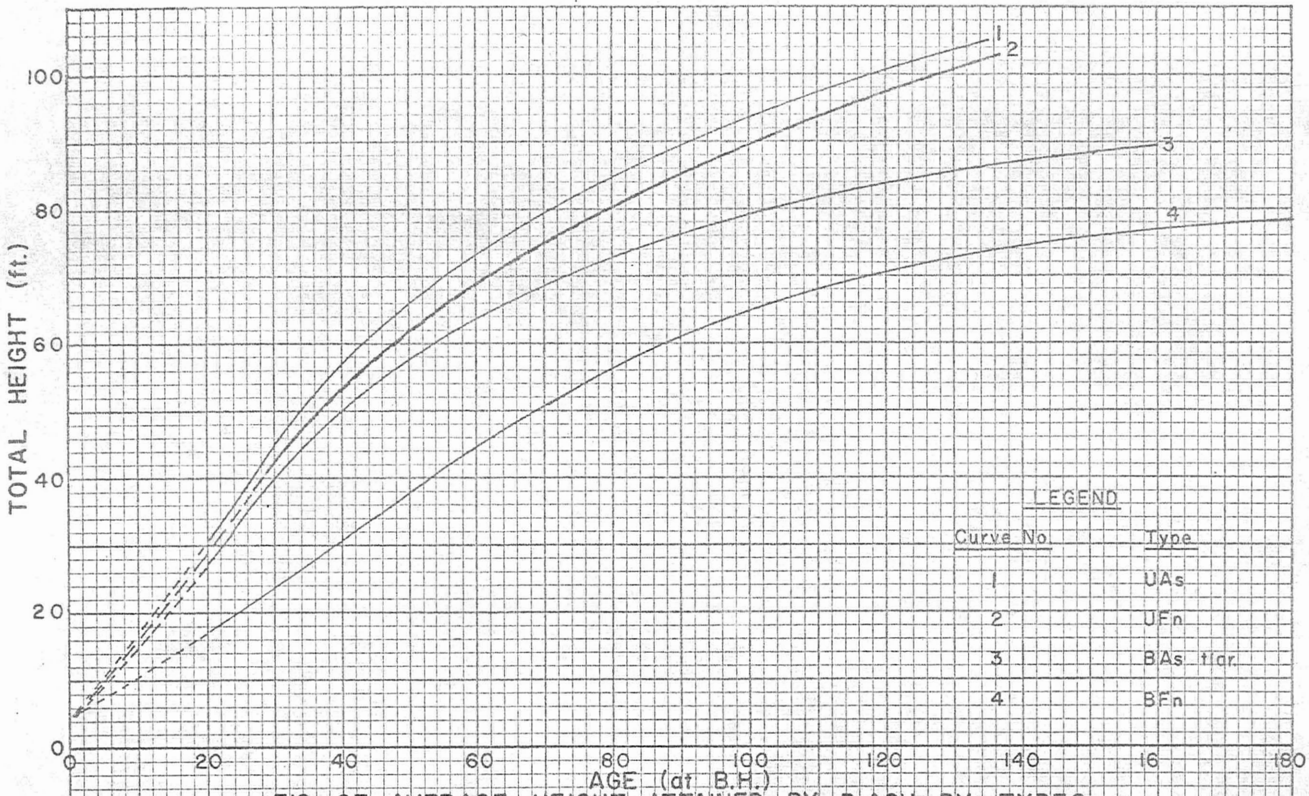


FIG. 67. AVERAGE HEIGHT ATTAINED BY B.ASH BY TYPES

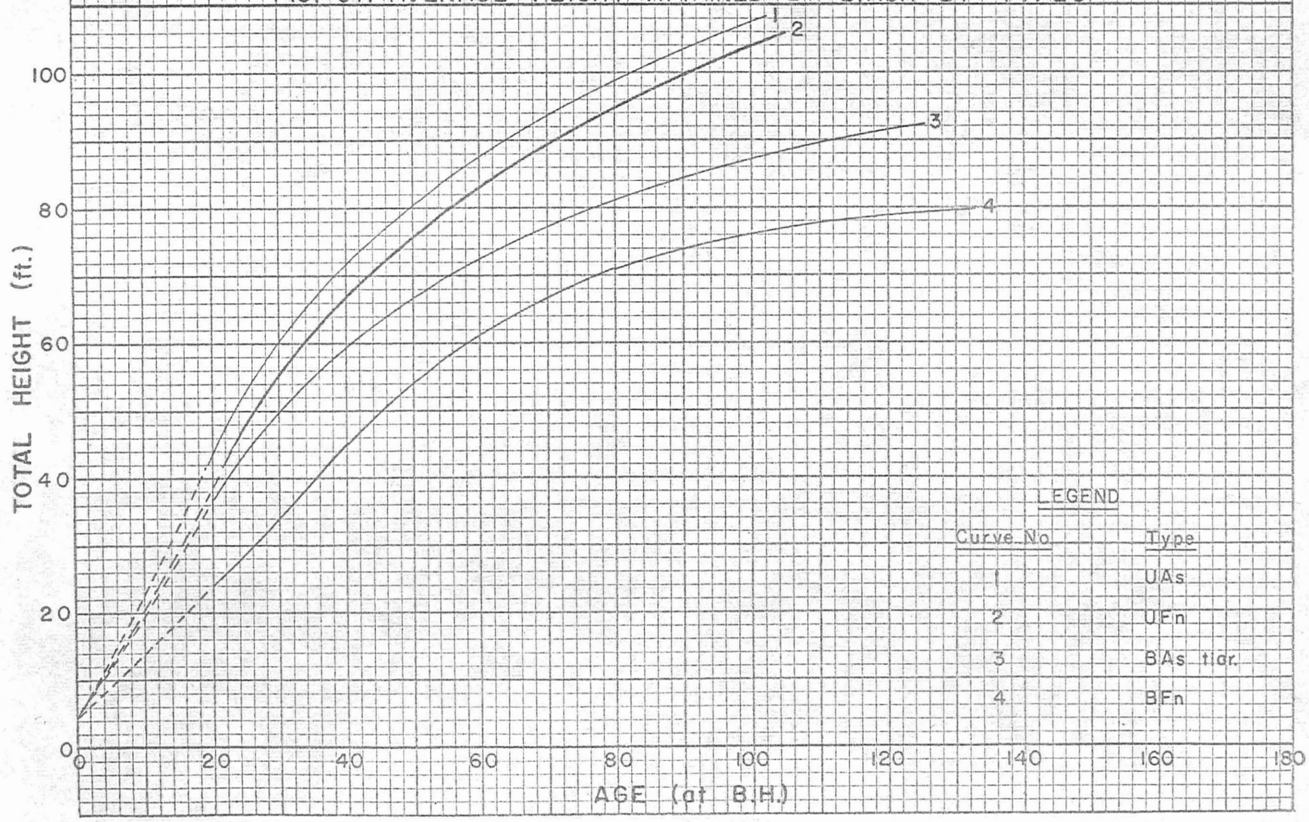


FIG. 68. AVERAGE MAXIMUM HEIGHT ATTAINABLE BY B.ASH BY TYPES

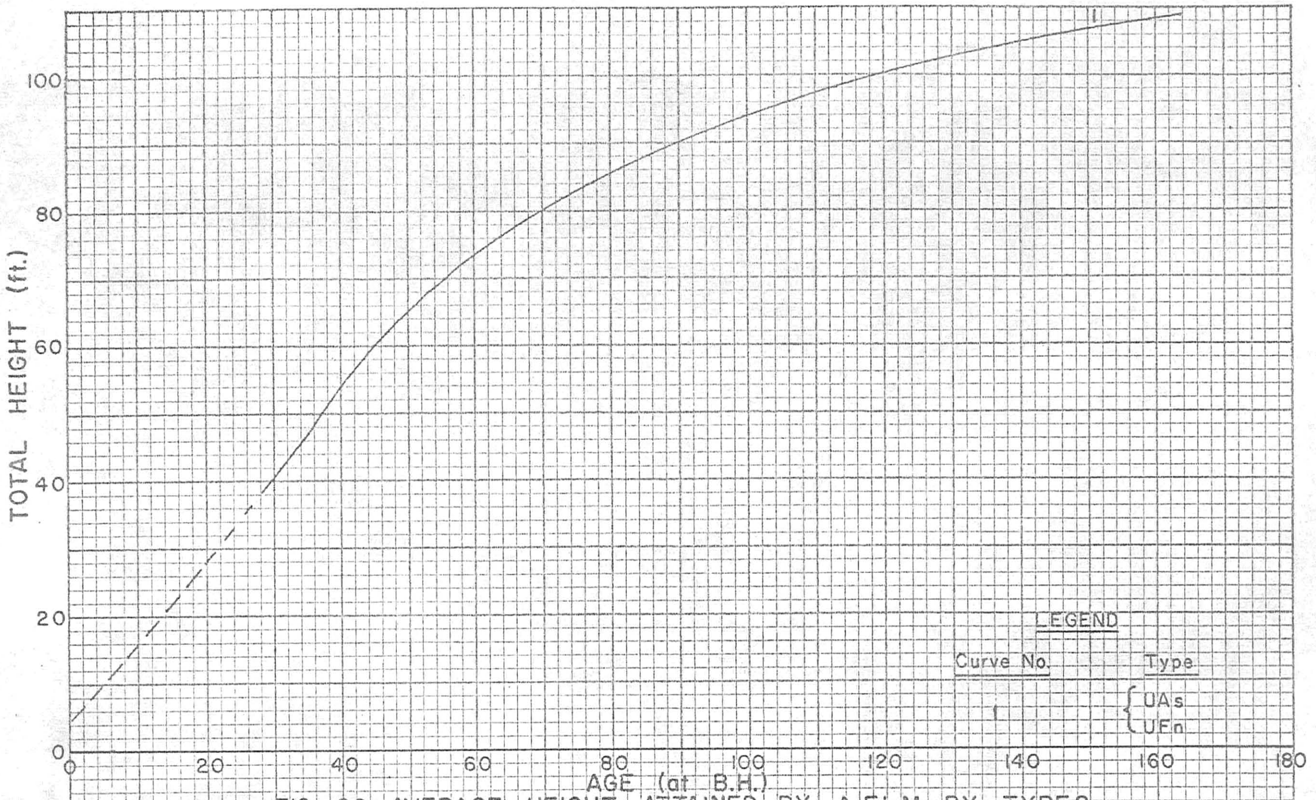


FIG. 69. AVERAGE HEIGHT ATTAINED BY A.ELM BY TYPES

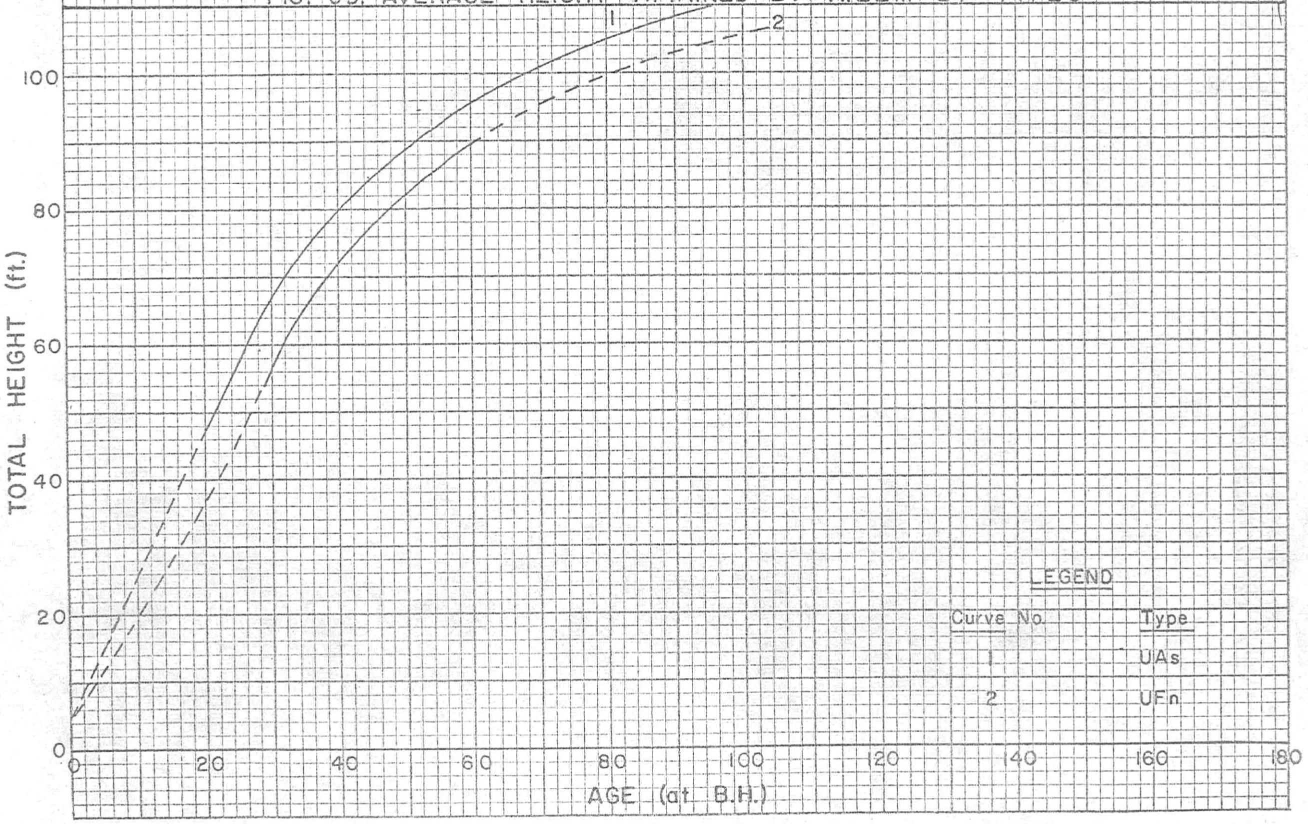


FIG. 70. AVERAGE MAXIMUM HEIGHT ATTAINABLE BY A.ELM BY TYPES

But it is also logical that such a trend could represent what generally happens in these stands. Both basswood and elm are fast-growing species and they reach 15 to 20 feet more in height than the other species on these sites. Both also have long clean boles and a relatively shallow crown. Logically height growth of maple should be comparatively free till its crown reaches the barrier of the basswood and elm crowns. Then persistent overtopping could slow down height growth appreciably. Presumably if the early trend kept on, sugar maple could reach 85 to 90 feet at 100 years in these types.

Yellow birch generally shows the same height growth as sugar maple and beech on the sites where they occur together and the relative position of the curves is equally consistent with the ecological evaluation of the sites. One curve, common to both subassociations of the Abieti-Betuletum luteae, shows a trend which contrasts with the trend of all the other curves. This would seem to be due primarily to the greater severity of die-back on these sites [2/]. The heights actually measured were certainly inferior to the true heights the trees did attain earlier and consequently the curves do not properly indicate the potential height growth of these sites. The relative position of the black ash curves is as expected. Height at 100 years ranges from 65 feet in the B-Fn type to 94 in the U-As type.

As for basswood and elm they occur on a limited range of sites and there is little difference in the heights at maturity. It must be noticed however that on any given site, they reach greater heights than the accompanying sugar maple and beech.

[2/] Confirmed by Dr. M. Lortie in private communication.

For all species, the curves of maximum height attainable remain in the same relative position but are higher than the average curves by 7 to 10 feet.

The very shape of these curves, their rapid rise for the first fifty or sixty years, already indicates that height growth is less affected by competition in these stands than diameter growth. It is not surprising then to see both sets of height-age curves agree more closely with the ecological data than the diameter-age curves.

Can these curves however be used as site index curves, that is quick reference curves against which one can check the site quality of any new plot? The answer is no. Such a procedure would be very misleading.

It is true that we do have site classes but the range between the lowest and the highest is narrow, about 25 feet and there is a variation of 10 to 15 feet around each curve for each ecosystem type to start with. What is more, the variation inside each plot is the same as for the whole type and the possible error in height measurements of hardwoods is large. This means that a large sample of trees is necessary every time to obtain reliable values and the "height-age site index" method becomes most cumbersome.

The main value of these height-age curves is that they now give us concrete, quantitative site classes where originally we only had qualitative site classes based on ecological knowledge.

The Clear Bole Length

One last parameter of the individual tree was worth studying: the length of clear bole in trees of commercial size for sawtimber (10 in.+). This data was also plotted on scatter-diagrams and a straight horizontal line was the best fit in all cases. Repeated observations showed that the clear bole length is determined early in the life of a tree. In many instances, trees 6 or 7 inches at d.b.h. (30 to 40 years old) already showed a fork or large branch which definitively set the clear bole length. The logical thing to do then was to simply calculate the mathematical average. Table 11 shows these average lengths by species and types, their standard deviation, the number of trees measured in each case and the maximum value encountered.

These values do not represent the true overall average for stands and types. Such a value would be useless in the evaluation of sites. Wolf-trees and bushy-type trees are common in all types. But they are nevertheless a minority, at least in all the stands investigated here, their form being due more to contingencies of biology (genetics) or competition than to site quality. So the average best were measured in every case.

In all types where they occur together, sugar maple, beech, yellow birch and red oak tend to show the same average clear bole length while basswood, elm, and black ash generally present a longer clean bole. There is also a definite trend towards a longer clean bole on the average for sugar maple, beech and yellow birch on the better sites: *Betulo-Aceretum* s. *tiarelletosum*, *Fago-Aceretum* s. *polystichetosum*, *Fago-Aceretum* s. *tilietosum*, *Tilio-Aceretum* s. *typicum*, *Tilio-Aceretum* s. *juglantetosum* and *Ulmo-Aceretum* s. Because of the variation that does exist however inside each type and also in each plot, this parameter cannot be used either as a reliable indicator of site quality.

Table 11. Clear Bole length by species and types

TYPES SPECIES	B-As tax.	B-As fag.	B-As fag. hum.	B-As tiar.	F-As ox.	F-As til.	F-As pol.
Sugar Maple (+Beech)							
Mean	28	33	32	38	33	40	38
S D	± 6	± 5	± 6	± 8	± 8	± 7	± 7
Max.	41	49	50	48	60	60	56
No. Trees	38	41	45	17	62	34	50
Yellow Birch							
Mean	32	35	33	37	32	32	40
S D	± 8	±10	± 7	±12	± 8	-	± 9
Max.	47	56	50	60	60	40	56
No. Trees	19	29	47	6	32	4	11
Basswood							
Mean	-	-	-	-	-	42	52
S D	-	-	-	-	-	-	-
Max.	-	-	-	-	-	48	60
No. Trees	-	-	-	-	-	4	2
A. Elm							
Mean	-	-	-	48	-	-	-
S D	-	-	-	-	-	-	-
Max.	-	-	-	60	-	-	-
No. Trees	-	-	-	4	-	-	-
Red Oak							
Mean	-	-	-	-	-	-	-
S D	-	-	-	-	-	-	-
Max.	-	-	-	-	-	-	-
No. Trees	-	-	-	-	-	-	-
Black Ash							
Mean	-	-	-	-	-	-	-
S D	-	-	-	-	-	-	-
Max.	-	-	-	-	-	-	-
No. Trees	-	-	-	-	-	-	-

Table 11. Clear bole length (continued)

TYPES SPECIES	T-As typ.	T-As jug.	U-As	O-As	A-Bl typ.	A-Bl tsug.	B-Fn
Sugar Maple (+ Beech)							
Mean	30	30	38	35	-	-	-
S D	± 7	-	± 8	± 8	-	-	-
Max.	48	30	50	60	-	-	-
No. Trees	28	2	23	120	-	-	-
Yellow Birch							
Mean	32	-	36	-	33	24	28
S D	-	-	-	-	± 6	± 4	± 6
Max.	39	-	50	-	51	35	43
No. Trees	4	-	6	-	45	26	32
Basswood							
Mean	44	44	42	-	-	-	-
S D	±12	±11	-	-	-	-	-
Max.	60	60	45	-	-	-	-
No. Trees	12	10	4	-	-	-	-
A. Elm							
Mean	-	-	39	-	-	-	-
S D	-	-	±13	-	-	-	-
Max.	-	-	60	-	-	-	-
No. Trees	-	-	16	-	-	-	-
Red Oak							
Mean	31	32	-	-	-	-	-
S D	± 6	-	-	-	-	-	-
Max.	42	36	-	-	-	-	-
No. Trees	13	6	-	-	-	-	-
Black Ash							
Mean	-	-	46	-	-	-	38
S D	-	-	-	-	-	-	± 6
Max.	-	-	55	-	-	-	49
No. Trees	-	-	6	-	-	-	26

In conclusion, the results just presented seem to indicate that the height-age relationship is still a valid measure of site productivity in unmanaged uneven-aged stands and that it confirms quantitatively the qualitative evaluation arrived at by ecological means. On the other hand, the height-d.b.h. and the d.b.h.-age relationships as well as the clear bole length only supply additional quantitative data about each ecosystem type. They would be unreliable as indicators of site quality in the same unmanaged uneven-aged stands.

SUMMARY AND CONCLUSIONS

An evaluation of the productivity of Quebec's northern hardwood forests was badly needed. Such an evaluation however presupposed a stratification or classification of the sites to be evaluated. The present investigation tried to fulfill the double purpose of classification and evaluation.

A combination of macro- and microclimate, soil moisture and nutrients allowed the separation of 15 ecosystem types characterized by a definite plant community. Each ecosystem however was described into all its major ecological components some of which are essential to photo-interpretation. The ecological data alone already permitted a first qualitative evaluation of the ecosystems v.g. brown forest soils are richer than podsols, mesic sites are better than very dry or waterlogged soils, etc.

But a quantitative evaluation of forest productivity is possible only through mensuration. The problem was particularly complex because of the uneven-aged structure of the forests studied. Such a structure precluded any per-acre increment values based on a single measurement. What is more, no decent volume tables exist for the area. The only possible avenue of investigation was to rely on the growth rate of individual trees. Even this approach however was not trouble-free. Trees of a given size showed a large variation in age in one and the same plot and a large portion of the bigger trees had rotten cores. The methods used in this investigation are believed to have overcome these difficulties in the most logical way and to have produced the best results possible.

The height-age curves do correlate with the qualitative ecological evaluation and along with the diameter-age curves do give a measure of average growth under unmanaged conditions. Both sets of diameter-age curves also contradict the common belief, even among foresters, that hardwoods are slower growing than softwoods.

This is a commentary not a summary.

Because of the large age variation of trees of the same size in any given plot, the use of the height-age curves as site index curves, that is quick reference curves, is impossible. It is my conviction that there is no way of preparing a meaningful set of site index curves for unmanaged uneven-aged stands. The ecological characteristics of the site are not only the best and most rapid indicator of productivity but also the only one feasible in this case.

The results of the present investigation should prove most useful to silviculture and management. The ecological classification provides an appropriate stratification of sites for growth and yield studies and silvicultural experiments.

The curves of average maximum diameter attainable at various ages give an evaluation of the potential growth attainable with moderately intensive silviculture. Judging from the maximum values found for individual trees, I believe even better results can be expected with intensive silviculture and good selection of residual trees. The rotation necessary to get commercial size timber could be shortened by 30 to 40 per cent. In other words, individual trees could be made to realize in 70 years the size they attain presently in 100 years.

In addition, the rates of diameter growth together with a study of the crown width-d.b.h. relationships should produce most useful standards of optimum residual stands in uneven-aged management of various intensities. They should also provide precious guides for thinning intensities in even-aged management of the same forests. For clear-cutting should not be excluded as a treatment for these forests at least for the first cutting cycle. Their pathological condition is so bad that clear-cutting may be the only means of sanitation. The poor shape of the majority of the trees and the great variation in clear bole length in any single stand may be due to genetics or competition. After due study of the relative influence of these two factors, clear-cutting might be the only means of improving the genetic stock if genetics is the main cause. If the type of competition particular to uneven-aged stands is the main cause, growing the trees by even-aged groups might be the solution.

It is imperative to start controlled silvicultural experiments if we want to study growth and yield of these uneven-aged forests. Investigations in pathology, genetics and autecology should also be carried on concurrently.

Finally, all the other ecosystems occurring in the region should be studied: natural softwood stands of bottomlands and dry ridges and secondary succession forests of pine, birch and aspen. Here again it is the writer's contention that the only valid complete approach is through the study of the whole ecosystem of which the plant community is an inseparable part. Any other approach will only result in a partial solution of the problem of site classification.

APPENDIX

List of latin and common names of plant species mentioned in the text.

TREES

Abies balsamea (L.) Mill.	Balsam fir
Acer rubrum L.	Red maple
Acer saccharinum L.	Silver maple
Acer saccharum Marsh.	Sugar maple
Betula lutea Michx. f.	Yellow birch
Betula papyrifera Marsh.	White birch
Fagus grandifolia Ehrh.	Beech
Fraxinus americana L.	White ash
Fraxinus nigra Marsh.	Black ash
Juglans cinerea L.	Butternut
Ostrya virginiana (Mill.) K.	Ironwood
Picea glauca (Moench) Voss	White spruce
Picea mariana (Mill.) BSP.	Black spruce
Picea rubens Sarg.	Red spruce
Pinus Strobus L.	White pine
Prunus serotina Ehrh.	Black cherry
Quercus rubra L.	Red oak
Thuja occidentalis L.	White cedar
Tilia americana L.	Basswood
Tsuga canadensis (L.) Carr.	Eastern hemlock
Ulmus americana L.	American elm

SHRUBS

Acer pensylvanicum L.	Striped maple
Acer spicatum Lam.	Mountain maple

Alnus rugosa (Du Roi) Spreng.	Speckled alder
Cornus alternifolia L.f.	Green osier
Cornus stolonifera Michx.	Red osier
Corylus cornuta Marsh.	Beaked hazel
Dirca palustris L.	Leatherwood
Lonicera canadensis Bartr.	Fly-honeysuckle
Prunus virginiana L.	Choke cherry
Ribes lacustre (Pers.) Poir.	Bristly black current
Ribes triste Pall.	Red current
Sambucus pubens Michx.	Red-berried elder
Taxus canadensis Marsh.	Ground hemlock
Viburnum acerifolium L.	Arrow-wood
Viburnum alnifolium Marsh.	Moosewood
Viburnum cassinoides L.	Witherod

HERBS

Actaea pachypoda Ell.	White baneberry
Adiantum pedatum L.	Maidenhair-fern
Allium tricoccum Ait.	Wild leek
Amphicarpa bracteata (L.) Fern.	Hog-peanut
Aralia nudicaulis L.	Wild sarsaparilla
Aralia racemosa L.	Spikenard
Arisaema atrorubens (Ait) Blume.	Jack-in-the-pulpit
Asarum canadense L.	Wild ginger
Aster acuminatus Michx.	Acuminate aster
Aster macrophyllus L.	Large-leaved aster
Athyrium Filix-femina (L.) Roth.	Lady-fern
Athyrium thelypterioides (Michx.) Desv.	Silvery spleenwort

Botrychium virginianum (L.) Sw.	Rattlesnake-fern
Carex intumescens Rudge	Swelled-up sedge
Carex plantaginea Lam.	Plantain-like sedge
Caulophyllum thalictroides (L.) Michx.	Blue cohosh
Chelone glabra L.	Smooth snakehead
Chrysosplenium americanum Schwein.	Water-mat
Cinna latifolia (Trev.) Griseb.	Wood reedgrass
Circaea alpina L.	Enchanter's nightshade
Claytonia caroliniana Michx.	Spring-beauty
Clintonia borealis (Ait.) Raf.	Bluebead-lily
Coptis groenlandica (Oeder) Fern.	Goldthread
Corallorhiza maculata Raf.	Spotted coral-root
Cornus canadensis L.	Bunchberry
Dentaria diphylla Michx.	Two-leaved toothwort
Dicentra canadensis (Goldie) Walp.	Squirrel-corn
Dicentra Cucullaria (L.) Bernh.	Dutchman's-breeches
Dryopteris disjuncta (Ledeb.) C.V. Mort.	Oak-fern
Dryopteris marginalis (L.) Grey	Marginal shield-fern
Dryopteris noveboracensis (L.) Gray	New York fern
Dryopteris Phegopteris (L.) Christens.	Long beech-fern
Dryopteris spinulosa (O.F. Muell.) Watt	Spinulose wood-fern
Equisetum sylvaticum L.	Wood horsetail
Erythronium americanum Ker	Yellow dog's-tooth-violet
Galium triflorum Michx.	Sweet-scentel bedstraw
Habenaria viridis (L.) R. Br. var. bracteata (Muhl.) Gray	Bracted green orchis
Hepatica acutiloba DC.	Acute-lobed liverwort
Impatiens capensis Meerb.	Spotted touch-me-not

Laportea canadensis (L.) Wedd.	Wood-nettle
Linnaea borealis L. var. americana (Forbes) Rehd.	Twinflower
Listera cordata (L.) R. Br.	Heartleaf twayblade
Lycopodium annotinum L.	Bristly clubmoss
Lycopodium lucidulum Michx.	Shining clubmoss
Lycopodium obscurum L.	Tree clubmoss
Lycopus uniflorus Michx.	Bugleweed
Maianthemum canadense Desf.	Wild lily-of-the-valley
Medeola virginiana L.	Indian cubumber-root
Mitchella repens L.	Partridge-berry
Mitella diphylla L.	Coolwort
Mitella nuda L.	Mitterwort
Monotripa Hypopithys L.	Pinesap
Monotropa uniflora L.	One-flowered Indian pipe
Onoclea sensibilis L.	Sensitive fern
Oryzopsis asperifolia Michx.	Mountain-rice
Osmorhiza Claytoni (Michx.) C.B. Clarke	Sweet jervil
Osmunda cinnamomea L.	Cinnamon fern
Osmunda Claytoniana L.	Interrupted fern
Oxalis montana Raf.	Common wood-sorrel
Parthenocissus quinquefolia (L.) Planch.	Woodbine
Polygonatum pubescens (Willd.) Pursh.	Hairy Solomon's-seal
Polystichum acrostichoides (Michx.) Schott	Christmas fern
Polystichum Braunii (Spenner) Fée var. Purshii Fern.	Pursh's holly fern
Prenanthes altissima L.	Rattlesnake-root
Pteretis pensylvanica (Willd.) Fern.	Ostrich-fern

Pyrola elliptica Nutt.	Shinleaf
Rubus odoratus L.	Thimbleberry
Rubus pubescens Raf.	Dwarf raspberry
Sanguinaria canadensis L.	Bloodroot
Sanicula marilandica L.	Sanicle
Sanicula trifoliata Bickn.	Sanicle
Smilacina racemosa (L.) Desf.	False Solomon's-seal
Streptopus roseus Michx.	Twisted-stalk
Thalictrum polygamum Muhl.	Tall meadow-rue
Tiarella cordifolia L.	False mitterwort
Trientalis borealis Raf.	Star-flower
Trillium erectum L.	Purple trillium
Trillium grandiflorum (Michx.) Salisb.	Large-flowered trillium
Trillium undulatum Willd.	Painted trillium
Urtica procera Muhl.	Tall nettle
Uvularia grandiflora Sm.	Merry-bells
Veronica americana (Raf.) Schwein.	American brooklime
Viola canadensis L.	Canada violet
Viola incognita Brainerd	Large-leaved white violet
Viola pensylvanica Michx.	Smooth yellow violet

MOSSES AND HEPATICS

Bazzania trilobata (L.) S.F.Gray

Climacium dendroides (L.) Web & Mohr.

Hylocomium proliferum (L.) Lindb.

Hylocomium triquetrum (L.) B. & S.

Hypnum Haldanianum Grev.

Mnium cuspidatum (L.) Leyss.

Mnium hornum L.

Mnium punctatum L.

Thuidium delicatulum (L.) Mitt.

Trichocolea tomentella (Ehrh.) Dum.

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