Biology M.Sc.

THE PHYTOSOCIOLOGY OF THE NORTHERN CONIFER-HARDWOOD FORESTS OF THE CENTRAL ST. LAWRENCE LOWLANDS OF QUEBEC AND ONTARIO

This study presents a phytosociological analysis of 141 Northern Conifer-Hardwood forest stands located within the Central St. Lawrence Lowland Plain of south-western Quebec and adjacent south-eastern Ontario. The investigation presents qualitative and detailed quantitative data on the ecological relationships of 54 trees and 516 herbs and shrubs in a wide variety of forest communities.

The importance of individual arboreal and understory elements is presented first on a broad regional basis. The distribution of individual species is then related to phytosociological and major environmental gradients, of which soil moisture characteristics are found to predominate.

The continuous character of forest patterns was determined and related to certain successional tendencies and to specific environmental factors.

The findings of this investigation are compared to studies previously undertaken within the western St. Lawrence Lowland Plain in Ontario and within the adjacent Appalachian Uplands in Quebec.

The existence of a forest continuum composed of a wide variety of deciduous and evergreen trees forming individual complexes related to environmental features, particularly soil moisture, are confirmed for this region.

Jacques Op de Beeck

THE FORESTS OF THE CENTRAL ST. LAWRENCE LOWLANDS

THE PHYTOSOCIOLOGY OF THE NORTHERN-CONIFER HARDWOOD FORESTS OF THE CENTRAL ST. LAWRENCE LOWLANDS OF QUEBEC AND ONTARIO

by

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A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science

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INTRODUCTION

The present study is part of a larger project initiated in the Plant Ecology Laboratory of McGill University in 1957, and now continued in the Ecology Laboratory at Erindale College of the University of Toronto. It consists of gathering detailed quantitative phytosociological data for all of the forest regions of Ontario and Quebec, and interpreting these in terms of plant responses to major environmental influences.

The St. Lawrence Lowlands, underlain by Palaeozoic bedrock, are separated by the Precambrian Frontenac Axis into Western and Central Lowland Plains. Both of the regions supported extensive mixed northern conifer-hardwood forests in presettlement times. The extreme south-western extent of the region supports deciduous forests which have been studied by Maycock (1963). The northern conifer-hardwood formation of Central Southern Ontario was studied by Davies (1969). These Western Lowlands, with the Central St. Lawrence Lowlands, form a tension zone between the deciduous forests to the south and the boreal forests to the north. This intermediate situation is reflected in the fact that forests in the south-western area of the study region contain elements of definite southern affinity, while those areas in the north-eastern section have components of boreal affinity. The more easterly forest communities of the Eastern Lowlands also have floristic relationships with the nearby Laurentian Uplands to the north and the Appalachian

Highlands to the south.

The study region is centered on the St. Lawrence and associated river systems. These have been of great importance as migration routes for plants since the retreat of the last glaciers, and account for the presence of both southern and boreal elements within the region (Raymond, 1950).

Despite these regional characteristics, the forests of the region can be interpreted as a single vegetational unit, and may be related to major environmental influences. The individual tree, shrub and herb species may be similarly examined in so far as their importance and abundance along major environmental gradients is concerned.

A long and varied history of colonization and land clearance is responsible for the fact that various sections of the study region present varying facets of forest vegetation in its succession toward a climactic climax formation. Certain of these facets are examined in relation to environmental factors as they limit individual species in their distribution along a successional gradient.

The forest vegetation of the region is compared with the vegetation of Central Southern Ontario and of the Appalachian Foothills of southern Quebec. These comparisons are both of a quantitative and a floristic nature.

DESCRIPTION OF THE REGION

Location and Physical Features:

The Central St. Lawrence Lowlands are distinct from the Western Lowlands, west of Kingston and from the Eastern Lowlands which consist of the southern part of the Gaspé coast and Anticosti Island. The study region is a plain, underlain by unfolded sedimentary rocks (sand-stones, shales and limestones) of Cambrian, Ordovician and Silurian ages. The strata are gently dipping or lie in low, broad dome-like folds traversed by faults.

Physiographically this area comprises the eastern counties of Southern Ontario and the Southwestern part of Quebec on both sides of the St. Lawrence River to a few miles below Quebec City. It spreads North and Northwest to the Laurentian Uplands, east and southeast to the Appalachian Highlands and southward to the Adirondack Massif. Geologically the "northern boundary of the central part is marked by the overlap of Palaeozoic formations of the Lowlands with the Precambrian crystalline rocks of the Canadian Shield." (Scott, 1967).

Two projections of the Canadian Shield move across the Lowlands. The Frontenac Axis forms the western boundary at the Brockville-Renfrew line (Leeds and Lanarck Counties). The Beauharnois Axis does not reach as far south but separates the Palaezoic rocks of the Ottawa area from those of the St. Lawrence Valley in the Oka-Rigaud area. The latter forms the confluence of the Ottawa and St. Lawrence Rivers. To the east and southeast "Logan's Fault" forms the geological boundaries between the Lowlands and the Appalachian Highlands. The Central Lowlands thus are wedge-shaped with a maximum width between Ottawa and Brockville at the southwestern limit and gradually taper to the apex of a narrow triangle at Quebec City. The land is flat and low around Montreal and gradually rises from 100 feet a.s.l. (above sea level) at river's edge to 300 feet a.s.l. at Quebec City, whereas at the northwest and southeastern boundaries it may reach 400-500 feet.

Bedrock Geology:

The bedrock patterns of Eastern Ontario and Western Quebec have been described by Scott (1967) and Clark (1956) respectively. In Eastern Ontario, spreading into Vaudreuil and Soulanges counties, Quebec, the Palaeozoic rocks of Ordovician age form a basin which is gradual and undulating with the occurrence of fault zones. East of the Beauharnois Axis, Palaezoic rocks of Cambrian and Ordovician age have been warped into an elongated syncline. The axis of the syncline bisects the whole area on the south side of the St. Lawrence River.

The syncline runs from Lotbinière to near the international border at Philipsburg on Mississquoi Bay (Clark, 1956). The oldest rocks of the Quebec section of the Lowlands are of sporadic occurrence and consist of crystalline limestone, granite and gneiss of Precambrian age. They are found along the Beauharnois Axis at Oka, Deux-Montagnes

County, and at Rigaud, Vaudreuil County. Thin- to medium-bedded, white quartz sandstone of the Potsdam Formation occurs mainly in the southwest at Covey Hill, Huntingdon County and in Vaudreuil-Soulanges County, on Ile Perrot and in Deux-Montagnes County. They are deepest in the southwest and become progressively thinner to the northeast and are not found in the Nicolet area. Reworked sands, grey dolomite and sandstone form the overlying Beekmantown Group to the south and south-west. Limestones with dolomite, shale and sandstone layers characterize strata of the Chazy group in Chateauguay, Napierville, Laprairie and St-Jean counties. On the St-Maurice River, Chazy sandstone replaces Potsdam sandstone and forms the base on the Precambrian bedrock. The Trenton Group, predominant in the north and northeast, is found in Terrebonne and l'Assomption counties and lies next to the Precambrian rocks in Berthier, Maskinongé, St-Maurice, Champlain and Portneuf counties. To the northeast side of the basin, this group consists of well-bedded limestones with shale partings which to the southwest are replaced by shale. Forming river-banks and flood-plains of l'Assomption, Berthier, St-Maurice, Champlain, Yamaska, Nicolet and Lotbinière counties are the grey shales, fine-grained sandstones and limestones of the Lorraine Group. Finally, adjacent to the syncline axis in St-Hyacinthe, Richelieu, Yamaska and Nicolet Counties are red and green shales and sandstones of the Bécancour River Formation.

Glacial and Post-Glacial History:

Much of the glacial and post-glacial history of the St. Lawrence Lowlands has been summarized by Flint (1957), MacClintock (1965), Lasalle (1966) and Terasmae (1960). The Pleistocene era was marked by periods of great climatic fluctuation. A progressively cooler climate developed and culminated in severe glaciation. Extensive ice-sheets moved across the land, gathering and moving loose debris in their path, and completely obliterated pre-glacial landscapes. After several thrusts of glacial ice southward over North America, the ice front, marked by retreats and readvances, reached the St. Lawrence Lowlands Region between 18,000 and 12,500 B.P. More recent studies (Lasalle 1966, Lasalle and Terasmae 1968) now indicate that part of the St. Lawrence Lowlands was deglaciated prior to 12,500 B.P.

The excessive weight of the glacier depressed the landscape to a maximum depth in the region of Quebec City of about 650 feet. With the retreat of the ice-sheet, the meltwaters created vast pro-glacial lakes including Lakes Agassiz, Barlow-Ojibway, Algonquin and Iroquois. By 12,000 B.P., the highest parts of the lowlands and also large areas north of the Champlain Valley and St. Lawrence Valley west of Montreal were free of ice (Lasalle, 1966). With more rapid deglaciation, Lake Iroquois drained first via the Mohawk Valley and Hudson River south of the Adirondack Highlands. With the retreat of the ice-sheet to the east, drainage then took place through Covey Pass (present shore line at

725 feet) into the Champlain Valley. Further ice-retreat opened the eastern part of the St. Lawrence River Valley and the lowlands were inundated by marine waters forming the Champlain Sea.

The melting ice left behind debris. This drift was re-worked to form deposits of coarse gravel, sand and clay. Fine sands are found in the deeper parts of the Champlain Sea and medium-sized particules near the edges. The retreating glaciers removed the heavy ice weight from the land and isostatic uplift was initiated and with this resulted in the recession of marine waters. Through time, different beach levels became established, the earliest at a height of 725 feet near Covey Hill. Torrents of melt water from high-lying regions in the Laurentians, Lakes Nipissing, Barlow-Ojibway and developing Lake Ontario, deposited vast quantities of debris on the lowlands and re-worked superficial deposits of sand and clay. The Ottawa and St. Lawrence Rivers fell to the present level which corresponds fairly well to the pre-glacial beds. Tributaries, especially northern ones, took more time to settle and are still bringing debris to the heads of the rivers.

Even though the vegetation before and during interglacial periods is not precisely known, the pollen deposits of the numerous bogs have given clues to post-glacial vegetation. Recent works have produced a calendar of post-glacial plant invasion (Courtemanche and Legault 1958, Terasmae 1960). An initial warm-dry period was characterized by the abundance of <u>Betula</u> and <u>Pinus</u> and a cooler, more humid period followed with <u>Pinus</u> replaced by <u>Picea</u> and <u>Abies</u>. A third period, warmer and drier, witnessed the disappearance of Betula, a decrease in Abies and Picea and an increase in Pinus banksiana with P. resinosa and P. strobus subsequently. Pinus gave way to Tsuga canadensis with Fagus grandifolia, Quercus and Betula lutea during a fourth warm and humid period. A fifth cooler and humid period followed with a decline of the first three species and Betula lutea, Abies and Picea became prominent.

In the time interval since, the lowlands have become occupied by forests which are composed predominantly of broad-leaved tree species with an admixture of conifers and particularly conifers of more southern affinities.

Soil Relationships:

During and following the recession of the ice-sheet, extensive amounts of clay and sand were deposited in the waters of the Champlain Sea. As the land started to rise and salt water was replaced by glacial melt water, extensive sand-dune systems and deltaic sand plains were laid down covering the former marine deposits (Scott 1967). Under the post-glacial climatic regime and the influences of the invading vegetation, and coupled with other prevailing regional and local environmental conditions, a number of soil groups, more or less well-represented throughout the study region, developed.

Matthews (1960) and Putnam and Chapman (1966) have summarized the existing major soil patterns. Podsols are found on well drained and imperfectly drained sandy deposits, Grey-Brown Podsolics on glacial till plains and Brown Podsolic profiles occur on well drained gravelly soils. Brown Forest profiles become well developed on glacial till plains where the limestone bedrock is sparsely covered with loam soil. Grey Wooded and Dark-Grey Gleysolic profiles have developed on level areas with deposits of water-worked silt loam and clay, generally in situations with poor drainage. Glacial till plains are widespread throughout the region and are mainly found adjacent to contact zones with older bedrock. This glacial till has a loamy texture and contains a high proportion of limestone. Soils of water-lain silt loam and clay have developed on these plains.

Old beaches and dune systems with medium to fine water-lain sand and sandy loams are scattered throughout the Ottawa and St. Lawrence River Valleys. Podsol profiles have developed on the well-drained sites but about 75% of these soils are imperfectly drained Podsols and poorly drained Gleysols. These sands have low moisture-retaining capacity, low fertility and low organic content and are very susceptible to wind and water erosion. The most extensive regions representing this soil group are the Edwardsburg sandplain in Grenville County and the Prescott and Russel sand plains between Ottawa and Hawksbury. In Quebec, extensive sand deltas are found at the mouths of most tributaries of the St. Lawrence River. Most noteworthy include the delta of the St. Maurice from Three Rivers to Shawinigan and the extensive sand banks at the west end of Lake St. Peter. This latter beach and dune system spreads westward to Joliette, Lanoraie, Lorraine and the St. Janvier area. Another extensive sand plain is found at Oka on Lake of Two Mountains and across the Ottawa continues into Prescott and Russell counties. A substantial sand deposit is situated at the foot of Rigaud Mountain and is related to this system at the confluence of the Ottawa and St. Lawrence Rivers. In the east central section of the Montreal plain are sandy loams of deltaic origin in Yamaska, Drummond and Nicolet counties.

Deltaic outwash and lacustrine plains are situated on the low-lying shores of the Ottawa and St. Lawrence Rivers. The largest area of occurrence is from east of Lake St. Peter to Quebec City on both sides of the St. Lawrence and running north and south respectively up to the Laurentians and Appalachian contact zones. Here there are three more or less distinct soil patterns evident. On the river flood plains there are deep clay and loam deposits. There may be a narrow belt of clay along the shore or this may be overlain with undulating sand deposits as is found in Champlain and Portneuf counties. Then, in the intervening areas up to the contact zones of Pre-cambrian and Cambrian origin, "undulating to hilly gravelly and sandy outwash soils are interspersed with fine sand and loam till soils and water-lain clay and silt loam soils". (Matthews 1960). On Ile d'Orleans sandy clays are found above the river flats and run in a ridge overlying gravelly loams.

Lacustrine plains occupy an extensive portion of the western half of the study region. These include the Winchester Clay Plain, between the Glengarry Till Plain and the sand plains of Russell and Prescott counties, the Lancaster Flats in South Glengarry County, which extend into Vaudreuil and Soulanges counties, and the Ottawa Valley Clay Plains between Pembroke and Hawksbury (Putnam, 1951). These consist mainly of "silt loams, clay loam, and clay loam materials that are slowly permeable, of good natural fertility and imperfectly to poorly drained." (Matthews, 1960). In the main, they are formed from Champlain Sea sediments. Grey Gleysolic soils predominate although in well-drained situations grey-brown podzolic and podzol profiles occur.

Throughout the region there are areas with inadequate drainage systems which are underlain extensively by peat and muck deposits. It is in these that bogs have become established. Examples are the Mer Bleue Bog near Ottawa, Alfred Bog (Prescott County), and bogs at Ste. Thérèse (Terrebonne Co.), Ste. Clothilde (Napierville Co.), Lanoraie (Berthier Co.), Farnham (Mississquoi Co.), and Bulstrode (Lotbinière Co.). The lowland conifer forests which have been long established in these situations are not included in the present investigation but have formed the basis for other studies (Warder, 1970).

The variable soil patterns which occur in this central section of the St. Lawrence Lowlands have a direct influence on the composition of forest communities and their distribution within the region.

Climate:

The influence of climate has been of great importance in the development of particular vegetation patterns observed throughout the Central St. Lawrence Lowlands of Quebec and Ontario. This influence is manifested through the combined effect of temperature and precipitation and depends on the geographic features of a specific site such as altitude, latitude, topography and degree of slope. The topography of the study region is uniform. Most areas bordering the river systems and the low-lying adjacent areas of the plain benefit from the ameliorated climatic conditions.

Climatic indices for the study region vary mainly with latitude. The Eastern Counties of Ontario benefit from the moderating climates due to proximity to the Great Lakes. The southwestern part of Quebec is subject to the same climatic influences as the Lower Lakes region of Ontario but is without the protection of the Great Lakes. Quebec City is open to the cooler climates of the North Shore and Gulf regions. The effects of these last influences are observed as far west as Three Rivers.

Climatic data relevant to past and present vegetation has been compiled by Villeneuve (1946, 1969) and Grandtner (1966) for Quebec, and by Putnam and Chapman (1938) and Sanderson (1950) for Southern Ontario. The studies effected by Grandtner (1966) are most relevant to the present vegetational studies. Villeneuve (1946), in relating existing forest vegetation to climatic conditions, divided the Quebec study area into an Upper and Lower St. Lawrence section of the Hardwood Forest region. The two regions were delimited at Three Rivers. The Upper St. Lawrence section has decreasing temperatures while precipitation increases. Mean monthly summer precipitation for Upper and Lower sections is 2.5-4.0 inches, and 4.0-5.0 inches, respectively. The P.-E. (Potential Evapotranspiration) quotient in summer is 0.4-0.6 and 1.0-1.2, respectively for Upper and Lower St. Lawrence sections.

The mean annual temperature decreases from 43°F at Kemptville, to 42°F at Ottawa and Montreal and reaches a low of 39°F at Quebec City. The January mean temperature ranges from 14°F at Kemptville and Montreal, to 12°F at Ottawa, to a low of 10°F at Three Rivers and Quebec City. The July mean temperature is 70°F at Kemptville and Montreal, and only 67° at Quebec City. The degree days of temperature over 42°F are an index of the length and warmth of the growing season. Areas to the south of the Precambrian Shield in both Quebec and Ontario have records of from 3000 to 3500 degree days, although a low value of 2500 degree days has been recorded in the Quebec City region. The length of the growing season (or more relative, that of the frost-free period) may vary within the study region from 135 to 155 days. The Eastern Counties of Ontario have an average growing season of 140 days, Montreal has a growing season of 143 days, and a value of 125 days is encountered at Drummondville.

Mean annual precipitation shows a marked increase with latitude. Kemptville has a record of 35", Montreal 37" and Quebec City has a mean annual precipitation of 45". The Eastern Counties of Ontario, lying between the St. Lawrence and Ottawa Rivers, are under the influence of a belt of heavier precipitation. This effect is also noticed in areas surrounding Lake St. Louis and Lake of Two Mountains.

The most useful indices relating climate to vegetation are those combining temperature and precipitation. Potential evapotranspiration, defined as the water need of the existing vegetation in relation to effective precipitation, temperature, and duration of growing season, decreases from 24" at Kemptville, to 23" at Ottawa and Montreal, to 22" at Quebec City. The actual evapotranspiration for the St. Lawrence-Ottawa Lowland is 22-23". Nowhere within the study region is there any serious shortage of water. Average annual water deficiency (with 4" storage) amounts to 2" within the Eastern Counties of Ontario. At Montreal there is a deficiency of 1" which decreases to 0" in the eastern part of the region. East of Montreal surplus water conditions exist as a result of cooler temperatures, heavier precipitation and a substrate of heavy clay soils.

Tables 1 and 2 show mean temperature (^{o}C) and precipitation (mm) for 17 stations within the study region. Table 3 presents a summary of climatic data accumulated by various workers. The annual radiation balance presents a sum of annual temperatures above 50^{o}F. Values of 25 kg.cal. and more are found to the west of Lake St. Peter. The eastern half of the Lowlands has values ranging from 23.5 to 24.9 kg.cal.

The Lang Index evaluates precipitation against temperature, and the Dokuchaev-Vysotskii Index measures precipitation against evapotranspiration. Both show a pattern of increasing water surplus in the northeast of the study region.

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Table 1:

Mean monthly temperature (°C) for selected localities within the region studied. (Department of Environment, 1971)

MEAN TEMPERATURE (°C) FOR SELECTED LOCALITIES WITHIN THE REGION STUDIED

Month Station Coordinates	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Monthly Mean
Berthierville 46 06'N-73 11'W	-11.7	-12.1	- 4.9	4.7	11.6	17.3	19.6	18.1	13.5	7.0	- 0.1	- 8.2	4.6
Brockville 44 35'N-75 41'W	-11.5	- 6.8	- 3.6	4.1	12.8	17.9	19.4	19.1	17.6	12.5	3.8	- 9.4	6.3
Cornwall 45 02'N-74 45'W	-11.9	- 7.3	- 4.3	3.4	13.2	18.4	20.3	19.7	18.0	12.4	1.3	- 9.6	6.1
Donnaconna 46 43'N-71 44'W	-12.0	-11.3	- 4.3	3.9	11.3	17.4	20.0	18.7	13.9	7.2	- 0.3	- 8.6	4.6
Drummondville 45 50'N-72 30'W	-11.7	-11.7	- 4.4	4.0	11.4	16.8	19.4	18.2	13.7	7.3	- 0.3	- 8.4	4.5
Farnham 45 17'N-72 59'W	- 9.9	- 9.9	- 2.9	4.6	11.7	17.2	19.9	18.6	12.6	7.9	1.0	- 7.3	5.3
Kemptville 45 01'N-75 37'W	-13.9	- 8.7	- 5.2	2.9	12.6	18.0	19.0	18.6	16.9	11.6	0.3	-11.0	5.1
l'Assomption 45 50'N-73 28'W	-10.8	-11.4	- 9.9	4.3	12.2	17.8	20.0	19.2	14.2	7.7	0.2	- 8.9	4.5
Montreal 45 30'N-73 35'W	-10.1	- 9.3	- 3.3	5.3	13.0	18.4	21.0	19.7	15.0	8.3	0.8	- 6.9	6.0

	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Monthly Mean
Morrisburg 44 52'N-75 10'W	-13.4	- 8.1	- 5.5	2.7	12.9	17.4	19.5	18.8	16.9	12.0	0.5	-11.2	5.2
Nicolet 46 15'N-72 36'W	-11.4	-12.2	- 4.7	4.1	11.7	17.1	20.1	18.6	13.3	7.4	- 0.1	- 8.2	4.6
Ottawa 45 24'N-75 43'W	-11.1	-10.6	- 4.1	4.9	12.8	18.1	20.9	19.0	14.6	7.7	0.6	- 8.4	5.4
Quebec 46 48'N-71 13'W	-12.0	-11.1	- 5.2	2.6	10.7	16.4	19.3	17.6	13.2	6.7	- 0.7	- 9.2	4.0
Ste. Clothilde 46 00'N-72 19'W	-11.1	- 9.1	- 2.3	4.8	12.6	17.7	19.9	18.9	13.8	7.3	1.1	- 7.3	5.5
St. Hubert 45 31'N-73 26'W	-10.0	-10.0	- 4.4	5.0	12.8	18.3	20.6	19.4	14.4	8.3	0.6	- 6.7	5.7
St. Hyacinthe 45 37'N-72 58'W	-11.2	-10.7	- 4.1	5.3	12.1	18.3	20.9	20.0	13.3	7.7	0.4	- 7.8	5.3
Trois Rivières 46 22'N-72 33'W	-12.2	-11.1	- 4.4	3.9	11.1	17.2	20.0	18.9	13.3	7.2	0.0	- 8.9	4.6

Table 2:

Mean monthly precipitation (mm) for selected localities within the region studied. (Department of Environment, 1971)

PRECIPITATION (mm.) FOR SELECTED LOCALITIES WITHIN THE REGION STUDIED

Month Station Coordinates	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Annual
Berthierville 46 06'N-73 11'W	78	58	71	83	66	87	87	88	85	83	76	78	940
Brockville 44 35'N-75 41'W	42	121	67	54	49	70	99	75	99	46	58	97	877
Cornwall 45 02'N-74 45'W	62	139	89	59	69	58	80	83	77	31	57	153	961
Donnaconna 46 43'N-71 44'W	105	78	83	85	85	96	110	119	105	68	97	80	1,106
Drummondville 45 50'N-72 30'W	98	71	77	92	87	128	121	107	118	107	92	89	1,187
Farnham 45 17'N-72 59'W	77	58	78	86	75	92	94	85	101	84	89	72	991
Kemptville 45 01'N-75 37'W	36	110	52	51	33	47	72	86	41	55	54	93	730
l'Assomption 45 50'N-73 28'W	83	61	74	76	67	91	97	93	87	73	69	69	940
Montreal 45 30'N-73 35'W	96	77	88	66	80	87	95	88	93	87	90	91	1,038

Month Station Coordinates	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Annual
Morrisburg 44 52'N-75 10'W	58	136	54	54	64	60	114	71	114	33	62	116	936
Nicolet 46 15'N-72 36'W	93	71	68	84	83	106	103	95	93	93	95	86	1,070
Ottawa 45 24'N-75 43'W	75	55	70	69	63	89	86	65	82	74	76	66	870
Quebec 46 48'N-71 13'W	88	70	77	60	80	93	102	101	91	87	87	82	1,013
Ste. Clothilde 46 00'N-72 19'W	56	69	76	82	92	104	88	83	98	79	69	73	969
St. Hubert 45 31'N-73 26'W	92	61	84	81	74	84	84	74	82	70	82	81	949
St. Hyacinthe 45 37'N-72 58'W	80	93	56	74	85	88	89	126	81	79	70	83	1,004
Trois Rivières 46 22'N-72 33'W	80	61	60	74	84	98	100	108	101	90	101	74	1,031

Table 3:

Annual radiation balance, potential evapotranspiration, Dokuchaev-Vysotskii and Lang Indices for selected localities within the study region. (Grandtner, 1966)

ANNUAL RADIATION BALANCE, POTENTIAL EVAPOTRANSPIRATION, DOKUCHAEV-VYSOTSKII AND LANG INDICES FOR SELECTED LOCALITIES WITHIN THE STUDY REGION

Station	Annual Radiation Balance kg. cal.	Potential Evapotranspiration mm/yr.	Dokuchaev -Vysotskii Index ppt/evt	Lang Index ppt(mm)/T(C)
Berthierville	24.5	441	2.1	204
Donnaconna	24.9	448	2.4	240
Drummondville	24.3	437	2.7	264
Farnham	24.5	441	2.2	187
Kemptville	26.8	462	1.6	143
l'Assomption	25.5	459	2.4	209
Montreal	26.7	481	2.1	173
Nicolet	24.7	445	2.4	233
Ottawa	26.1	470	1.8	161
Quebec	23.6	425	2.4	253
Ste. Clothilde	25.4	457	2.1	176
St. Hyacinthe	25.9	466	2.1	190
Trois Rivières	24.7	445	2.3	224

VEGETATION

As a result of extensive and repeated glacial action, mainly one of deposition, the topography of the study region is in general quite uniform and is related to the major river systems. Topographic variation does exist and has given rise to certain edaphic conditions. These combined have influenced the establishment of a vegetational cover dependent upon and influenced by dry, wet or moist soil conditions. Gradations and combinations in species composition occur between extremes of the moisture gradient with species more or less restricted to or occurring in common on certain soil moisture conditions. This general description of the forest vegetation is thus presented largely in relation to the influence of the overriding soil moisture factor.

For the past 300 years most of the natural vegetation has been extensively and drastically altered. In the vicinity of the major river systems, vast tracts of land were cleared for agriculture. The forested areas have been selectively logged or cut over to varying degrees and these practices have exerted considerable influence on the present composition of the forests. Lumbering, pasturing, agricultural practices, the effect of fire before and after the initiation of settlement, as well as other forms of disturbance, have continually modified the vegetation and maintained it in a successional condition and have produced instability in the ecosystems.

The driest sites of the Central St. Lawrence Lowlands support forests in which a predominance of Pinus strobus, P. resinosa, Quercus rubra, Populus grandidentata, and Quercus macrocarpa occur. These sites are formed on the sandy ridges and old dune systems laid down during the Champlain Sea interval. Acer rubrum is one of the common trees of occurrence but is seldom of strong importance. Extensive sand deposits occur at the western end of Lake St. Peter, a former delta of the St. Lawrence and Richelieu Rivers. On the north shore at Lanoraie, Pointe-du-Lac, Joliette, Lorraine, Ste. Anne-des-Plaines and Pincourt sandy ridges parallel the present shore line of the St. Lawrence. Here are found forest complexes of Pinus strobus, P. resinosa, Betula papyrifera, B. populifolia, Quercus rubra, Tsuga canadensis, Acer rubrum and Populus grandidentata. Extensive tracts of forest still exist on these ridges. The fine wind-blown or beach sands cannot be completely cleared because of grave erosion dangers.

Not all of the driest stands are found on sand deposits. Depauperate hardwoods situated on limestone outcrop and dominated by Quercus macrocarpa with Ostrya virginiana, Carya cordiformis, and Ulmus thomasi are found in Carleton County. At St. Laurent de l'Ile d'Orléans, Montmorency County, drier hardwoods are dominated by Quercus rubra, with Ostrya virginiana, Acer saccharum and Betula papyrifera occurring as co-dominants. On the south shore of the St. Lawrence, at a height of 200 feet and overlooking the Quebec bridge, dry savanna-like stands of Pinus strobus, Quercus rubra, Pinus resinosa, and Picea rubens are found on very shallow soils over bedrock, on the rim of the Chaudière basin. The type is frequent in the area on rocky ridge tops.

At the edges of bogs, extensive sand plains have been deposited and such sites occur in Prescott, Champlain and St. Maurice counties. Both drier and wetter edaphic conditions may be found, depending on underlying drainage patterns. The drier sites may have savanna-like stands of a successional nature with Pinus strobus, P. resinosa, Betula papyrifera, Populus grandidentata and Acer rubrum. Pinus banksiana is very rare in the study region and was encountered only as scattered trees in the St. Maurice Valley and at Constance Bay, Renfrew County. In both locations it has apparently invaded the sand plains from the adjacent granites of the Canadian Shield. Pinus rigida is found only at Cairnside, Huntingdon County. A general feature of the driest sites of the region is the predominance of the coniferous element over the broad-leaved.

Conditions of excessive moisture are present mainly in lowland depressions or bottomlands which occur adjacent to the major river systems. Bottomlands owe their features to the topographic characteristics of river banks, particularly flood-plains, and are periodically flooded when they receive run-off waters in spring and in late fall. Most of the water drains off relatively quickly and these sites are then dependent on precipitation during the rest of the season. Rich bottomlands can still be found along the upper St. Lawrence and Lower Ottawa

Rivers, in the vicinity of the Hochelaga Archipelago, along Rivière des Mille Iles where industrial development has been slow, on the Richelieu River, the south shore of Lake St. Peter and along the shore line of Portneuf County. The predominant tree species in these bottomlands is Acer saccharinum, although other species such as Quercus bicolor and Ulmus americana may achieve dominance on certain sites. Associated with Acer saccharinum may be Fraxinus pennsylvanica, F. americana, Ulmus americana, Acer rubrum and Quercus macrocarpa. All these sites have alluvium deposited seasonally on heavily compacted clays. Although water does drain off with the cessation of flood conditions, extensively inundated areas in certain stands may remain flooded longer and have a much less luxuriant ground-cover than elsewhere in the same stand. Bands of organic debris and alluvium, brought in by flood waters, frequently form indicating the fertilization process. Ice rubbing is also a phenomenon related to flooding and substantiates the considerable depth of water as shown by scars on the tree trunks. These may occur to a height of 6 feet. Typical of bottomlands are widely spaced trees forming a cathedral-like aspect. Saplings are often very sparse in these sites. Tree seedlings, although they may extensively cover the ground in early summer, seldom survive in quantity into the next season.

In the Richelieu Valley, on Ash Island, quite near Lake Champlain, an unusual and luxuriant open-canopied and savanna-like bottomland forest is dominated by Quercus bicolor. Ulmus americana and Quercus macrocarpa are also present.

Bottomland situations may also occur on second level terraces or higher flood levels which are less subject to flooding than lower terraces. Here, Acer saccharinum is usually less important and Ulmus americana, Tilia americana, Fraxinus pennsylvanica, and Carya cordiformis are significant species depending upon the local situation. In Nicolet County and at the mouth of the St. Maurice River an unusual park-like forest, dominated by Populus deltoides, occupies the lower flood level.

Lowlands occur in depressions which accumulate run-off waters from surrounding higher land. They are characterized by poor drainage generally due to impervious clays and hardpans. The water usually tends to stagnate and persists well into the growing season. Although Acer saccharinum is still an important element in lowland forest types, the Ulmus americana - Fraxinus americana community is predominant. Other trees occurring on these sites are Fraxinus pennsylvanica, F. nigra and Acer rubrum. As with the bottomland formations there may be a marked absence of saplings and seedlings. In the very wet lowland sites pure stands of Salix nigra can be found, but are infrequent.

The Dutch elm disease has decimated most of the white elm stands in areas in the southern parts of the study region and is slowly but surely progressing northward in the Central St. Lawrence Lowlands. The quantitative studies undertaken here have accumulated data on species composition in the elm and ash communities and this may well prove to be of use in comparing successional trends within these stands. It may be possible to determine the manner in which Fraxinus americana or Acer rubrum or other species will replace the declining Ulmus americana.

Throughout the Central St. Lawrence Lowlands, bogs are found in situations of cooler microclimate and of insufficient drainage. The dominant tree species of these sites are Picea mariana, Abies balsamea and Larix laricina, trees of boreal affinity. Although such forest types were not the subject of this investigation, these are stands in the related successional series which, although predominantly composed of hardwood species, nevertheless have a component of boreal trees present. At Yamachiche, St. Maurice County and at Brown's Gore, Argenteuil County, such forest types are frequent. These boreal trees species, Picea mariana, Abies balsamea and Larix laricina may achieve co-dominance with Acer rubrum, Betula populifolia and Betula lutea.

During a long period of settlement, much of the original forests of the Central St. Lawrence Lowlands have been cleared or modified and particularly the forests of the fertile remnants of the moist uplands. Remnants of the natural, luxuriant mesophytic forests can still be found in scattered woodlots and in infrequent extensive tracts in Terrebonne, l'Assomption, Joliette and Berthier counties. These upland sites, on undulating terrain with optimum moisture conditions, support stands in which Acer saccharum is dominant. In the warmer southwestern part of the region, Carva cordiformis, Fagus grandfolia, Tilia americana, and Carya ovata may be found with

Acer saccharum on mesic sites. In the cooler northern and western areas _Tsuga canadensis_, _Fagus grandifolia_, _Acer rubrum_ and _Betula lutea_ are found in similar fashion.

The mesic upland forests dominated by sugar maple have long been exploited for maple syrup production. In order to make this operation more productive, most sugar bushes have been managed to varying degrees. This has consisted mainly in "cerclage" which involves in extreme examples the eventual removal of all other tree species to facilitate a complete dominance of _Acer saccharum_. Most saplings are removed to facilitate movement through the bush, with only a few left to replace older trees. The general picture of a heavily exploited sugar bush presents a park-like aspect with a buffer zone to adjacent fields and pastures. This zone is usually a remnant of the natural bush and is dominated by _Acer saccharum_ with scattered occurrences of _Fagus grandifolia_, _Ostrya virginiana_, _Ulmus americana_ or _Quercus rubra_. Sugar bushes are fairly well distributed within the study region, but the heaviest concentrations occur in Deux Montagnes, Terrebonne, l'Assomption, Berthier, Joliette, Verchères, St. Hyacinthe, Richelieu, Glengarry and Stormont counties. A problem resulted from the various levels of exploitation to which stands with _Acer saccharum_ are subjected for sugar production. This was particularly true in the northern sections of the region.

Considerable vegetational variation exists within the region. The forest types discussed thus far are generally quite widespread throughout the region and the major tree dominants are tolerant of a greater range of soil moisture conditions. On the other hand, some forest types are quite local in their distribution and are much more dependent on specific microclimatic situations or on minor topographic deviations.

Thuja occidentalis is observed in both wetter sites (cedar swamps) and on drier limestone pavement. In Dundas, Glengarry, Huntingdon, Vaudreuil and Soulanges counties pure stands of Thuja occidentalis occur. Cedar will also invade abandoned pastures where shallow soils occur over limestone bedrock.

Old field succession may also be dominated in initial stages by Betula populifolia with progressive occurrence of Acer rubrum, Populus tremuloides or Tsuga canadensis. Water-logged sites, alder swales and willow carrs are invaded by Populus tremuloides as the first tree species. Trees of minor importance in secondary succession trends are Ulmus americana, Populus balsamifera, Betula papyrifera, Fraxinus americana, Tsuga canadensis and Betula lutea.

PREVIOUS STUDIES

Many of the works dealing with the vegetation types of the region have, in most cases, included them as a part of a broader geographical consideration. In chronological order, early botanists dealt more with the flora rather than with the vegetation types. This is understandable because certain plants were important for their nutritive and medicinal values. Lumber was necessary for building and for fuel. These early works nevertheless have historical value. They describe the flora, the dominant tree species, the lesser trees, and the herbs and shrubs found during the exploration of new regions.

In subsequent periods, the vegetation types are described and delimited on a continental and later on a more regional basis. Later detailed qualitative and quantitative studies analyze both broad and specific regional vegetation patterns.

Major geological and palynological works have discussed the effects of recent glaciation and have outlined the chronological order of vegetation types in areas as they became free of glacial ice. (Lasalle 1966, Lasalle and Terasmae 1968, Terasmae 1960). Cleonique (1936), in describing the development of the vegetation in terms of waves of invasion, emphasizes the importance of the innumerable lakes left by the receding Champlain Sea in the developing organization of the Laurentian "phytomosaic".

The first record of the flora and vegetation of the St. Lawrence Lowlands was made by Jacques Cartier in 1535. After viewing the desolate and disappointing north shore of the Gulf, he came upon the rich alluvial areas of the St. Lawrence. ".... durant lequel temps, avons veu et trouvé aussi beau pays, et terres aussi unyes que l'on sçauroit desirer, plaines, des beaulx arbres du monde, savoir: chaisnes, hourmes, noyers, pins, seddrez, pruches, frannez, boulx, saudres, oziers, et force vignes..." (Biggar, 1924).

Rousseau has made important contributions to the anthropography of Eastern Canada and has discussed the relationships of the various peoples to the land and to the forests. "The various peoples who have successively inhabited this forest, have either used it as members of the bio-sociological unit or tried to modify its ecology depending on their traditional cultures." (Rousseau, 1962). The Red-ochre man, Algonkian forest hunters, and Iroquoian agriculturalists and hunters lived in and in harmony with the natural environment. The colonists saw the forest as an enemy. Land clearance was a necessity for agriculture, travel and settlement. One and a half centuries were spent clearing the land, and the previous century for fur-trapping. In the late 1700's and early 1800's, the final ravage of the forests took place. Albion (1926) gives a detailed account of the historical aspects involved. Indiscriminate cutting of pine and oak on the plain left little of the original vegetation standing. What did remain was on land unsuitable for agriculture.

> "To these agricultural forest reserves belong the maple groves of which Canadians are so proud. This timber wealth occupies the poorest or most rocky of soils, those most unsuitable for agriculture... The woods are sometimes isolated or sometimes grouped like those extending from Terrebonne to Berthier and they are the last vestiges of the mighty forest that formerly covered the Central plain of the St. Lawrence. Here were once the most beautiful forests of pine, spruce, and cedar, also of oak, elm, ash, beech, cherry, maple, and other woods." (Chapais, 1914)

By the end of the 19th century numerous botanists, including Kalm, Michaux, Holmes, Torrey, Gray and Macoun, had presented descriptive accounts of the flora encountered on numerous expeditions. Merriam, by 1898, had divided the continent into life zones. His Boreal Zone included the province of Quebec and was subdivided into Arctic, Hudsonian, and Laurentian regions. The latter includes the study area, characterized by coniferous and mixed forests.

In the early 1900's numerous works were published in which various forest regions were delimited. Frothingham (1915) described the Northern Hardwood Forest Region as co-extensive with the geographical range of yellow birch, and considered *Betula lutea*, *Pinus strobus* and *Tsuga canadensis* as the most characteristic species, and *Acer saccharum* and *Betula lutea* as the most characteristic hardwoods. Ab-Yberg (1933), noting physiographic differences, subdivided the province on the basis of both climate and forest. His fifth region was the St. Lawrence River Plain, and is more or less co-extensive with the area of study.

The Hemlock-White Pine-Northern Hardwood Region of Nichols (1935) is more or less co-extensive with Frothingham's Northern Hardwoods Region. He considers the conifer-hardwood region as a tension zone in which various elements from both the deciduous and boreal forests meet, but yet one which may nevertheless be independent, having most of the species of the climax forest with centers of distribution either within the region or to the south of it. He decided that Pinus strobus and Pinus resinosa form but minor constituents in the climax.

Blanchard (1935), while discussing in depth both the physical and human geography of French Canada, describes the history of colonization and some aspects of the vegetation and agriculture. Of the area to the south of Lake St. Peter he says:

> "Cette forêt, c'est déjà un royaume des arbres à feuilles caduques, en flèches ici vers le Nord-Est. On y trouvait des plantes à affinités méridionales, noyers, chênes, inconnus ou à peu près dans la région de Québec; Bouchette en 1815 signale la présence de chênes et hickorys sur les bords de la Yamaska, avec des platanes et des hêtres. Trop exploités, les premiers ont disparus; les ormes, les frênes, les platanes, ne sont plus guère des essences forestfères mais des arbres dispersés au long de ruisseaux ou de chemins. Ce sont aujourd'hui

> les différentes variétés d'érables, les hêtres, les merisiers, les tilleuls, les bouleaux, qui constituent la grande masse des 'bois francs'. Avec eux on trouve des conifères, le Pin blanc fréquent sur les sables, le sapin et l'Epicéa et dans les lieux humides le mélèze, l'épinette noire, le cèdre. Affectionant chacun des sols variés, secs ou mouillés, compacts ou légers, ces arbres étaient partout, garnissaient entièrement le sol."

Marie-Victorin (1935), in the first complete work on the Laurentian flora, included the study region in a triangle formed by Ottawa, Quebec City and Lake Champlain. The western end of this triangle consists of well worked over soils on which a deciduous forest with _Acer rubrum_, _Carya cordiformis_, _Carya ovata_, _Fraxinus pennsylvanica_, _Quercus rubra_, _Quercus macrocarpa_, _Tilia americana_, and _Ulmus americana_ has become established. A large part of this section is covered by sand beds, especially in the vicinity of Lake St. Peter. "On y trouve des formations pures de _Pinus strobus_ ... et de _Pinus banksiana_, des formations de _Betula populifolia_ ...; des formations mixtes de _Pinus resinosa_ et de _Populus grandidentata_."

Halliday (1937), considering floristic, physiographic, edaphic and climatic factors together, divided the forests of Southern Quebec and adjacent Ontario into a Boreal Forest Region and the Great Lakes - St. Lawrence Region. The latter, "compressed and fragmented by boreal invasion in glacial times, shows northern coniferous trees with broad-leaved trees which are almost exclusively in the Southern Deciduous Forest of Quebec." Certain authors disagree as to the extent of the Boreal

Forest. Dansereau (1959) recognizes no Mixed Forest and considers the Boreal Forest borders on the Deciduous Forest. Rousseau (1952) recognizes an extensive mixed Conifer Hardwood zone between Coniferous and Deciduous forest zones.

Within Halliday's (1937) Upper St. Lawrence Section:

> "the general character of the tree cover is broad leaved, there is a fair representation of coniferous growth, which, previous to settlement, was probably more extensive. The dominant association is made up of...sugar maple and beech, together with small quantities of yellow birch, white elm, red maple, basswood, white ash, (northern) red, white, and bur oak, and large-toothed aspen, with local occurrence of rock elm and blue beech. In the immediate river-valleys there is some local distribution of butternut, cottonwood, and slippery elm, with intrusions, up the Champlain Valley, of shellbark hickory. Within the general association are patches of hemlock, white spruce, balsam fir, and some white pine; and on the light soils an association of white and red pine, now as second growth stands, is relatively common. In the poorly drained depressions small areas of either tamarack, Eastern white cedar, and black spruce, or black ash are found, and clumps of cedar are often characteristic of poor stony sites. After fires second growth stands of aspen, mainly large-toothed, and white birch with balsam fir and white spruce are often found."

The mixed forest of the lower St. Lawrence Section portrays a very northern influence. Here:

> "the principal association is made up of sugar maple, hemlock, white pine, and yellow birch with considerable balsam fir and white birch and scattered white spruce -- the last three all Boreal species. In the above are distributed some silver maple, (Northern) red oak, beech,

> white ash, butternut, red pine and white elm. Aspen and white birch are relatively common after disturbances; cottonwood and red maple are found on river-banks, and swamps are composed of both black ash and black spruce with cedar."

Surprisingly, no mention is made of wire birch, Betula populifolia, which today is present as a major species over extensive areas.

Numerous authors have written about the floristic composition of the forests of various regions of the province. Raymond (1950) follows essentially the same phytogeographical plan as Marie-Victorin. His Laurentian section is divided into eighteen sub-provinces, of which the Ottawa Valley, the alluvial plain of the St. Lawrence, the Richelieu Valley, and the Hochelaga Archipelago make up the study region. The distribution of common and rare plants in all sections is discussed and northern limits and invasion paths are described. The most characteristic arboreal elements of the Lowland Plain are Acer saccharum, Acer saccharinum, Carya spp., Quercus alba, Quercus bicolor, Quercus macrocarpa, among others. He draws attention to the impact of man on the environment by agricultural practices:

> "L'Homme s'est installé dans cette partie du pays depuis plusieurs siècles. L'agriculture, l'élevage sous toutes leurs formes y sont intenses et la flore, en raison de l'activité humaine, a une forte allure européenne, surtout dans les lieux ouverts. Les bois que la hache ou le feu ont respectés conservent seuls la flore primitive, avec les abords immédiats des cours d'eau, les marécages et les tourbières."

Villeneuve (1946) stresses the importance of climate in controlling patterns of forest vegetation. His Upper St. Lawrence Region is the warmest, with a longer frost-free period and light summer precipitation. The milder climate of the Upper St. Lawrence Region has permitted certain tree species to invade and to establish themselves on a local scale. The more temperate Lower St. Lawrence Region reflects the influence of coniferous forest species on forest composition. However, Quercus rubra, Fagus grandifolia, Fraxinus americana, Juglans cinerea, Populus deltoides, and Populus balsamifera are still present due to the overall warmer climate of the Hardwood Forest Region.

Braun (1950) agrees with Nichols (1935) and emphasizes the transitional nature of the Northern Conifer-Hardwood Region between the Boreal Forest complex to the North and the Beech-Maple complex to the South. Whereas Halliday (1937) equated his regions with the climatic climaxes of Clements (1936), Rowe (1959), in his revision of the forest classification, described each section in terms of the major tree species of the predominant forest type. His classification of the Hardwood Forest Region is now based on the greater representation of broad-leaved species rather than on the absence of conifers.

In anticipation of the St. Lawrence Seaway project, Dore and Gillett (1955) conducted a rapid survey of the flora and forest vegetation of some 8,000 acres that were to be flooded in the area between Cornwall and Prescott. Only original or near original sites were sought out and described. On poorly drained sand white pine, red maple, red oak, white birch and black cherry were present. Acer saccharum, Fagus grandifolia, Tilia americana, Betula lutea and Pinus strobus grew on slopes with better drainage. Wetter woods were sites for Ulmus americana, Fraxinus americana, Acer rubrum, Tilia americana and Pinus strobus. Second-growth woods were composed of Betula populifolia, Ulmus americana, Fraxinus americana, Acer rubrum and Amelanchier spp.. With the formation of Lake St. Lawrence, due to the Seaway Project, an important segment of the vegetation of wetter sites has disappeared.

A few stands were studied quantitatively before the area was inundated. Putnam and Chapman (1966), in studying the physiography of Eastern Ontario, noted the major trees found in each geographical area. They describe hardwoods with maple, oak and pine; ridges with pine, hard maple, beech and burr oak; and poorly drained sites and swamps with elm, ash, soft maple, white cedar, swamp oak, basswood and willow.

In addition to these general and well-presented floristic and phytogeographical treatments, synecological studies were conducted by Dansereau (1943, 1946, 1959) and Grandtner (1966). These ecological studies were based on field data collected using the methodology of the Zurich-Montpellier School, described in Braun-Blanquet (1932) or an adaptation of it. Having encountered 346 species in 186 stands studied, Dansereau (1943) developed an index value for each species based on the life-form, percentage presence, reaction to light and humidity, and fidelity to the maple grove. These values are considered to delimit typical stands that could be included in the association chart and biological spectrum of the ACERETUM SACCHAROPHORI association. A paper on succession patterns of all associations found within the region and leading to what was considered the climatic climax, ACERETUM SACCHAROPHORI LAURENTIANUM association, was later presented (Dansereau, 1946). Finally, Dansereau (1959) published a synoptic list of the principal plant associations of the St. Lawrence Valley. Within the study region, 30 forest associations are named, of which there are 12 types of maple forest. The region under study is co-extensive with the maple forest (érablière) surrounded by Northern Hardwoods (bois francs nordiques) of which certain isolated areas impinge upon the former. A few associations are of interest. ACERETUM SACCHAROPHORI TSUGOSUM, characteristic of the Great Lakes - St. Lawrence Region, is considered the climax formation for the Northern Hardwoods. Nichols (1935) considered it the key association for the region. The BETULETUM POPULIFOLIAE association is mentioned as a very common subclimax in the sandy areas of the fluvioglacial deposits of the St. Lawrence. It is an early invader of dunes and fields on sand. In wetter areas it will occasionally occur with Thuja occidentalis and has been known to occur on peat deposits with improved drainage. PINETUM BANKSIANAE is a subclimax in the Canadian Forest, the Taiga and the Northern Hardwoods. These "jack pine 'barrens' are frequent on the dry, flat, sand plains of the north and have two extensions to the south: at the mouth of the St. Maurice River on undulating sand plain bordering Lake St. Peter and on the quartzite hills of Kamouraska County near Ste.-

Anne-de-la-Pocatière." (Dansereau, 1946).

THUJETUM OCCIDENTALIS is an association of trees growing densely, casting deep shade and excluding all other vegetation. This association may be found on wetter sites or on dry schistose or calcareous slopes where it has invaded old fields.

Finally, ACERETUM SACCHAROPHORI is hypothesized as a climax swarm for the Central St. Lawrence Lowlands. Twelve variants, of which four are related to human intervention, are considered to lead to ACERETUM SACCHAROPHORI LAURENTIANUM, the climatic climax.

In the most recent contribution, Grandtner (1966) discusses the forest vegetation of southern Quebec emphasizing the physical environment, geography, geology, climate and soils. The floristic aspects and extent of the forest types in the phytogeographical ensemble, their regional character, composition, structure, dynamics and relation to edaphic factors are carefully discussed. Boreal Forest and Deciduous Forest are treated as the two forest formations in Quebec province below 50^{o} latitude. He places the study region within the Deciduous Forest belt where he describes l'érablière à caryer (hickory-maple forest), l'érablière laurentienne (Laurentian maple forest), and l'érablière à bouleau jaune (yellow birch-maple forest). The first two groups occupy the Central Lowland Plain. The hickory-dominated maple bush is situated along the valleys of southwestern Quebec and extends eastward to Lake St. Peter. Due to extensive land clearance in that part of the province, only small remnants now exist. In this type of formation one finds Acer saccharum, Fagus grandifolia, and specifically Juglans cinerea, Carya ovata, and Carya cordiformis. In certain situations Fagus grandifolia may be replaced by Acer nigrum.

The eastern half of the plain is dominated by the Laurentian Maple Bush. The climax formation is dominated by Acer saccharum with Fagus grandifolia, Ostrya virginiana, Tilia americana, Juglans cinerea and Tsuga canadensis. Not present in this formation are Carya ovata, C. cordiformis, Quercus macrocarpa, Carpinus caroliniana and Acer rubrum. Depending on edaphic factors, it is possible to find Ulmus americana and Fraxinus nigra on wetter sites and Quercus rubra on drier sites. Fagus grandifolia may dominate on certain isolated sites, an example of which is found on l'Isle d'Orléans. In this eastern section younger transitional forests occur and are represented by Populus tremuloides, Betula populifolia and Acer rubrum. Across the Lowland Plain compositional complexity of the forest gradient is thought to trend latitudinally but from southwest to northeast and also altitudinally.

METHODS

A) FIELD METHODS

Stand Selection:

During two consecutive field seasons of investigating the forest vegetation of the Central St. Lawrence Lowlands, a large amount of descriptive information concerning regional topography, soil type distribution, regional and local forest vegetation groupings and patterns of vegetational succession was amassed. The limits of the study region were in the main determined by change in the type of bedrock and by the changes in topography which accompanies them. All of the stands studied occur at elevations below 450 feet and this in turn, with minor exceptions (Rigaud and Oka), is the elevation of the Paleozoic-Precambrian contact. The study region is approximately triangular in shape with the Precambrian region forming the northern (Renfrew to Quebec) and western (Renfrew to Brockville) limits. The southern boundary is clearly delimited by the Appalachian Foothills on the Eastern Quebec Uplands.

Stands of forest vegetation were selected to represent regional and local vegetation types and to include as broad a geographical coverage as possible. These stands were required to be relatively homogeneous in composition of major tree dominants and general physiognomy and uniform in relation to the prevailing environmental conditions.

Stands generally were 5 to 10 acres in size and had not been disturbed through severe or recent fire, logging or grazing.

Collection of Field Data:

Complete arboreal, shrub and herb presence was tabulated on previously prepared lists (samples of all data sheets are included in Appendix 2). General characteristics such as geographical location, topography, degree of slope, direction of exposure and natural or human disturbances were noted on the stand record sheet. Where the study area was encompassed by more extensive forest vegetation, the major tree dominants within this broader area were noted for further reference. The location of the 141 stands studied is given in Figure 1. The name and major tree dominants of each stand are given in Appendix 1.

The Quarter Method of Curtis (1959), used extensively at the Plant Ecology Laboratories of McGill University and Erindale College, University of Toronto, was used to measure the composition of the arboreal and sapling strata in each stand. When the boundaries of the study area had been determined, thirty (30) random points were recorded. In some cases fewer points were recorded, particularly in less frequently encountered forest types or in interesting stands of restricted size. Stands of this composition could then be included to provide a more complete picture of forest composition.

All individuals with d.b.h. (diameter breast height) greater

Figure 1:

Location of the 141 Northern Conifer-Hardwood stands studied within the Central St. Lawrence Lowland Plain of Ontario and Quebec.

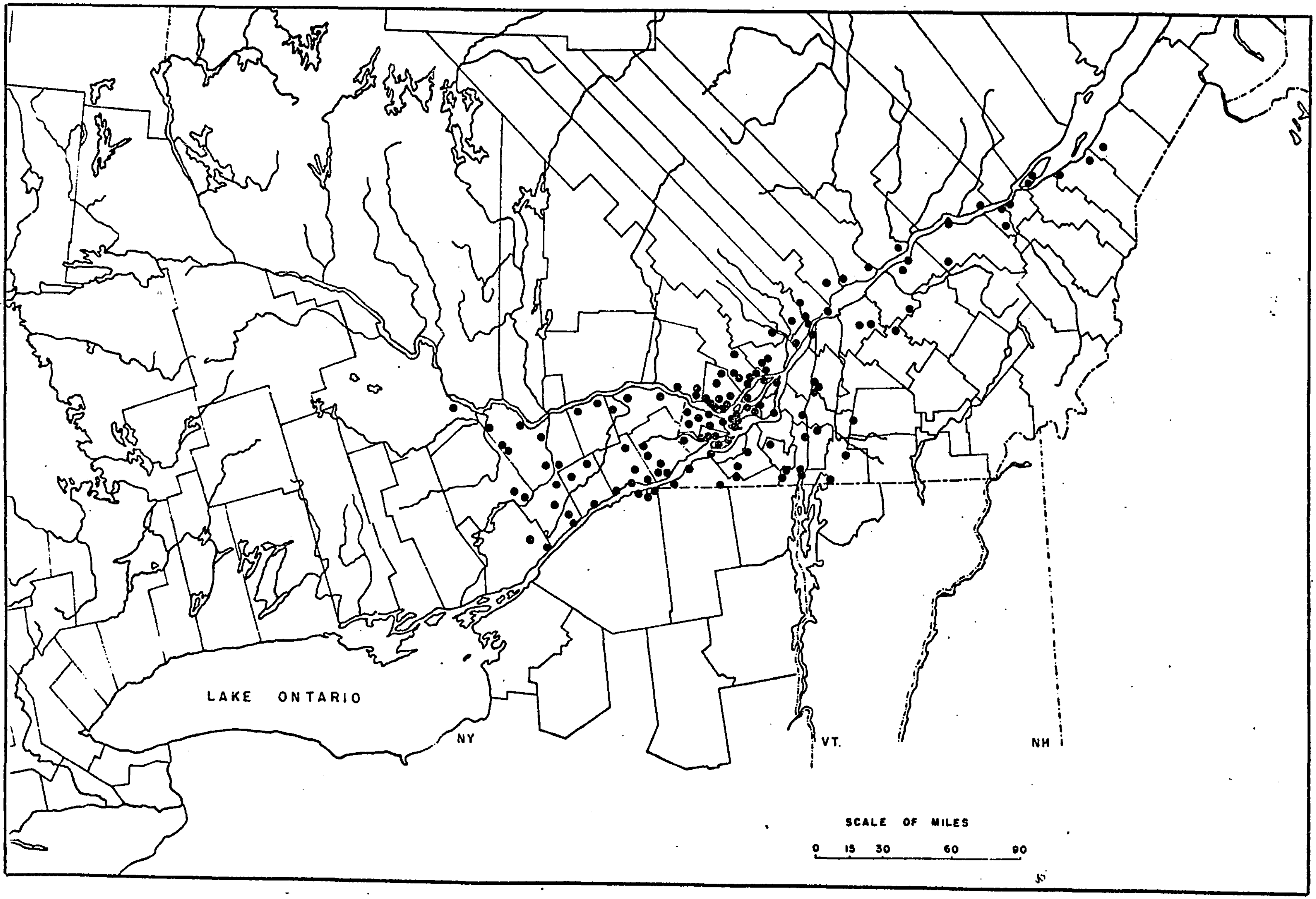
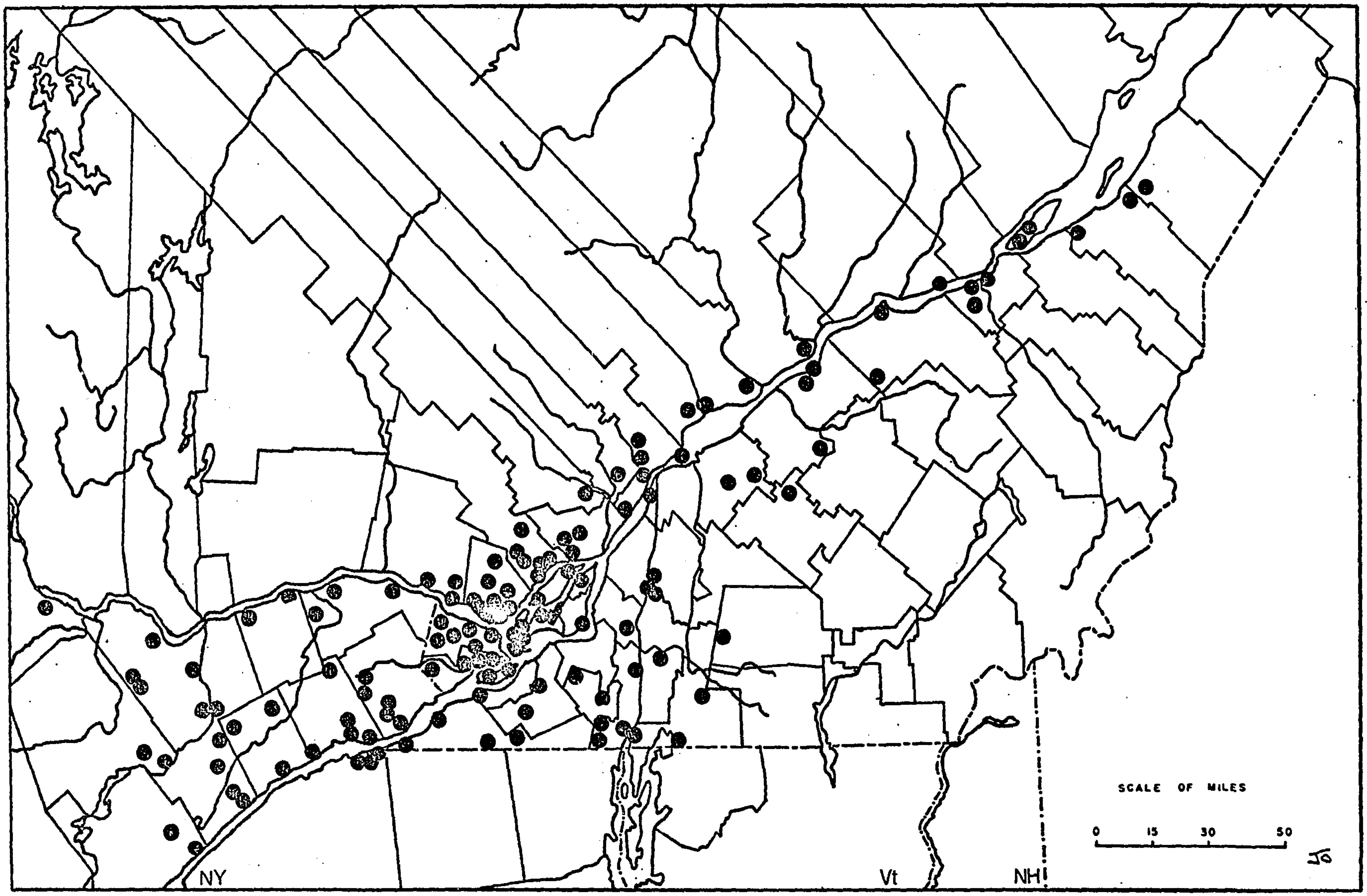

LAKE ONTARIO
NY
VT.
NH
SCALE OF MILES
0 15 30 60 90

Figure 2:

Location of the 141 Northern Conifer-Hardwood stands studied within the Central St. Lawrence Lowland Plain of Ontario and Quebec. (enlarged scale)


NY
Vt
NH
SCALE OF MILES
0 15 30 50
JO

than 4" were considered as trees, those between 1" and 4" d.b.h. as saplings, and those individuals with d.b.h. less than 1" as seedlings. A group of species found throughout the region does not regularly conform to these size categories. Acer spicatum, A. pensylvanicum, Amelanchier spp., Carpinus caroliniana, and Crataegus spp. do not consistently attain tree size and were only considered as trees and/or saplings if an individual within a particular stand attained tree size. At every other point herb, tree seedling and shrub presence was taken within a meter square quadrat. At every tenth point soil descriptions of Ao, A1, A2, B and if possible C layers were recorded and colorimetric pH measurements of all A1 layers were taken. Samples of these layers were collected together and later air-dried for laboratory analysis.

When the sampling was completed, an assessment of the moisture conditions of the site was made. In this regard topographic position, general physiognomy and observed soil characteristics were of assistance.

B) LABORATORY PROCEDURES

Herbarium Specimens:

In the field, voucher specimens of difficult and unidentifiable plants as well as representative species were collected. Over 2,500 specimens and duplicates have been deposited in the McGill College Herbarium and in the Plant Ecology Laboratory Herbarium, Erindale College. All specimens were identified or revised with the help of numerous authorities for difficult taxa. The nomenclature presented follows Gray's Manual, 8th edition (1950). All specimens thus identified were compiled and used in annotating the stand data sheets.

Soil Sample Analysis:

The soil samples were air-dried and passed through a 2mm. sieve in preparation for analysis. Using techniques outlined by Maycock (1963) the water retaining capacity (WRC) was determined. All samples were finally sent to the Quebec Soils Laboratory, Ste. Anne de la Pocatière, where analyses for acidity (pH) and important mineral and organic content were completed.

Analysis of Vegetation Data:

Quantitative information obtained for trees and saplings was converted to density - frequency - dominance (D.F.D.) values (Curtis and McIntosh, 1951). Relative density is the number of individuals of one tree species expressed as a percentage of the total number of individuals of all species recorded. Frequency was calculated as a percentage of points at which a species was recorded. Relative frequency is the frequency value expressed as a percentage of the sum of frequency values for all species. Relative dominance is the sum of basal areas of one species as a percentage of the sum of basal areas of all species. The combined D.F.D. value constitutes the Importance Value, the sum for all species in a stand being 300.

All tree-to-point distances were averaged and subsequently squared to obtain the average area occupied by a single tree in the stand. When this area is divided into the square-foot area of an acre (43,560), one obtains the number of trees per acre. The absolute dominance of trees per acre was calculated by multiplying the number of trees per acre by the average basal area per tree.

The relative density for tree saplings, as well as the number of saplings per acre, was determined using similar methods applied in analyzing the tree data. The percentage occurrence of herbs, shrubs, and tree seedlings in meter square quadrats provided a frequency value.

RESULTS

TREE STRATUM

Preliminary Analysis:

The basic quantitative data for 141 stands, including a total of 54 tree species, was summarized as shown in Table 4. It provides a cursory impression of regional forest composition and of the relative importance of each species and its contribution to the character and structure of the forests of the Central St. Lawrence Lowlands.

The general occurrence of the tree components of the regional forest complex is shown by the number of stands of occurrence, or constancy. Not one species is of such importance as to occur in more than 75% of stands studied, and only 6 species occur in more than 50% of the stands. These are *Acer rubrum*, *Ulmus americana*, *Acer saccharum*, *Betula lutea*, *Tilia americana* and *Fraxinus americana* with constancy values of 73, 58, 57, 55, 53, and 53 respectively. Fifteen species occur in 25 to 50 percent of stands, whereas 31 species have constancy values less than 25%.

Although the constancy values portray the widespread or narrow ecological tolerance of species, other significant values show that more relevant relationships may exist between and within forest communities. The average importance value shows the level of influence attained by

Table 4:

Summary of quantitative data for 54 tree species in 141 stands of the Northern Conifer-Hardwood Forests of the Central St. Lawrence Lowlands.

SUMMARY OF QUANTITATIVE DATA FOR 54 TREE SPECIES IN 141 STANDS OF THE NORTHERN CONIFER-HARDWOOD FORESTS OF THE CENTRAL ST. LAWRENCE LOWLANDS

Species	Stands of Occurrence	Constancy	Average I.V.	Maximum I.V.	No. of Stands Leading Dominant
Abies balsamea	55	39	5	122	2
Acer negundo	1	1	-	-	-
Acer nigrum	13	9	1	26	-
Acer pensylvanicum	24	17	-	15	-
Acer rubrum	103	73	48	240	27
Acer saccharinum	32	23	17	280	10
Acer saccharum	81	57	39	235	28
Alnus rugosa	2	1	-	3	-
Amelanchier arborea	13	9	-	12	-
Amelanchier laevis	5	4	-	9	-
Betula lutea	77	55	5	43	-
Betula papyrifera	62	44	4	69	-
Betula populifolia	45	32	15	283	8
Carpinus caroliniana	23	16	-	5	-
Carya cordiformis	40	28	4	93	2
Carya ovata	15	11	2	83	-
Celtis occidentalis	2	1	-	10	-
Crataegus spp.	15	11	-	11	-
Fagus grandifolia	67	48	13	189	4
Fraxinus americana	74	53	8	121	1
Fraxinus nigra	44	31	5	104	1
Fraxinus pennsylvanica	35	25	7	98	-
Juglans cinerea	25	18	1	24	-
Larix laricina	13	9	2	103	-
Ostrya virginiana	60	43	7	113	1
Picea glauca	43	31	2	30	-
Picea mariana	5	4	-	48	-
Picea rubens	9	6	1	31	-

Species	Stands of Occurrence	Constancy	Average I.V.	Maximum I.V.	No. of Stands Leading Dominant
Pinus resinosa	8	6	4	140	3
Pinus rigida	1	1	2	294	1
Pinus strobus	47	33	16	241	10
Populus balsamifera	14	10	1	69	-
Populus deltoides	4	3	-	-	-
Populus grandidentata	28	20	2	50	-
Populus tremuloides	41	29	11	234	8
Prunus pensylvanica	33	23	1	42	-
Prunus serotina	46	33	2	64	-
Prunus virginiana	4	3	-	3	-
Pyrus americana	3	2	-	-	-
Pyrus aucuparia	2	1	-	-	-
Pyrus decora	2	1	-	-	-
Quercus alba	5	4	1	70	-
Quercus bicolor	10	7	2	234	1
Quercus macrocarpa	27	19	3	122	2
Quercus rubra	46	33	10	160	6
Salix alba	1	1	-	12	-
Salix nigra	7	5	3	292	2
Salix spp.	3	2	-	24	-
Thuja occidentalis	46	33	9	300	4
Tilia americana	75	53	11	106	2
Tsuga canadensis	65	46	14	212	7
Ulmus americana	82	58	20	185	10
Ulmus rubra	20	14	2	37	-
Ulmus thomasi	5	4	2	98	1

each arboreal component within the general forest canopy on a regional basis. The maximum importance value indicates the ability of each tree species to attain a degree of purity in any one environmental situation. Acer rubrum, Acer saccharum and Ulmus americana have average importance values of 48, 39, and 20 respectively. These species have the most widespread influence. Other species with lower average importance values have either a local distribution pattern or depend on more exacting habitat and environmental factors. It is quite useful to consider both constancy and average importance values together in attempting to show the relative influence of each species and its contribution to the overall make-up of regional forest composition.

Acer rubrum is an overall important forest component. It dominates 27 of 141 stands with a constancy value of 73, an average importance value of 48 and a maximum importance value of 240. Acer saccharum is more restricted to optimum edaphic conditions with a constancy of 57 and an average importance value of 39. This tree species nevertheless dominates in 28 stands and has a maximum importance value of 235. Ulmus americana, the third species of importance in the Eastern St. Lawrence Lowlands, achieves dominance in only 10 stands. It has a constancy of 58, an average importance value of 20 and attains a maximum importance value of 185. As a result of looking at both constancy and average importance values, it is seen that certain tree species of broad ecological distribution are not able to achieve dominance nor are able to exert any major influence on forest composition.

Species with high constancy values may have very restricted influence on stands of occurrence. Betula lutea, Tilia americana, and Fraxinus americana show broad ecological amplitude with high constancy values of 55, 53, and 53 respectively, but are of minor importance in specific stands or in regional forest types. Betula lutea, a species of more northern and higher altitudinal distribution, is found on sites of disturbance within the study region, and has seedlings that will only germinate on mineral soils. Tilia americana and Fraxinus americana have low average importance values of 11 and 8 respectively and attain dominance in two and one stands respectively. These trees may be restricted ecologically by strong competition of such species as Acer saccharum, Ulmus americana and Acer rubrum.

Acer saccharinum, Pinus strobus, Betula populifolia, Tsuga canadensis, and Fagus grandifolia appear to be limited by specific edaphic factors. On a regional basis, they will occur as co-dominants with the more widespread species mentioned. Within a particular habitat, these species may attain high maximum importance values to the point of forming pure stands. These species were found to dominate in 10, 10, 8, 7, and 4 stands respectively.

Betula populifolia and Populus tremuloides are important secondary successional species within the forest vegetation of the Central St. Lawrence Plain. They are not widespread in their ecological distribution and have low constancy values of 32 and 29 respectively, although they have recorded maximum importance values of 283 and 234 respectively and may dominate over extensive areas.

The data for all stands has been summarized in terms of leading dominant status. Of the 54 tree species, 23 were dominant in at least one stand. Of these, 6 were dominant in only one stand, whereas 4 species were dominant in only 2 stands. All stands were evaluated on the basis of the 5 leading tree species, in order of decreasing importance. Seventy-six different combinations of the first two leading dominants were found to occur within all types studied. Acer saccharum - Tilia americana was the most frequent combination of leading dominants and was found in 7 stands. Tsuga canadensis - Acer rubrum occurred in 6 stands. One hundred and twenty different combinations of the first three leading dominants were found, and of these only Acer saccharinum - Fraxinus pennsylvanica - Ulmus americana and Betula populifolia - Acer rubrum - Populus tremuloides occurred three times each.

Coniferous trees of the forests of the Central St. Lawrence Lowlands have a lesser degree of importance than deciduous species and attain dominance in only 27 stands. Based on constancy values Tsuga canadensis (46), Abies balsamea (39), Pinus strobus (33), Thuja occidentalis (33) and Picea glauca (31) are the most important of the 10 coniferous species encountered. Tsuga canadensis and Abies balsamea have relatively high constancy values, but Pinus strobus, Tsuga canadensis and Thuja occidentalis are the species with highest average importance values of 16, 14, and 9 respectively.

Moisture Gradient Analysis:

Soil moisture has proven to be of primary importance in the formation of plant communities (Curtis 1959, Maycock and Curtis 1960, Maycock 1963). Certain factors relating to soil moisture were observed in the field while collecting quantitative data on these forest communities. Forest types situated on excessively drained steep slopes, on elevated sandy beach deposits and on areas of bare outcrop or shallow soils over bedrock could be considered as dry extremes for the study region. Bottomlands and lowlands, at varying periods of the year, are affected by standing water and could be classified as a wet type. Gradations exist between these extremes and by careful examination of various forest types found, five moisture categories were established. Of the 141 stands analyzed, 13 were designated as dry, 31 as dry-mesic, 26, 45, and 26 as mesic, wet-mesic, and wet respectively.

Stands so grouped according to moisture features could then be examined for their compositional components. Percent presence or constancy and average importance values were calculated for each tree species for all moisture categories. A detailed description of these calculations is shown in the section on methods. Constancy indicates the ability of an individual species to exist within each segment of the soil moisture gradient. The average importance value shows to what extent within each moisture segment a species can dominate or find expression.

This procedure illustrated that each species attains optimum importance in a particular moisture segment. Not one species occurs uniformly throughout the moisture gradient of forest conditions. In certain cases a tree species will occur at one extreme, or may be widespread, but it will still attain an optimum in one segment of the moisture gradient. Table 5 presents both constancy and average importance values for all tree species found within the study region. This Table has been organized to range from those tree species exclusively present in dry situations to those exclusively present in wet situations. A pattern of gradations results from maximum occurrence of one species at one extreme, to those species with broad amplitudes of tolerance, to those with major occurrence at the other extreme.

Various species are limited to certain moisture conditions and this is best shown for the dry and wet segments. Figure 3 illustrates that Pinus strobus, Pinus resinosa, and Quercus rubra show strong ecological dominance on dry sites, with average importance values of 79, 43, and 45 respectively. Pinus rigida was found in only a single specialized site within the central St. Lawrence Lowlands. Pinus resinosa is present in stands of an extremely dry character on wind-blown or beach sand. The incidence of previous fire in stands dominated by Pinus resinosa is high. Pinus strobus and Quercus rubra, on the other hand, are not so restricted. Pinus strobus has a wide amplitude of tolerance and is also found to a limited extent on wet sites. It has average importance values of 79, 29, 2, 6, and 0, while constancy values are 85, 35, 23, 36, and 11

Table 5:

Percent presence and average importance values for all tree species for segments of the soil moisture gradient.

PERCENT PRESENCE AND AVERAGE IMPORTANCE VALUES FOR ALL TREE SPECIES FOR SEGMENTS OF THE SOIL MOISTURE GRADIENT

	Percent Presence					Average Importance				
	D	DM	M	WM	W	D	DM	M	WM	W
Pinus rigida	8	-	-	-	-	22.6	-	-	-	-
Amelanchier laevis	39	-	-	-	-	0.7	-	-	-	-
Pinus resinosa	62	-	-	-	-	42.9	-	-	-	-
Quercus alba	31	3	-	-	-	9.1	0.1	-	-	-
Pyrus decora	8	3	-	-	-	-	-	-	-	-
Ulmus thomasi	8	10	-	2	-	2.3	5.0	-	0.1	-
Ulmus rubra	15	16	23	16	-	0.4	2.4	2.5	1.4	-
Acer pensylvanicum	31	36	15	11	-	-	1.2	0.2	0.1	-
Ostrya virginiana	39	68	92	22	-	9.1	17.9	9.3	0.8	-
Populus grandidentata	69	23	23	13	-	8.4	2.4	2.4	1.0	-
Fagus grandifolia	69	58	92	36	-	0.5	29.5	23.5	5.0	-
Quercus rubra	77	52	38	22	-	45.1	11.9	9.0	5.3	-
Pinus strobus	85	36	23	36	12	79.2	29.2	2.3	5.9	0.5
Betula papyrifera	69	45	31	44	42	6.4	7.7	1.5	3.7	0.8
Crataegus spp.	31	10	-	11	12	-	-	-	0.1	0.4
Prunus pensylvanica	23	29	23	24	15	-	2.0	1.1	1.7	0.6
Prunus serotina	23	39	50	36	8	0.2	0.9	6.8	2.0	-
Picea rubens	15	10	-	7	4	2.2	0.2	-	1.2	0.2
Carya ovata	15	7	19	11	4	2.0	1.4	1.4	2.3	-
Tilia americana	31	65	96	44	23	1.3	10.2	28.4	10.5	1.5
Acer saccharum	62	77	100	47	8	10.2	64.9	118.9	4.3	-
Tsuga canadensis	62	58	50	49	15	10.5	13.7	8.8	25.2	0.1
Abies balsamea	54	39	23	44	39	3.3	6.4	1.4	6.2	4.9
Fraxinus americana	23	68	81	40	42	2.1	12.0	10.8	9.1	3.5
Betula lutea	15	55	89	60	31	-	4.0	6.1	8.2	1.8
Picea glauca	31	42	8	38	27	-	2.3	0.5	2.9	1.4
Betula populifolia	31	29	8	49	31	6.5	1.8	-	32.3	21.3

	D	DM	M	WM	W	D	DM	M	WM	W
Populus tremuloides	39	23	4	40	39	0.6	6.1	-	23.4	9.5
Thuja occidentalis	46	26	12	42	39	-	8.1	0.1	18.1	8.0
Acer rubrum	92	55	65	82	77	20.1	41.1	42.4	71.8	35.6
Ulmus americana	23	48	62	58	85	1.3	6.6	9.2	20.4	57.7
Carya cordiformis	8	36	58	27	4	3.9	5.3	7.5	2.3	-
Juglans cinerea	8	19	38	13	8	-	1.8	1.8	0.3	-
Quercus macrocarpa	8	29	4	22	23	9.3	1.5	0.0	3.5	1.4
Picea mariana	8	-	-	7	4	-	-	-	0.1	1.8
Amelanchier arborea	-	16	4	16	-	-	0.1	-	0.4	-
Acer nigrum	-	7	19	11	4	-	0.1	1.4	1.5	-
Carpinus caroliniana	-	10	23	24	12	-	0.2	-	-	0.1
Larix laricina	-	3	-	16	19	-	0.8	-	2.7	5.6
Populus balsamifera	-	7	-	9	31	-	-	-	1.6	3.1
Fraxinus pennsylvanica	-	10	15	27	62	-	0.6	0.1	7.1	23.9
Fraxinus nigra	-	3	35	38	65	-	0.1	1.9	6.0	12.7
Acer saccharinum	-	-	15	24	65	-	-	0.3	10.8	73.4
Celtis occidentalis	-	-	-	4	-	-	-	-	0.3	-
Pyrus americana	-	-	-	4	4	-	-	-	-	-
Prunus virginiana	-	-	-	4	8	-	-	-	0.1	0.1
Quercus bicolor	-	-	-	4	31	-	-	-	0.6	10.0
Populus deltoides	-	-	-	2	12	-	-	-	-	-
Salix nigra	-	-	-	-	23	-	-	-	-	17.4
Salix spp.	-	-	-	-	12	-	-	-	-	1.4
Pyrus aucuparia	-	-	-	-	8	-	-	-	-	-
Alnus rugosa	-	-	-	-	8	-	-	-	-	0.2
Salix alba	-	-	-	-	4	-	-	-	-	0.5
Acer negundo	-	-	-	-	4	-	-	-	-	-

for respective moisture categories from dry to wet. In the 13 dry stands, Pinus strobus dominates in 5, whereas Pinus resinosa and Quercus rubra dominate in 3 stands each.

In contrast, Figure 7 shows the distribution across the moisture gradient of Acer saccharinum, Ulmus americana and Fraxinus pennsylvanica. These species attain optimum occurrence in wet sites where they have constancy values of 65, 85, and 61 and average importance values of 73, 58, and 24 respectively. These three species may be present in other segments but are of minor importance.

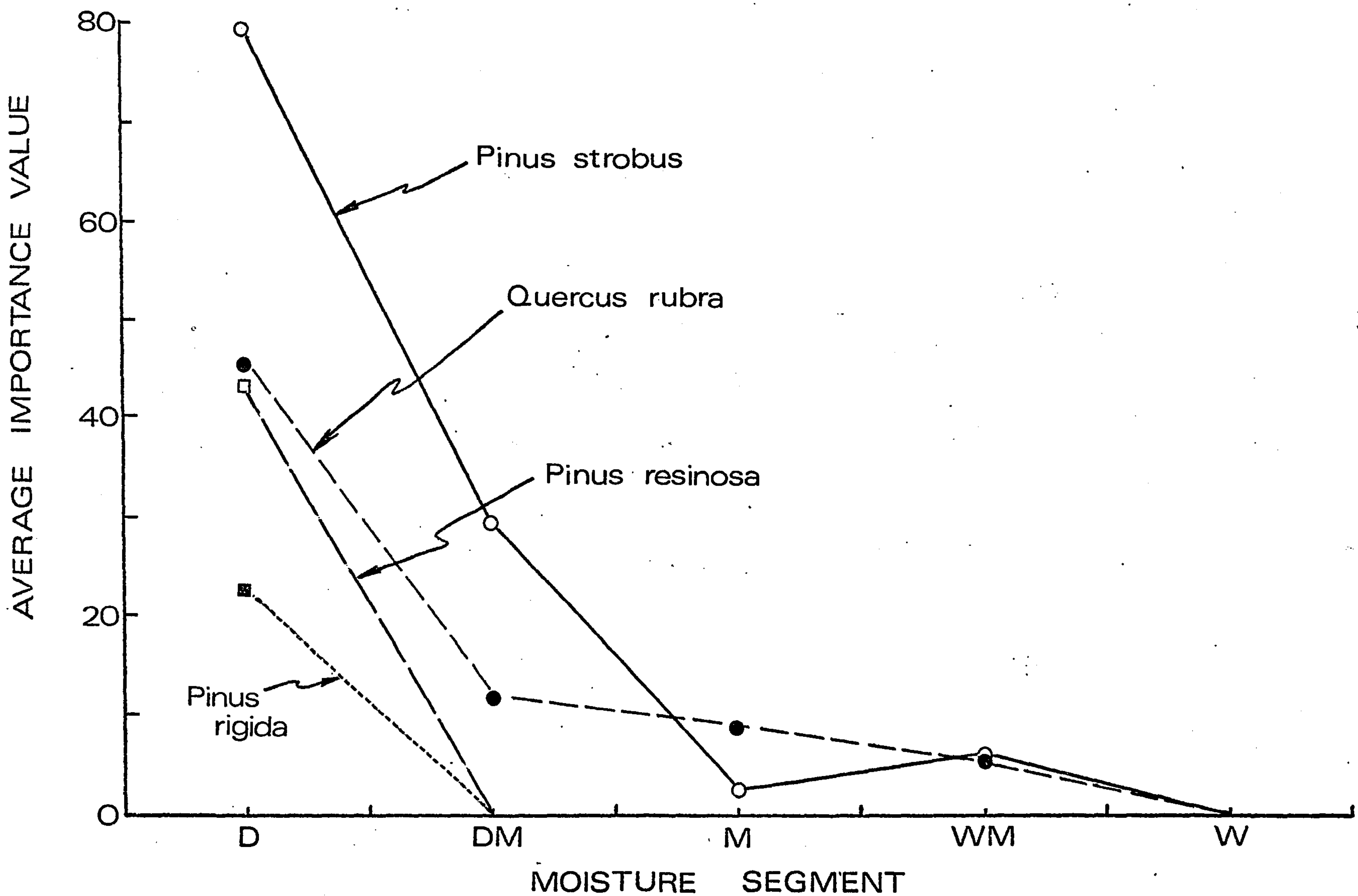
Acer saccharum is of broad ecological tolerance and, while achieving decided dominance in 19 of 26 mesic stands (73%), it also contributes significantly to general forest composition across the entire moisture gradient. Occurrence of the tree in dry and wet situations is often due to restricted local variations in topography. Figure 5 graphically presents the average importance values of certain species which attain optimum occurrence within the mesic segment. Acer saccharum effectively dominates most mesic sites with an average importance value of 119. Tilia americana has a broad amplitude of tolerance but perhaps because of extreme competition of Acer saccharum is of low representation and is important only in a few scattered individual stands dominated by Acer saccharum. With a high constancy of 96 in the mesic segment, Tilia americana nevertheless has an average importance value of only 28 there. Prunus serotina is the only other tree species of significance to attain optimum occurrence on mesic sites, although other trees such as Fagus grandifolia, Fraxinus americana, Betula lutea, Acer rubrum, Ulmus americana and perhaps Carya cordiformis can also be influential, although they attain optima under other moisture conditions.

Acer rubrum, Fagus grandifolia, and Fraxinus americana, with average importance values of 42, 23, and 11 and constancy values of 65, 92, and 81 respectively in mesic stands, have broad tolerance and attain optimum occurrence in intermediate segments of the soil moisture gradient.

Figures 4 and 6 show the distribution of species which attain higher values in both the dry-mesic and wet-mesic segments. Acer rubrum is shown to be widespread throughout the Lowlands. It has constancy values of 92, 55, 65, 82, and 77 and average importance values of 20, 41, 42, 72, and 36 respectively for each moisture category. In the wet-mesic conditions, Betula populifolia and Populus tremuloides, both initiators of arboreal succession, have constancy values of 49 and 40 and average importance values of 32 and 23. They are also important trees in dry-mesic sites. Betula papyrifera and Abies balsamea are trees of minor importance and show a bimodal type of distribution (Figure 8). Picea rubens, P. glauca, P. mariana, Larix laricina and Carya ovata are species of generally low average importance and yet also portray bimodal patterns in relation to moisture.

Figure 3:

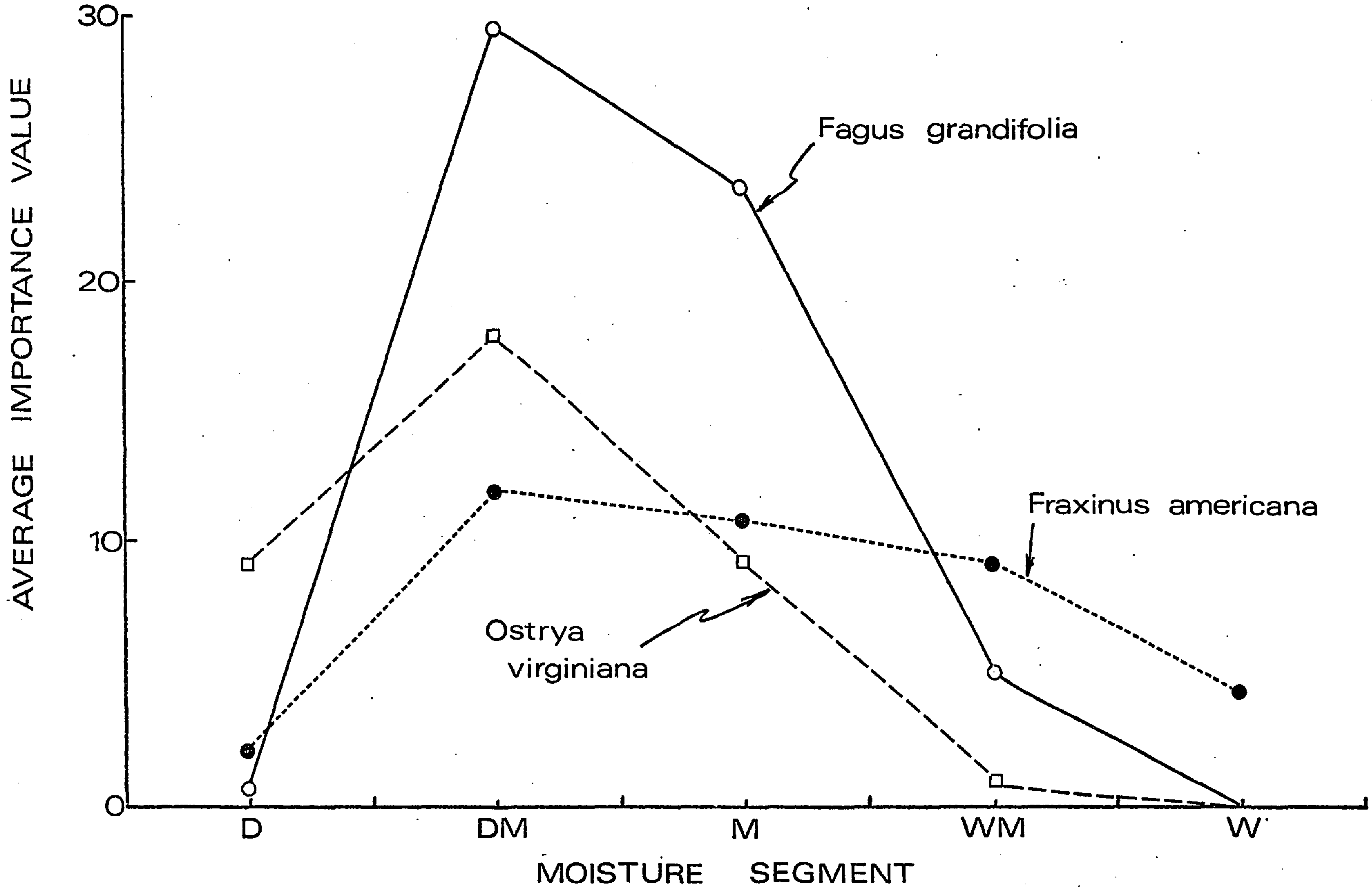
Average importance values for tree species with maximum values at the dry extreme of the moisture gradient.



AVERAGE IMPORTANCE VALUE
80
60
40
20
0
Pinus strobus
Quercus rubra
Pinus resinosa
Pinus rigida
D
DM
M
WM
W
MOISTURE SEGMENT

Figure 4:

Average importance values for tree species attaining maximum values in the dry-mesic moisture gradient.



AVERAGE IMPORTANCE VALUE
30
20
10
0
D
DM
M
WM
W
MOISTURE SEGMENT
Fagus grandifolia
Fraxinus americana
Ostrya virginiana

Figure 5:

Patterns of average importance values for tree species with optimum occurrence in mesic moisture conditions.

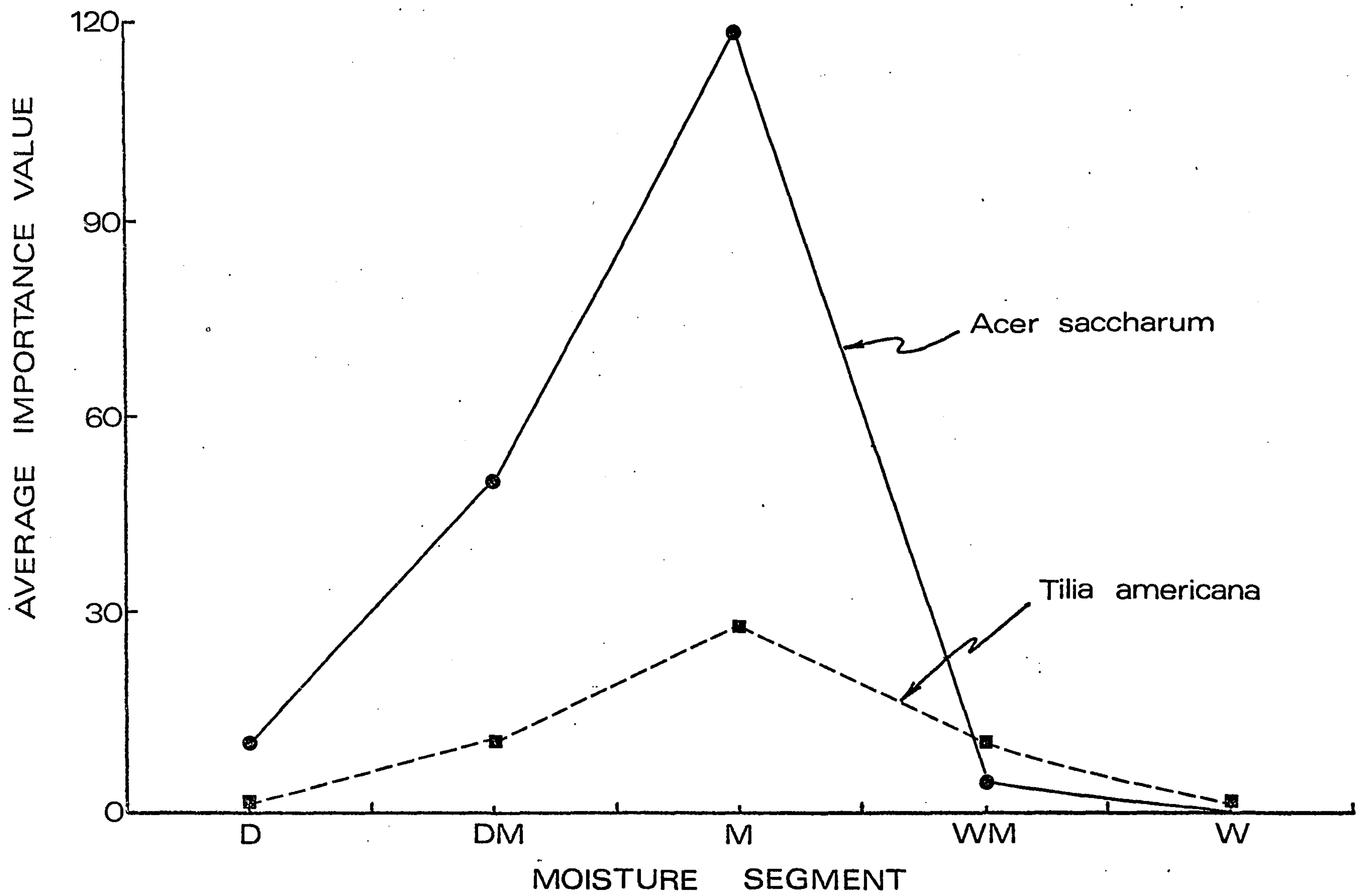

AVERAGE IMPORTANCE VALUE
120
90
60
30
0
D
DM
M
WM
W
MOISTURE SEGMENT
Acer saccharum
Tilia americana

Figure 6:

Average importance values for tree species with optimum values in the wet-mesic moisture segment.

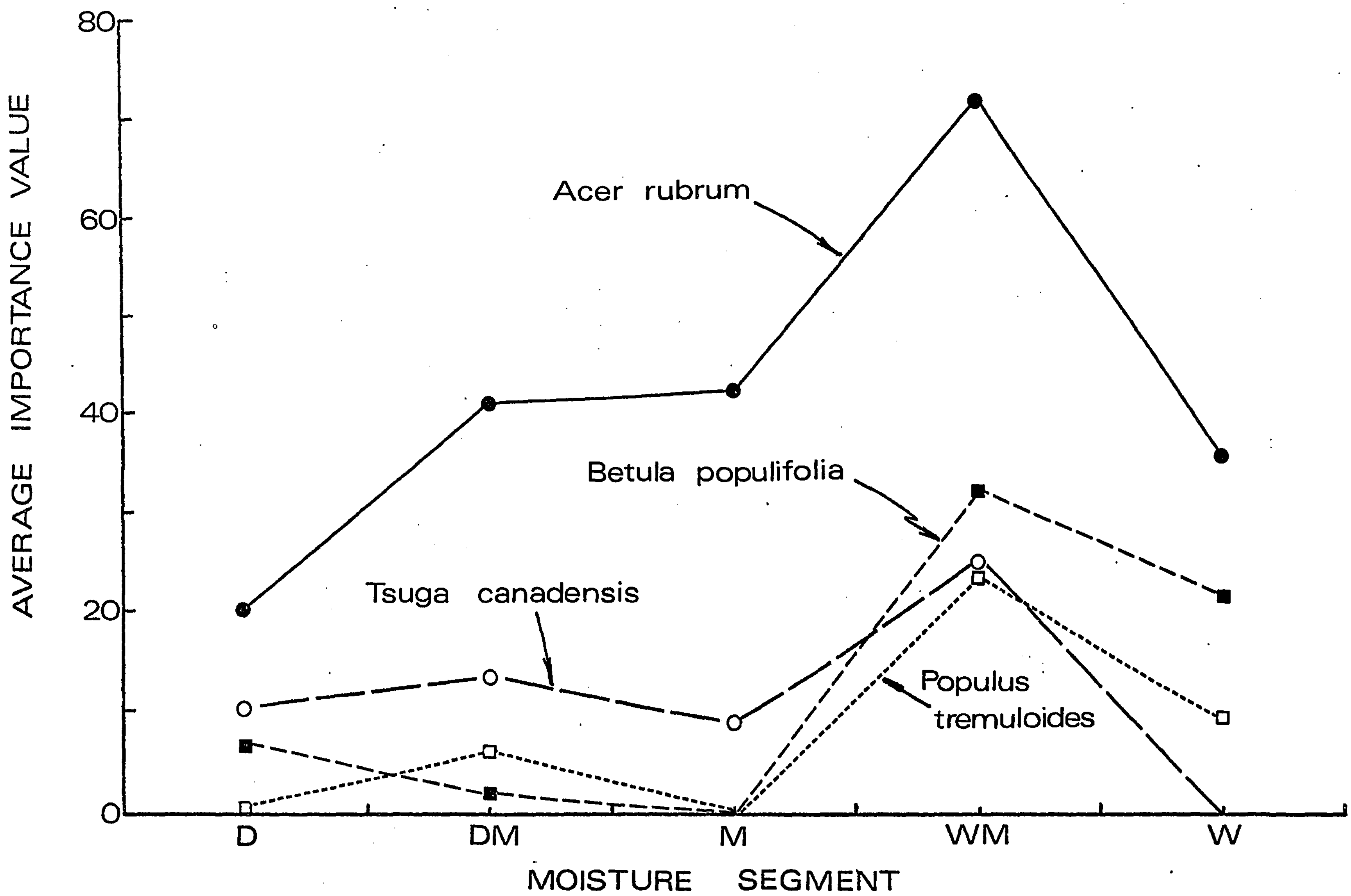
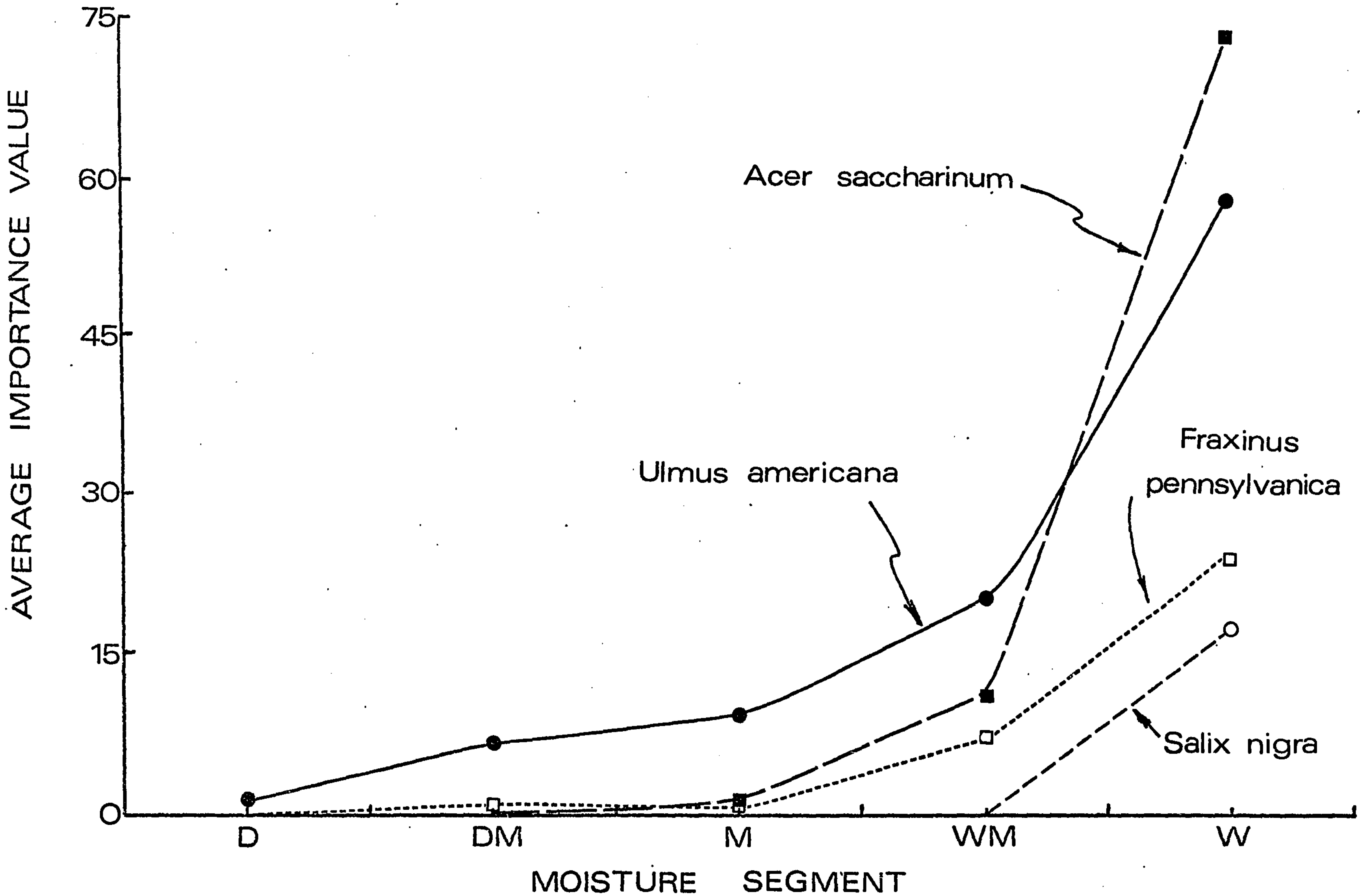

AVERAGE IMPORTANCE VALUE
80
60
40
20
0
D
DM
M
WM
W
MOISTURE SEGMENT
Acer rubrum
Betula populifolia
Tsuga canadensis
Populus tremuloides

Figure 7:

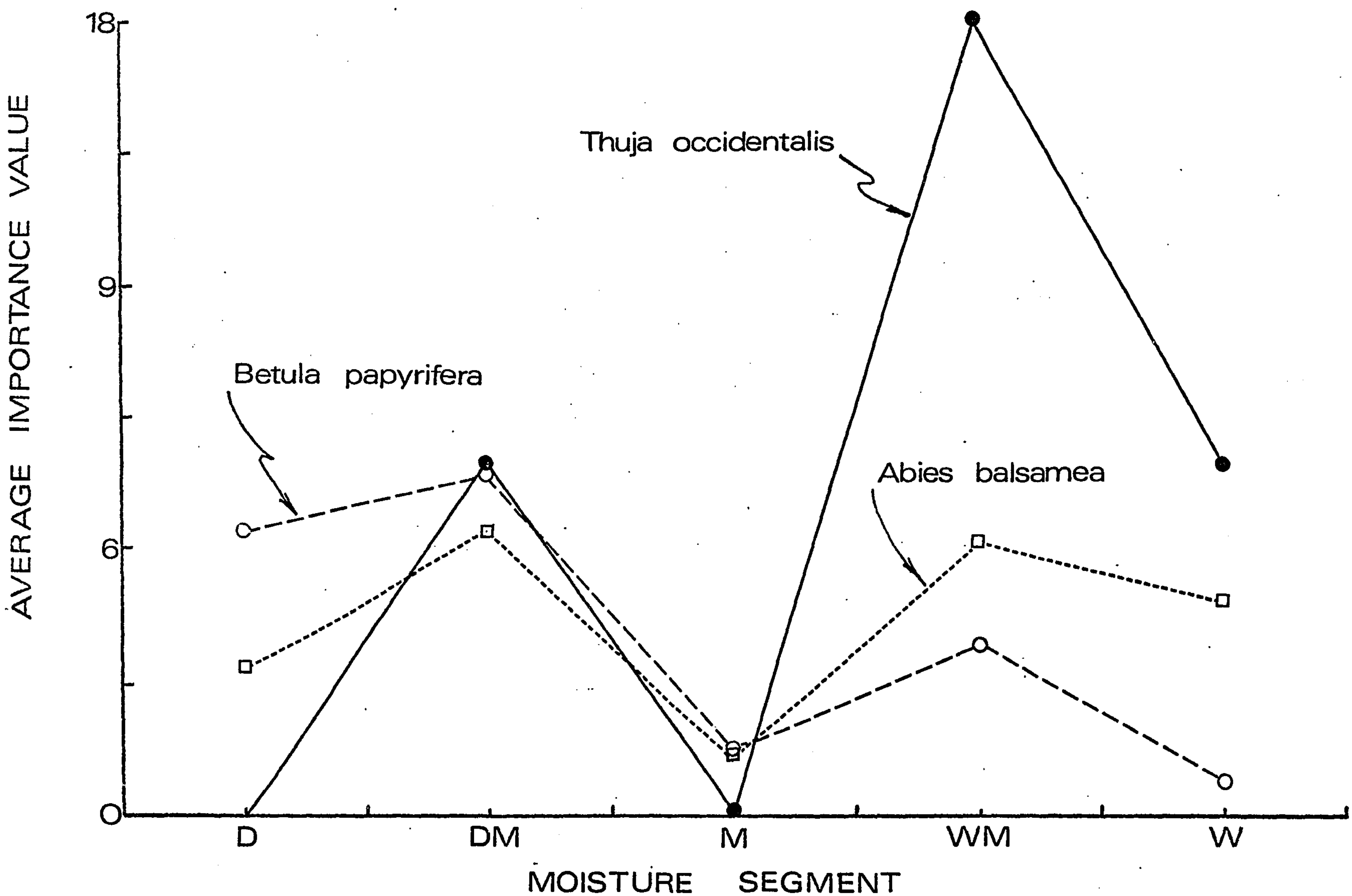
Average importance values by moisture segments for species with maximum values in wet conditions.



AVERAGE IMPORTANCE VALUE
75
60
45
30
15
0
D
DM
M
WM
W
MOISTURE SEGMENT
Acer saccharinum
Ulmus americana
Fraxinus pennsylvanica
Salix nigra

Figure 8:

Average importance values by moisture segments for tree species of minor importance with bimodal relationships.



AVERAGE IMPORTANCE VALUE
18
9
6
0
Thuja occidentalis
Betula papyrifera
Abies balsamea
D
DM
M
WM
W
MOISTURE SEGMENT

Tree Reproduction:

In the same way that soil moisture is of importance when discussing tree relationships, it is known that an amelioration of soil moisture conditions, whether an improvement of water retention or an improvement of drainage patterns, is of importance to definite successional sequences which will permit the re-establishment of particular vegetation series. The same ordination along the moisture gradient is used in analyzing the tree-sapling-seedling relationships to determine whether these successional changes are, in fact, taking place. The relative densities of trees and saplings of each species were averaged within each moisture segment. Frequency was averaged for each moisture category for the seedlings of each species to attempt to provide a comparison albeit on a different quantitative basis. This data is presented in Table 6. It is arranged to provide a similar arrangement as that presented in Table 5 for the trees. A positive ratio of sapling to tree values indicates a possible increase in sapling representation in succeeding periods. A negative ratio indicates a higher representation of trees over saplings and thus the possibility of gradual replacement by other species in time. In certain instances this may indicate trends toward maturity for particular species in local situations. The average frequency values for seedlings are given because comparable relative density values are unavailable. Thus, no direct comparisons can be made, and only general tendencies in relation

Table 6:

Average relative density of tree saplings, compared to relative density of trees, as well as average frequency for tree seedlings, for segments of the moisture gradient.

AVERAGE RELATIVE DENSITY OF TREE SAPLINGS, COMPARED TO RELATIVE DENSITY OF TREES, AS WELL AS AVERAGE FREQUENCY FOR TREE SEEDLINGS, FOR SEGMENTS OF THE MOISTURE GRADIENT

		D	DM	M	WM	W
Pinus resinosa	sapling	2.9	-	-	-	-
	tree	13.1	-	-	-	-
	seedling	0.5	-	-	-	-
Pinus rigida	sapling	6.3	-	-	-	-
	tree	7.6	-	-	-	-
	seedling	3.1	-	-	-	-
Quercus alba	sapling	0.8	-	-	-	-
	tree	2.6	-	-	-	-
	seedling	1.0	-	-	-	-
Carya ovata	sapling	0.1	0.1	-	0.2	-
	tree	0.6	0.1	0.4	0.6	-
	seedling	-	-	-	-	-
Pices rubens	sapling	0.3	-	-	0.5	-
	tree	0.9	0.1	-	0.4	-
	seedling	-	-	-	0.3	-
Ulmus thomasi	sapling	0.6	0.3	-	-	-
	tree	0.8	1.7	0.1	0.5	-
	seedling	3.1	0.6	-	-	-
Carya cordiformis	sapling	0.3	1.2	0.6	0.2	-
	tree	5.3	2.0	2.1	0.9	-
	seedling	1.5	4.8	4.5	1.5	0.3
Populus grandidentata	sapling	2.0	0.1	-	0.1	-
	tree	2.9	0.7	0.7	0.3	-
	seedling	1.5	0.6	0.7	-	-
Ostrya virginiana	sapling	14.3	12.4	10.9	0.5	-
	tree	3.7	6.5	3.2	0.3	-
	seedling	18.0	16.9	13.8	-	-
Quercus rubra	sapling	5.0	1.0	0.2	0.3	-
	tree	13.9	2.9	2.1	1.5	-
	seedling	10.4	3.8	1.2	1.1	-
Acer pensylvanicum	sapling	2.3	2.6	0.6	0.6	-
	tree	-	0.4	0.1	-	-
	seedling	8.9	10.5	3.8	0.6	-

		D	DM	M	WM	W
Prunus serotina	sapling	2.0	0.4	1.6	0.8	-
	tree	0.1	0.3	2.1	0.6	-
	seedling	0.5	2.5	7.3	2.4	-
Tsuga canadensis	sapling	6.9	2.4	3.6	9.1	-
	tree	3.3	4.2	2.8	8.8	-
	seedling	1.1	0.7	1.0	4.3	0.2
Fagus grandifolia	sapling	1.1	14.0	13.4	3.7	-
	tree	0.2	10.9	7.8	1.9	-
	seedling	0.7	9.7	5.0	1.5	-
Ulmus rubra	sapling	-	0.4	0.2	0.1	-
	tree	0.1	0.7	0.8	0.4	-
	seedling	-	1.3	0.7	0.5	-
Pinus strobus	sapling	15.4	1.6	-	0.8	-
	tree	26.2	8.8	0.4	1.6	0.1
	seedling	9.2	3.7	-	0.5	-
Betula papyrifera	sapling	3.8	1.0	0.1	2.7	0.1
	tree	2.3	2.5	0.5	1.1	0.2
	seedling	1.6	1.3	-	0.7	-
Quercus macrocarpa	sapling	-	0.3	-	0.3	-
	tree	2.7	0.4	-	1.2	0.3
	seedling	-	0.3	-	0.7	0.1
Tilia americana	sapling	0.3	2.1	3.4	3.5	1.5
	tree	0.4	2.7	8.0	3.3	0.5
	seedling	2.1	5.8	13.7	3.0	0.9
Acer saccharum	sapling	4.7	25.4	45.4	3.8	0.8
	tree	4.2	24.1	39.3	1.4	-
	seedling	8.2	38.7	72.5	10.8	1.2
Abies balsamea	sapling	3.4	5.7	0.8	5.5	3.4
	tree	1.2	2.4	0.4	2.2	2.0
	seedling	2.2	6.7	2.7	5.8	2.6
Fraxinus americana	sapling	0.6	5.1	2.5	2.6	2.5
	tree	0.7	4.3	2.9	3.2	1.1
	seedling	8.7	19.4	16.4	11.3	8.8
Populus tremuloides	sapling	0.2	1.0	-	3.1	1.1
	tree	0.2	2.3	-	8.4	3.3
	seedling	-	0.4	-	0.5	1.3

		D	DM	M	WM	W
Betula populifolia	sapling	4.5	0.3	0.1	9.5	6.2
	tree	2.7	0.6	-	12.2	8.0
	seedling	-	-	-	0.6	0.4
Acer rubrum	sapling	19.6	13.1	5.0	22.9	10.3
	tree	7.6	13.0	12.7	26.0	11.5
	seedling	23.0	22.5	20.2	52.5	23.1
Betula lutea	sapling	0.1	0.9	1.6	3.7	1.2
	tree	-	1.1	2.0	2.8	0.5
	seedling	-	0.6	0.5	0.8	0.3
Ulmus americana	sapling	0.1	1.2	0.7	6.3	20.2
	tree	0.4	1.8	6.4	6.7	18.2
	seedling	0.5	3.0	5.1	12.0	19.8
Pices glauca	sapling	0.1	0.7	0.3	0.9	0.2
	tree	-	0.6	0.2	0.7	0.3
	seedling	1.1	0.2	0.3	0.6	-
Thuja occidentalis	sapling	0.2	1.4	7.2	2.6	3.7
	tree	-	2.9	7.1	1.8	2.7
	seedling	0.6	0.3	1.8	1.4	1.2
Prunus pensylvanica	sapling	0.1	0.6	0.1	0.7	0.2
	tree	-	0.7	0.4	0.5	0.2
	seedling	-	-	0.2	0.3	0.5
Acer nigrum	sapling	-	-	0.3	1.8	-
	tree	-	-	0.5	0.4	-
	seedling	-	0.2	1.2	1.6	-
Juglans cinerea	sapling	-	-	-	-	-
	tree	-	0.6	0.5	0.1	-
	seedling	-	-	0.2	-	-
Carpinus caroliniana	sapling	-	1.7	0.7	3.3	0.2
	tree	-	0.1	-	-	-
	seedling	-	4.9	0.7	3.0	-
Fraxinus nigra	sapling	-	0.1	0.3	3.5	7.1
	tree	-	-	0.4	2.6	4.9
	seedling	-	-	-	1.4	7.3
Fraxinus pennsylvanica	sapling	-	-	-	1.4	8.0
	tree	-	0.2	-	2.5	8.2
	seedling	-	-	1.0	3.7	8.0

		D	DM	M	WM	W
Populus balsamifera	sapling	-	0.1	-	0.3	0.4
	tree	-	-	-	0.6	0.9
	seedling	-	0.2	-	-	0.2
Acer saccharinum	sapling	-	-	-	2.5	24.0
	tree	-	-	0.1	3.6	24.0
	seedling	-	-	-	2.1	24.1
Larix laricina	sapling	-	-	-	0.4	1.3
	tree	-	-	-	0.7	1.8
	seedling	-	-	-	-	-
Alnus rugosa	sapling	-	-	-	0.5	1.7
	tree	-	-	-	-	0.1
	seedling	-	-	-	-	-
Quercus bicolor	sapling	-	-	-	-	0.6
	tree	-	-	-	0.1	3.5
	seedling	-	-	-	-	1.5
Picea mariana	sapling	-	-	-	-	0.2
	tree	-	-	-	-	0.5
	seedling	-	-	-	-	-
Salix nigra	sapling	-	-	-	-	3.9
	tree	-	-	-	-	5.7
	seedling	-	-	-	-	-

to soil moisture conditions may be implied.

Certain arboreal species are found within the study region for which no meaningful interpretations can be made when comparing sapling to tree ratios. This is partly because insufficient values are available. This is true for Acer pensylvanicum, Carpinus caroliniana, Crataegus spp., Amelanchier spp., and Alnus rugosa because they seldom attain tree size and are mainly represented by saplings. Celtis occidentalis, Acer nigrum, Juglans cinerea and, to a certain degree, Carya ovata and C. cordiformis are only found as isolated individuals. These species have restricted occurrences and are representatives of more southern distribution. On the other hand Larix laricina, Picea spp. are of definite boreal distribution and are infrequent in northern conifer-hardwood stands.

Abies balsamea is the only species in addition to Acer saccharum with a higher sapling to tree ratio across the moisture gradient. It is a boreal species and is found mainly in successional sequences from bog hydrosere to drier or wetter hardwoods. Generally, these saplings are not able to reach adult size as a result of increasing competition by the hardwoods. Abies balsamea germinates best on moss and moist mineral soils.

The pattern of distribution of Betula lutea is definitely influenced by cooler climate and by increasing altitude. Within the Central St. Lawrence Plain it has a higher sapling representation in the wet-mesic segment of the moisture gradient. It is intermediate in shade tolerance and requires openings in the canopy and mineral soils for successful establishment.

Pinus strobus has a much lower sapling representation than mature individuals due to shade intolerance. This species germinates best on exposed mineral soils, and quickly builds up a thick needle mat. This prevents the establishment of its seedlings. Generally, a very high seedling and sapling representation of Acer rubrum is found in sites dominated by Pinus strobus. Pinus resinosa is less shade tolerant. It germinates and grows quite well on drier sites of lower nutrient status. It is restricted to the drier habitats. Quercus rubra has a decided negative ratio (5/14) on drier sites.

The patterns for Acer rubrum, a tree species of great importance in the Central Lowlands, are of particular interest. It has very wide tolerance across the moisture gradient. From a high sapling representation (20/8) in dry sites, where it succeeds well in stands dominated by Pinus strobus and Quercus rubra, to a stable ratio (13/13) in the dry-mesic stands, saplings decrease relative to mature individuals in the mesic (5/13), wet-mesic (23/26), and wet (10/12) segments. It is a successional species and has intermediate shade tolerance and seems to respond well to disturbance. It does not achieve significant dominance in wet sites although it will, in some instances, co-dominate with Acer saccharinum. This latter species seems to attain relative stability in wet lowlands and especially in bottomlands.

Ulmus americana has a higher sapling to tree ratio (20/18) in wet sites, but mature trees surpass sapling representation in mesic (1/6) and wet-mesic (6/7) situations. Fraxinus americana remains stable across the moisture gradient.

Betula populifolia and Populus tremuloides are the most important pioneering species in the study region. One finds a higher ratio (5/3) for Betula populifolia in drier situations with a negative ratio in wet-mesic (10/12) and wet (6/8) sites. Dansereau (1959) states: "On rencontrera ... dans le sud de notre aire, des formations pures de Betula populifolia, évoluant vers l'ACERETUM RUBRI, à partir de stades pionniers qui peuvent être secs ou humides."

Populus tremuloides is a pioneering species on wet-mesic sites on clay. As with Betula populifolia, the saplings are extremely intolerant of shade. Trees of the species may assume dominance (WM 3/8; W 1/3) but most are replaced by Pinus strobus, Acer rubrum, Quercus rubra or Ulmus americana.

Acer saccharum is the strongest potential dominant for the most stable situations. The saplings are very shade tolerant and there is a consistently stronger representation over the trees. (D 5/4; DM 25/24; M 46/39; WM 4/1; W 1/0). Acer saccharum does have certain competitors, present to varying degrees and dependent upon local environmental conditions.

Tsuga canadensis is part of the northern terminal stands of the region where it occurs with Acer saccharum, Fagus grandifolia, Acer rubrum and Betula lutea. (Dansereau, 1946). Hemlock has a remarkable ability to withstand suppression but it is not as shade tolerant as Acer saccharum. It requires more light for active growth and will not germinate in its own litter but requires exposed mineral soil. Saplings have a slightly higher representation in dry (7/3) and mesic (4/3) habitats.

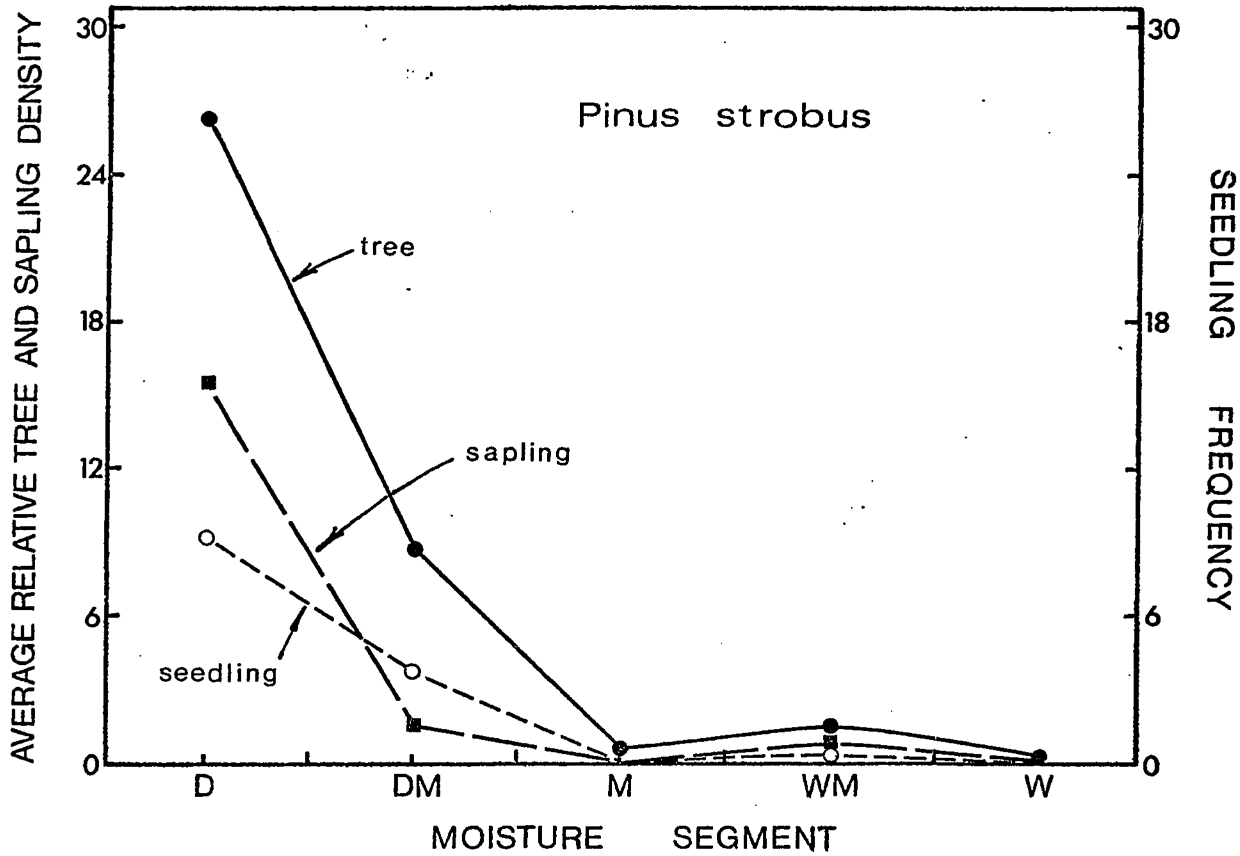
Fagus grandifolia is very shade tolerant and as Tilia americana produces sprouts which may offset the effects of shading and the competition of Acer saccharum. Beech has positive values for dry-mesic (14/11), mesic (13/8) and wet-mesic (4/2) habitats, while basswood has variable representation in dry-mesic (2/3), mesic (3/8), wet-mesic (3/0) and wet (2/1) segments.

Figures 9 to 11 show the patterns of relationships for selected saplings and trees, based on average relative density (and of frequency of seedlings) across the moisture gradient.

A comparison of frequency values for selected tree seedlings in all stands is shown in Figure 12. Only those species with a seedling representation over 1 are shown. Twenty of 54 tree species attain an average seedling frequency of 1 or more. The great importance of the seedlings of <u>Acer rubrum</u>, <u>A. saccharum</u> and <u>Fraxinus americana</u> in contributing to the character of the understory vegetation is well portrayed in this graph. As well, these great populations of seedlings represent a strong assurance of perpetuation of these species in subsequent generations.

Figure 9:

Average relative tree and sapling density, and average frequency of tree seedlings of selected arboreal components, for segments of the moisture gradient.


Pinus strobus
AVERAGE RELATIVE TREE AND SAPLING DENSITY
SEEDLING FREQUENCY
tree
sapling
seedling
30
24
18
12
6
0
D
DM
M
WM
W
MOISTURE SEGMENT

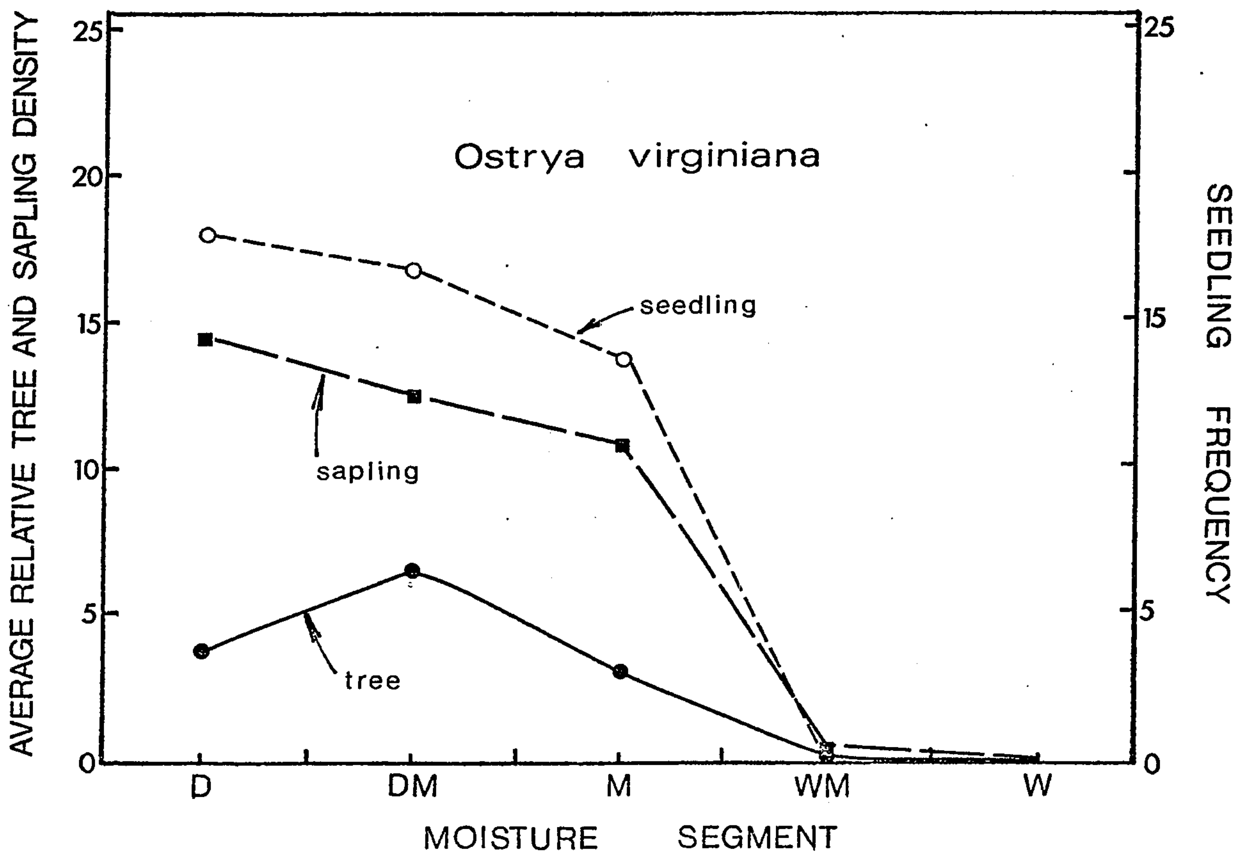
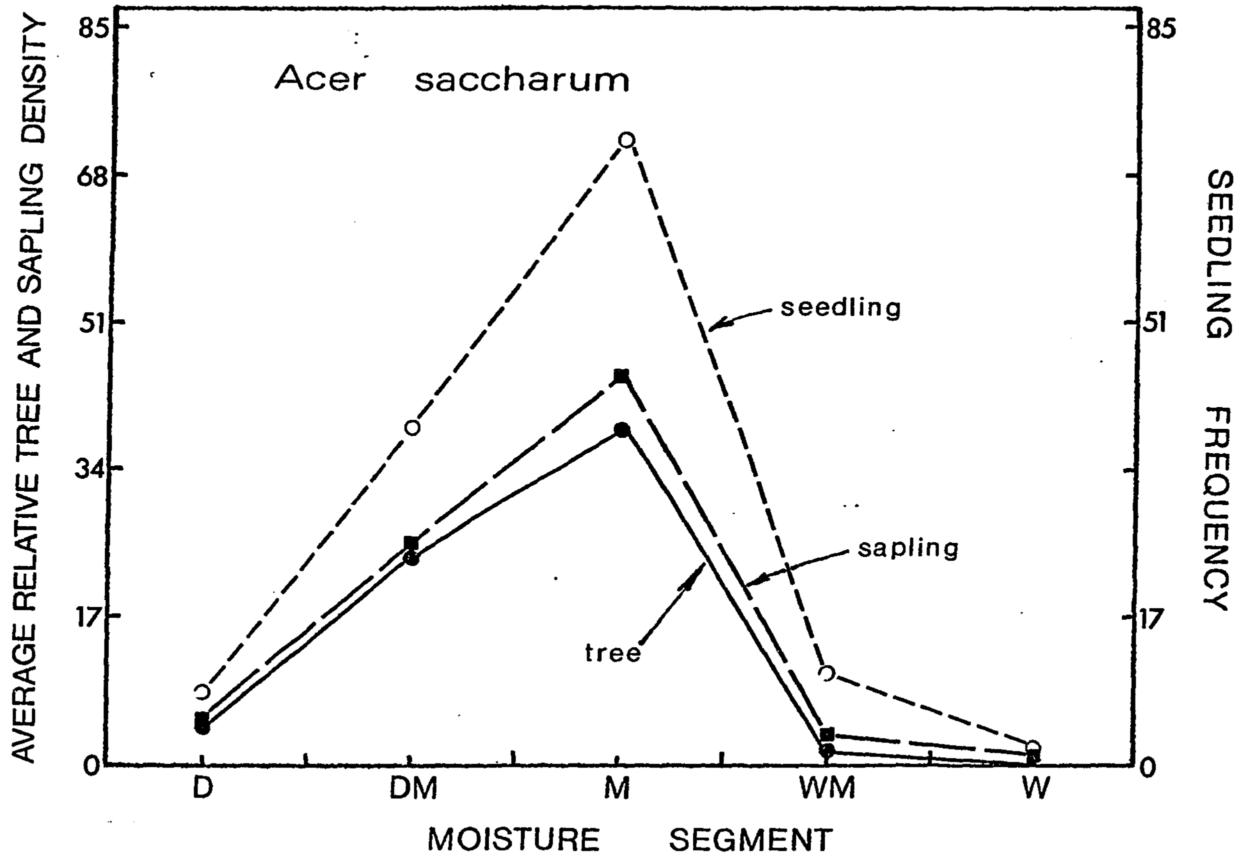

Ostrya virginiana
AVERAGE RELATIVE TREE AND SAPLING DENSITY
SEEDLING FREQUENCY
seedling
sapling
tree
25
20
15
10
5
0
D
DM
M
WM
W
MOISTURE SEGMENT

Figure 10:

Average relative tree and sapling density, and average frequency of tree seedlings of selected arboreal components, for segments of the moisture gradient.


Acer saccharum
AVERAGE RELATIVE TREE AND SAPLING DENSITY
SEEDLING FREQUENCY
85
68
51
34
17
0
seedling
sapling
tree
D
DM
M
WM
W
MOISTURE SEGMENT

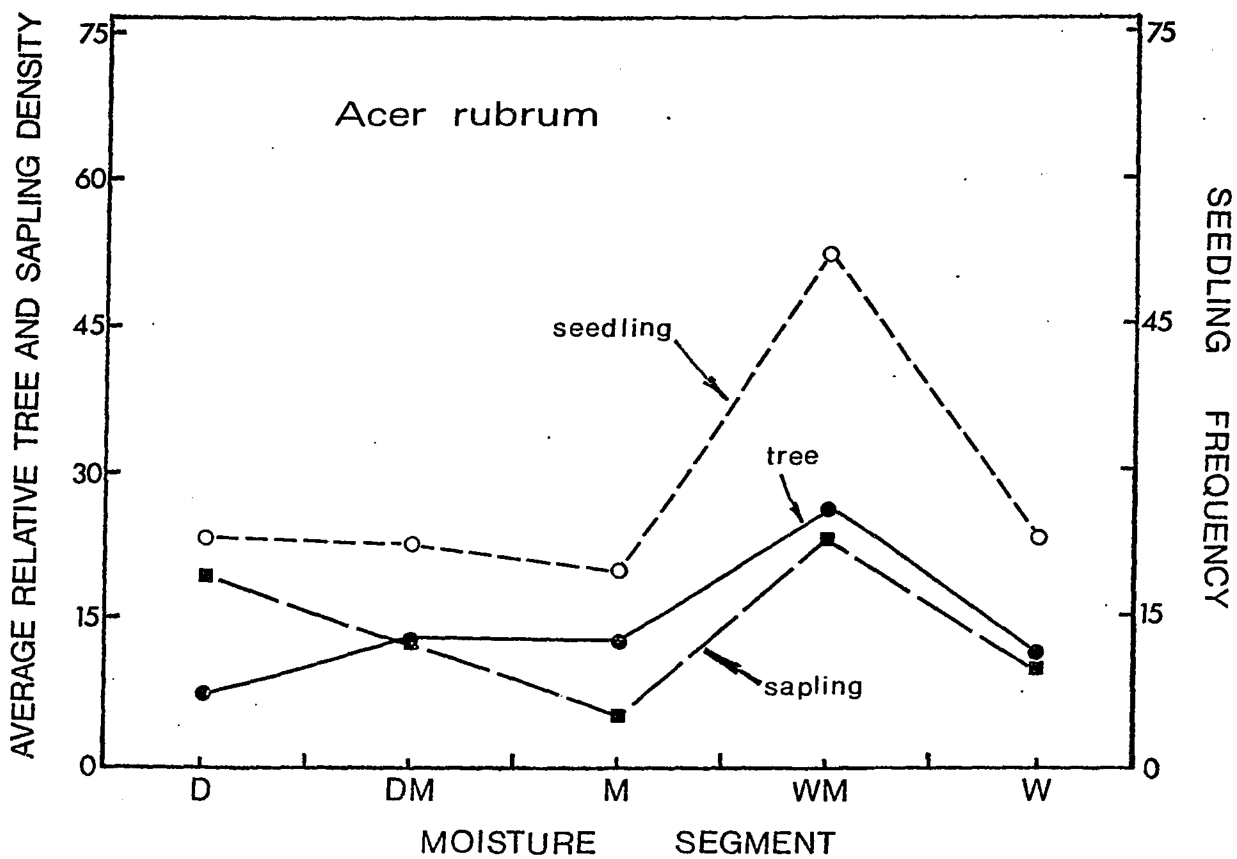
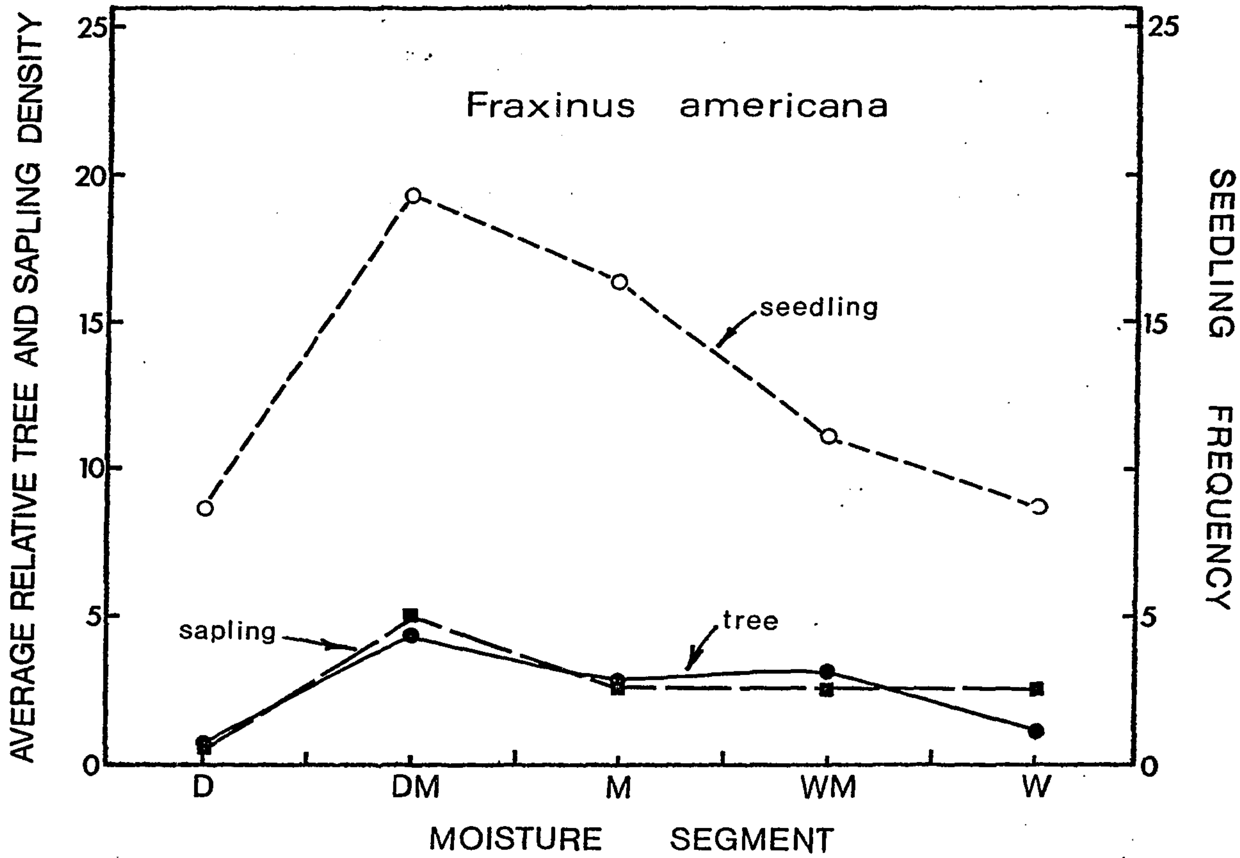

Acer rubrum
AVERAGE RELATIVE TREE AND SAPLING DENSITY
SEEDLING FREQUENCY
75
60
45
30
15
0
seedling
tree
sapling
D
DM
M
WM
W
MOISTURE SEGMENT

Figure 11:

Average relative tree and sapling density, and average frequency of tree seedlings of selected arboreal components, for segments of the moisture gradient.


Fraxinus americana
seedling
sapling
tree
AVERAGE RELATIVE TREE AND SAPLING DENSITY
SEEDLING FREQUENCY
0
5
10
15
20
25
D
DM
M
WM
W
MOISTURE SEGMENT

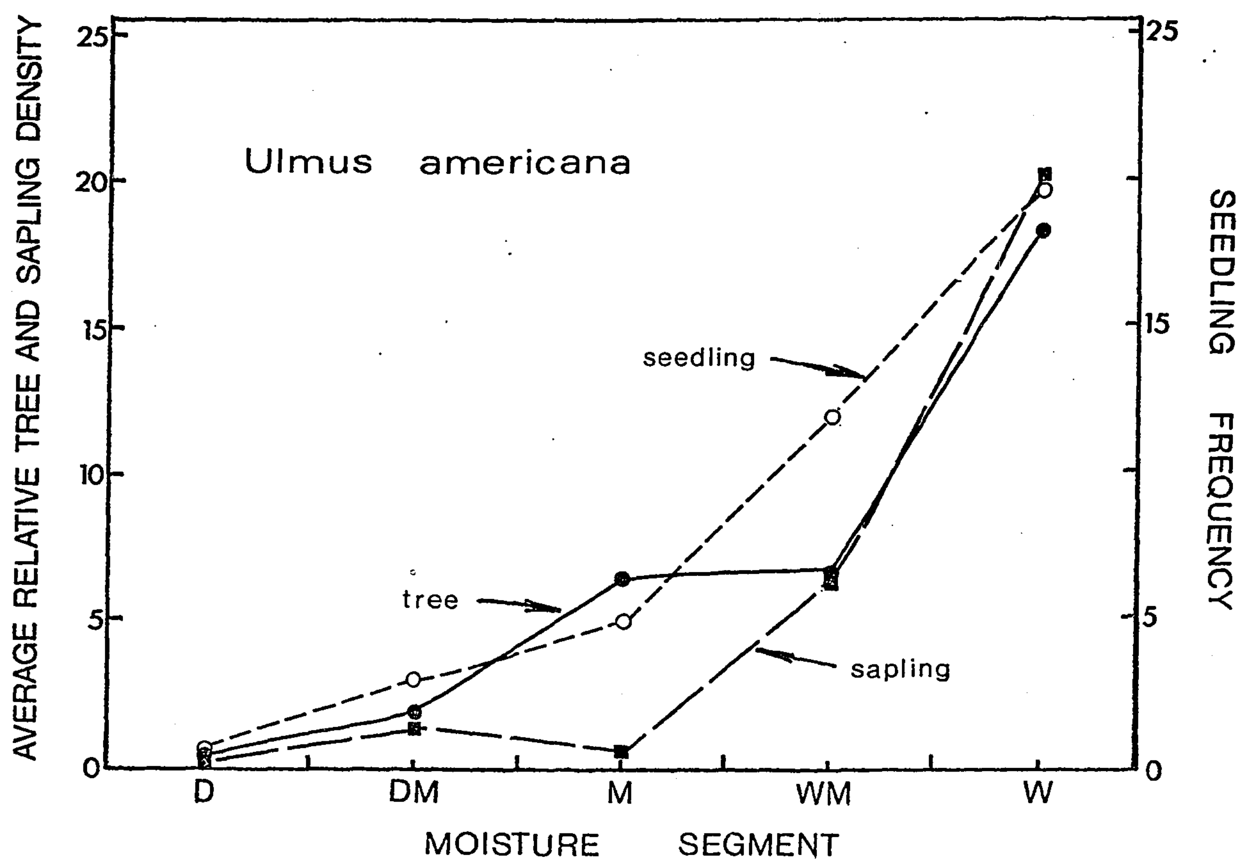
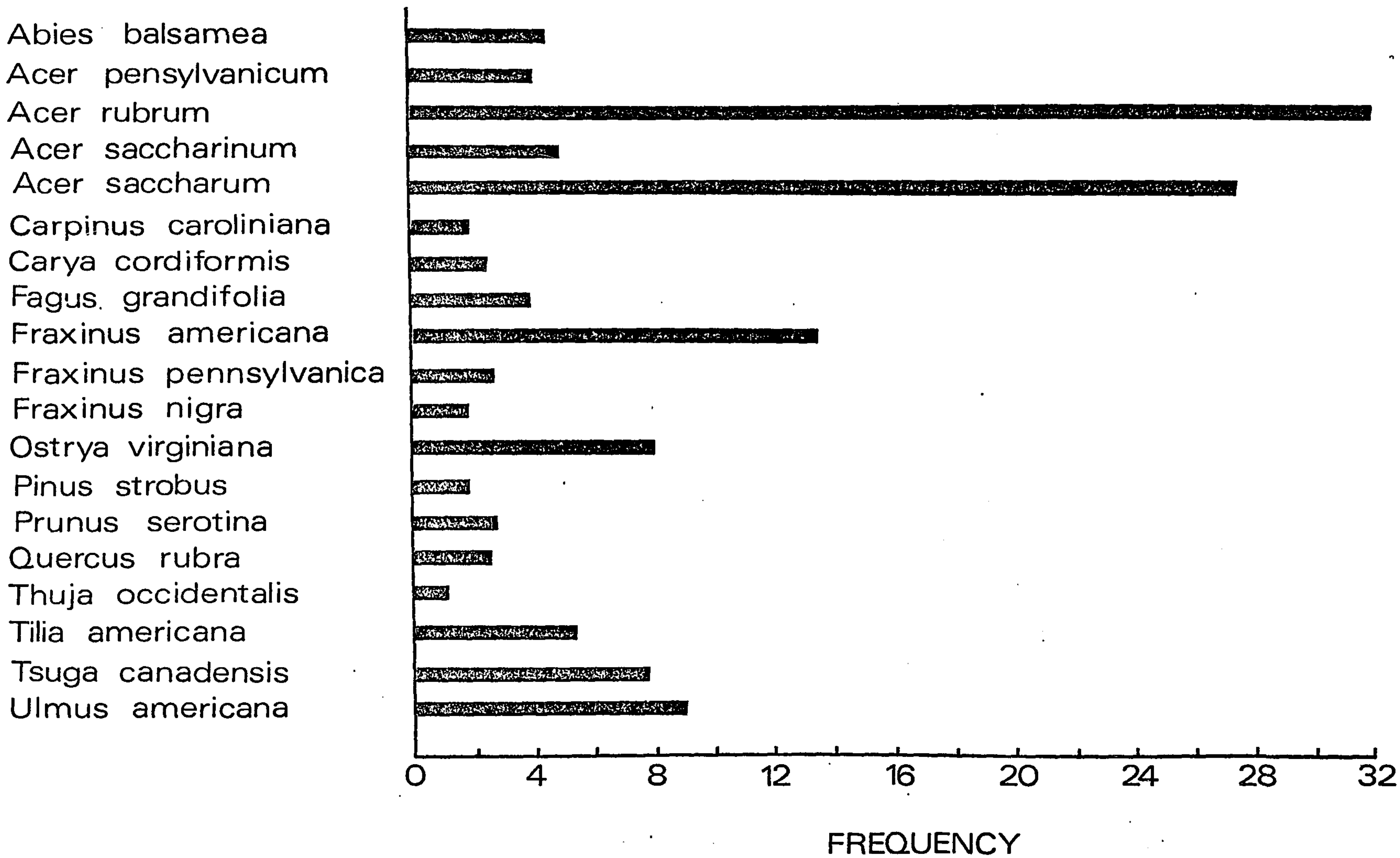

Ulmus americana
seedling
tree
sapling
AVERAGE RELATIVE TREE AND SAPLING DENSITY
SEEDLING FREQUENCY
0
5
10
15
20
25
D
DM
M
WM
W
MOISTURE SEGMENT

Figure 12:

Frequency values for selected tree seedlings in 141 stands.



Abies balsamea
Acer pensylvanicum
Acer rubrum
Acer saccharinum
Acer saccharum
Carpinus caroliniana
Carya cordiformis
Fagus grandifolia
Fraxinus americana
Fraxinus pennsylvanica
Fraxinus nigra
Ostrya virginiana
Pinus strobus
Prunus serotina
Quercus rubra
Thuja occidentalis
Tilia americana
Tsuga canadensis
Ulmus americana
0
4
8
12
16
20
24
28
32
FREQUENCY

HERB AND SHRUB STRATUM

Preliminary Analysis:

When the waters of the Champlain Sea retreated, newly created rivers became migration routes for plants from southern and western regions. These found their way along routes of now non-existent rivers as, for example, those connecting the Ottawa River to the Great Lakes thus carrying western plants into the Lowland region. Similarly the Richelieu River, running to Lake Champlain, and through to the Hudson Valley and Atlantic Coast, was at one time connected to the Hochelaga Archipelago at Laprairie and was as such in contact with the Ottawa River (Raymond, 1950). Numerous plants are found on the banks of both rivers, now isolated. Boreal elements are present in the forests, to a small degree reminiscent of the cooler post-glacial period, although the majority of these later migrated along the northern tributaries of the St. Lawrence and have established themselves in habitats with environments more suitable for their survival. Both Boreal and Alleghenian elements have contributed their imprint to the general character of the regional flora and vegetation.

Raymond (1950) discusses in detail the flora of Quebec province in relation to geographical origin and establishment through different migration routes. He compares the flora of the Ottawa and Richelieu rivers and notes the similarities between the two. "Le grand nombre de ces éléments centraux, prairéaux ou appalachiens qui se trouvent simultanément dans la vallée de l'Ottawa et le long du Richelieu nous invite à croire que ces plantes à l'époque Champlain, ont atteint les rivages outaouais à partir des Grands Lacs, le long d'un déversoir aujourd'hui disparu, et le Richelieu par une autre rivière fossile." Within the province-wide study of Raymond, the characteristics of the flora of the study region are well documented as are the northern limits of both arboreal and understory components. The south-western part of the province, including especially the marshes of Missisquoi Bay and the bottomlands of the upper Richelieu, is the richest in floristic composition. Various southern plants reach their northern limit here while others extend northward to Montreal, to Lake St. Peter or to Quebec City, The last region is squeezed between the Laurentian and Appalachian Uplands and, as a result, one finds a greater percentage of boreal elements within that section of the Lowlands.

A large number of herbs and shrubs exist within the mixed forests of the study region. In 141 stands sampled, 516 herb and shrub species were encountered. This number of species represents 251 genera in 77 families. Of this total, 42 species (24 genera) were Gramineae, 49 species (19 genera) were Compositae, and 17 species (11 genera) were Liliaceae. The genus Carex was represented by 58 species, while Viola was represented by 18. There are, in addition to the groups of species mentioned above, a relatively large number of genera which are represented by a number of different species. Actually these include an additional 15 genera which are represented by between 4 and 11 species. Of these, one group including Aster (9 species), Dryopteris (11), Lycopodium (6), Cornus (5), Poa (6), Pyrola (5), Solidago (10), Trillium (4), and Ribes (7) decidedly contribute in influencing the character of understories and possess relatively high constancy and overall high frequency values. The other group may or may not occur with high constancy values but generally have low overall average frequency and are not so important in this regard. Habenaria (6), Epilobium (4), Rubus (8), Viburnum (6), Amelanchier (5) and Ranunculus (5) are included among these.

The average number of species per stand was calculated and found to be 49. In an effort to obtain an understanding of the most significant herbs and shrubs contributing to the composition of stands, a list of prevalent species was determined by selecting the top 49 species from the list of all herbs and shrubs arranged in order of decreasing constancy or percent presence. This included all plants with a constancy of 30 or greater. This list includes those species "most likely to be encountered in any stand as well as those present with highest density within the stand." (Curtis, 1959). Eight prevalent species attain a constancy value of over 50. These are Maianthemum canadense (80), Prunus virginiana (70), Aralia nudicaulis (69), Athyrium filix-femina (62), Dryopteris intermedia (60), Onoclea sensibilis (56), Polygonatum pubescens (53), and Erythronium americanum (52 - calculated on the basis of 85 stands sampled for spring flora). The other prevalent species are shown in Table 7.

Table 7:

The 49 prevalent herbs and shrubs in 141 stands based on constancy values.

THE 49 PREVALENT HERBS AND SHRUBS IN 141 STANDS, BASED ON CONSTANCY VALUES

Maianthemum candense	80
Prunus virginiana	70
Aralia nudicaulis	69
Athyrium filix-femina	62
Dryopteris intermedia	60
Onoclea sensibilis	56
Polygonatum pubescens	53
*Erythronium americanum	52
Trientalis borealis	49
Dryopteris spinulosa	46
Trillium erectum	46
Galium triflorum	45
Ribes cynosbati	45
Rubus pubescens	43
Arisaema atrorubens	43
Carex pedunculata	43
Carex arctata	42
Cornus alternifolia	41
Clintonia borealis	41
Smilacina racemosa	41
Pteridium aquilinum	39
Taxus canadensis	39
Carex rosea	39
Viola incognita	39
Rhus radicans	37
Fragaria virginiana	36
Prenanthes altissima	36
Lycopodium obscurum	36
Actaea rubra	35
Corylus cornuta	35
Sambucus pubens	35
Tiarella cordifolia	35
Trillium grandiflorum	35

Circaea quadrisulcata	34
Mitchella repens	34
Aster lateriflorus	33
Osmunda cinnamomea	33
Parthenocissus quinquefolia	33
Impatiens capensis	32
Pyrola elliptica	32
Osmorhiza claytoni	32
Viola pensylvanica	31
Brachyeletrum erectum	30
Coptis groenlandicum	30
Lonicera canadensis	30
Medeola virginiana	30
Osmunda regalis	30
Rubus idaeus	30
Viburnum cassinoides	30

* Calculation based only on a sample of spring flora in 85 of the 141 stands.

Table 8:

The overall constancy and average frequency values of the 24 more important herbs and shrubs.

OVERALL CONSTANCY AND AVERAGE FREQUENCY OF 24 IMPORTANT HERBS AND SHRUBS

	Constancy	Average Frequency
Maianthemum canadense	80	33
*Erythronium americanum	52	29
Onoclea sensibilis	56	14
Aralia nudicaulis	69	11
Prunus virginiana	70	8
Trientalis borealis	49	10
Athyrium filix-femina	62	7
Rubus pubescens	43	10
Dryopteris intermedia	60	7
Carex pedunculata	43	8
Polygonatum pubescens	53	6
Impatiens capensis	32	8
Pteridium aquilinum	39	6
Viola incognita	39	6
Dryopteris spinulosa	46	5
Rhus radicans	37	5
Trillium erectum	46	4
Fragaria virginiana	36	5
Tiarella cordifolia	35	5
Trillium grandiflorum	35	5
Carex rosea	39	4
Viola pensylvanica	31	5
Coptis groenlandicum	30	5
Viburnum cassinoides	30	5

Twelve species attain constancy values between 40 and 49. These include Trientalis borealis (49), Dryopteris spinulosa (46), Trillium erectum (46), Galium triflorum (45), Ribes cynosbati (45), Rubus pubescens (43), Arisaema atrorubens (43), Carex pedunculata (43), Carex arctata (42), Cornus alternifolia (41), Clintonia borealis (41), and Smilacina racemosa (41). The remaining 29 prevalent species attain constancy values between 30 and 39. Thirty-eight species have constancy values between 20 and 29; 67 between 10 and 19; whereas 185 species attain values between 2 and 9. On the other hand, 189 species (36%) have a constancy of only 1 and occur in just one or two stands. This category represents rare or specialized species, weeds, invaders and hybrids. The prevalent species include a large number of plants of very broad ecological tolerance which are important in other forest communities. On the other hand, there are a number which may be considered as being more representative of common species in the Northern Paleozoic Northern Conifer-Hardwoods. These include Trillium erectum, Carex arctata, Prenanthes altissima, Mitchella repens, Medeola virginiana and Viburnum cassinoides.

Table 9 presents the overall average frequency of herbs and shrubs encountered within all stand communities of the study region. Only 169 (33%) have a value of 1 or more. Of these 83 occur with an overall average frequency of 1; 60 with a value of 2, 3, or 4; 21 with values between 5 and 10. Aralia nudicaulis, Onoclea sensibilis, Erythronium americanum and Maianthemum canadense have overall average frequency values of 11, 14, 29 and 33 respectively.

One can obtain an overall impression of importance of certain herbs by analyzing the relationships of both constancy and average frequency values. In Table 8 one finds these values for 24 of the most common and widespread herb species of the St. Lawrence Lowlands. These include Maianthemum canadense (constancy 80; average frequency 33), Erythronium americanum (52;29), Onoclea sensibilis (56;14), Aralia nudicaulis (69;11), Prunus virginiana (70;8), Trientalis borealis (49;10), Athyrium filix-femina (62;7), Rubus pubescens (43;10) and Dryopteris intermedia (60;7).

Table 9:

Overall constancy and average frequency, constancy and average frequency in the segments of the moisture gradient for 516 herb and shrub species.

OVERALL CONSTANCY AND AVERAGE FREQUENCY, CONSTANCY AND AVERAGE FREQUENCY IN THE SEGMENTS OF THE MOISTURE GRADIENT FOR 516 HERBS AND SHRUBS

	OVERALL CONSTANCY	OVERALL AVERAGE FREQUENCY	CONSTANCY					AVERAGE FREQUENCY				
			D	DM	M	WM	W	D	DM	M	WM	W
Solidago hispida	2	-	23	-	-	-	-	2	-	-	-	-
Panicum latifolia	1	-	15	-	-	-	-	2	-	-	-	-
Arctostaphylos uva-ursi	1	-	15	-	-	-	-	-	-	-	-	-
Carex tonsa	1	-	8	-	-	-	-	-	-	-	-	-
Carex backii	1	-	8	-	-	-	-	-	-	-	-	-
Panicum linearifolium	1	-	8	-	-	-	-	-	-	-	-	-
Panicum tsugetorum	1	-	8	-	-	-	-	-	-	-	-	-
Viburnum rafinesquianum	1	-	8	-	-	-	-	-	-	-	-	-
Symphoricarpos alba	1	-	8	-	-	-	-	-	-	-	-	-
Spiranthes lacera	1	-	8	-	-	-	-	-	-	-	-	-
Scirpus verecundus	1	-	8	-	-	-	-	-	-	-	-	-
Rumex acetosella	1	-	8	-	-	-	-	-	-	-	-	-
Phleum pratense	1	-	8	-	-	-	-	-	-	-	-	-
Melampyrum lineare	1	-	8	-	-	-	-	-	-	-	-	-
Lycopodium tristachyum	1	-	8	-	-	-	-	-	-	-	-	-
Lathyrus ochroleucus	1	-	8	-	-	-	-	1	-	-	-	-
Juncus bufonius	1	-	8	-	-	-	-	-	-	-	-	-
Houstonea caerula	1	-	8	-	-	-	-	-	-	-	-	-
Geranium maculatum	1	-	8	-	-	-	-	-	-	-	-	-
Galeopsis terrahit	1	-	8	-	-	-	-	-	-	-	-	-
Dactylis glomerata	1	-	8	-	-	-	-	-	-	-	-	-
Corydalis sempervirens	1	-	8	-	-	-	-	-	-	-	-	-
Convolvulus spithaneus	1	-	8	-	-	-	-	1	-	-	-	-
Comptonia peregrina	1	-	8	-	-	-	-	-	-	-	-	-

			CONSTANCY					AVERAGE FREQUENCY				
			D	DM	M	WM	W	D	DM	M	WM	W
Comandra richardsiana	1	-	8	-	-	-	-	1	-	-	-	-
Barbarea vulgaris	1	-	8	-	-	-	-	1	-	-	-	-
Amelanchier sanguinea	1	-	8	-	-	-	-	-	-	-	-	-
Hypericum perforatum	3	-	15	7	-	-	-	-	-	-	-	-
Pyrola rotundifolia	2	-	15	3	-	-	-	1	-	-	-	-
Goodyera tesselata	2	-	15	3	-	-	-	-	-	-	-	-
Hieracium vulgatum	2	1	15	3	-	-	-	9	-	-	-	-
Aquilegia canadensis	2	-	8	7	-	-	-	-	1	-	-	-
Verbascum thapsus	2	-	8	7	-	-	-	-	-	-	-	-
Oryzopsis asperifolia	8	1	39	16	4	-	-	7	-	-	-	-
Anemone virginiana	6	-	15	16	4	-	-	1	1	-	-	-
Polypodium virginianum	5	1	15	13	4	-	-	5	1	-	-	-
Viburnum acerifolium	7	-	15	13	15	-	-	-	1	-	-	-
Carex peckii	6	-	15	10	4	-	-	-	-	-	-	-
Cornus rugosa	3	-	15	3	4	-	-	-	1	-	-	-
Pyrola secunda	8	-	8	13	12	-	-	2	-	-	-	-
Waldsteinia fragarioides	4	1	8	10	4	-	-	1	4	-	-	-
Corallorhiza maculata	4	-	8	10	8	-	-	-	-	-	-	-
Deschampsia flexuosa	1	-	8	-	4	-	-	2	-	-	-	-
Habenaria hookeri	1	-	8	-	4	-	-	-	-	-	-	-
Carex hitchcockiana	3	-	8	-	8	-	-	-	-	-	-	-
Gaultheria procumbens	16	4	77	16	-	18	-	32	2	-	3	-
Chimaphila umbellata	13	1	62	23	8	4	-	5	1	-	-	-
Smilacina racemosa	41	3	31	58	96	24	-	2	2	11	1	-
Danthonia spicata	8	1	31	10	-	11	-	6	-	-	-	-
Antennaria spp.	6	-	23	10	-	4	-	-	-	-	-	-
Amelanchier spicata	3	-	23	-	-	2	-	1	-	-	1	-
Gaylussacia baccata	3	-	23	-	-	2	-	3	-	-	-	-
Thalictrum dioicum	11	1	15	19	15	7	-	1	6	-	-	-
Carex communis	12	-	15	13	27	4	-	-	-	1	-	-
Pyrola asarifolia	3	-	15	-	4	2	-	1	-	-	-	-
Hepatica acutiloba	18	3	8	36	46	2	-	1	6	8	-	-
Epifagus virginiana	15	1	8	29	23	11	-	1	5	-	1	-

			CONSTANCY					AVERAGE FREQUENCY				
			D	DM	M	WM	W	D	DM	M	WM	W
Oryzopsis racemosa	8	1	8	23	12	2	-	-	2	2	-	-
Rubus odoratus	8	-	8	19	8	4	-	-	1	-	-	-
Allium tricoccum	11	2	8	16	27	7	-	-	5	1	1	-
Hieracium florentinum	4	1	8	7	4	2	-	1	-	3	-	-
Carex albursina	9	-	8	7	27	4	-	-	1	1	-	-
Milium effusum	4	-	8	3	4	4	-	-	-	-	-	-
Rubus allegheniensis	1	-	8	-	-	2	-	-	-	-	-	-
Spiranthes cernua	1	-	8	-	-	2	-	1	-	-	-	-
Satureja vulgaris	1	-	8	-	-	2	-	-	-	-	-	-
Zizia aurea	2	-	8	-	-	4	-	1	-	-	-	-
Lycopodium clavatum	11	1	39	7	-	20	-	-	-	-	2	-
Vaccinium corymbosum	4	-	15	-	-	7	-	1	-	-	1	-
Hieracium aurantiacum	8	-	15	7	-	16	-	-	1	-	1	-
Medeola virginiana	30	2	15	32	31	51	-	1	2	2	3	-
Carex convoluta	7	-	8	7	12	9	-	2	-	-	-	-
Equisetum hyemale	9	1	8	3	15	16	-	-	-	1	1	-
Diervilla lonicera	12	1	85	10	4	2	4	11	-	-	-	-
Pteridium aquilinum	39	6	85	48	19	42	23	28	6	-	5	2
Carex pensylvanica	28	5	62	42	15	11	8	19	9	2	2	-
Polygonatum pubescens	53	6	54	81	89	36	19	3	10	13	4	1
Corylus cornuta	35	3	54	45	46	22	27	11	5	2	1	-
Aster macrophyllus	13	1	54	23	8	2	4	3	5	-	-	-
Vaccinium myrtilloides	14	4	54	10	-	20	4	26	1	-	3	1
Mitchella repens	34	4	39	52	27	42	4	8	4	2	5	-
Dryopteris marginalis	27	1	31	42	50	11	15	-	2	2	-	-
Lonicera canadensis	30	1	31	48	27	24	23	3	1	-	1	-
Lycopodium complanatum	23	3	31	32	23	27	4	2	3	1	4	-
Linnaea borealis	6	-	31	3	-	4	8	3	-	-	-	-
Apocynum androsaemifolium	8	-	23	19	15	2	4	1	-	-	-	-
Poa compressa	4	1	23	13	-	7	8	1	2	-	-	-
Lonicera dioica	10	-	23	10	8	9	8	1	-	-	-	-
Poa pratensis	8	1	23	10	-	9	8	6	-	-	-	-

			CONSTANCY					AVERAGE FREQUENCY				
			D	DM	M	WM	W	D	DM	M	WM	W
xErythronium americanum	52	29	17	65	94	54	6	15	39	64	18	-
Uvularia grandiflora	28	4	15	36	65	18	8	7	2	11	2	-
Epipactis helleborine	25	2	15	32	46	22	4	3	3	6	1	-
Carex deweyana	21	1	15	29	38	11	12	-	1	2	-	-
Schizachne purpurascens	10	-	15	19	15	-	8	-	1	-	-	-
Ranunculus acris	11	1	15	16	-	9	15	1	2	-	1	2
Poa palustris	4	-	15	3	-	4	4	-	-	-	-	-
Trillium grandiflorum	35	5	8	48	77	24	12	-	9	25	2	-
Osmorhiza claytoni	32	4	8	48	58	24	12	-	7	11	3	-
Trillium erectum	46	4	8	45	100	42	19	-	4	16	5	-
Solidago flexicaulis	26	2	8	45	54	11	12	-	7	5	1	-
Sanguinaria canadensis	18	1	8	29	35	13	4	-	2	3	-	-
Circaea quadrisulcata	34	4	8	23	58	40	31	-	2	4	6	3
Viola conspersa	13	1	8	26	4	11	15	-	2	-	-	2
Solidago caesia	14	1	8	19	15	16	8	1	1	2	1	1
Carex laxiflora	25	1	8	19	19	7	12	1	2	1	1	2
Sanicula marilandica	12	-	8	16	8	18	4	-	1	-	1	-
Sanicula gregaria	12	1	8	16	23	9	4	-	2	1	1	-
Celastrus scandens	9	-	8	16	12	4	8	-	1	-	-	-
Veronica officinalis	5	-	8	13	-	2	4	1	-	-	-	-
Xanthophylum americanum	6	-	8	10	-	-	15	-	-	-	-	-
Vicia cracca	4	-	8	7	-	2	8	-	-	-	-	-
Trifolium repens	4	-	8	7	-	2	4	1	-	-	-	1
Arctium minus	4	-	8	7	-	4	4	1	-	-	-	-
Agrostis perennans	5	-	8	7	-	4	8	-	-	-	-	2
Fragaria vesca	2	-	8	3	-	-	4	-	-	-	-	-
Anaphalis margaritacea	2	-	8	3	-	-	4	-	-	-	-	-
Cornus racemosa	1	-	8	-	-	-	4	-	-	-	-	1
Salix petiolaris	2	-	8	-	-	2	4	-	-	-	-	-
Erigeron strigosus	2	-	8	-	-	2	4	-	-	-	-	-
Ledum groenlandicum	3	-	8	-	-	4	4	-	-	-	-	-
Salix bebbiana	5	-	8	-	-	9	8	-	-	-	-	-
Epilobium glandulosum	6	-	8	-	-	4	19	-	-	-	-	2
Agrimonia gryposepala	9	-	8	3	-	16	15	-	-	-	-	-

			CONSTANCY					AVERAGE FREQUENCY				
			D	DM	M	WM	W	D	DM	M	WM	W
Achillea millefolium	9	-	8	3	-	16	15	-	-	-	1	-
Aster umbellatus	14	1	8	7	-	31	12	1	-	-	1	1
Equisitum sylvaticum	13	1	8	7	-	22	23	-	-	-	1	4
Solidago rugosa	22	2	8	10	-	36	42	-	1	-	4	5
Sambucus canadensis	18	1	8	3	12	22	39	-	-	-	1	2
Cinna latifolia	6	-	8	7	4	4	8	-	-	-	-	-
Viola septentrionalis	6	-	8	7	4	9	4	-	-	-	1	1
Osmunda claytoniana	15	-	8	7	19	22	12	-	-	-	-	-
Aralia racemosa	16	-	8	10	35	18	8	-	-	1	2	-
Osmunda cinnamomea	33	4	8	16	12	60	42	-	1	-	9	7
Geum canadense	25	2	8	19	19	31	39	2	1	-	3	3
Vitis riparia	28	2	8	19	27	27	54	-	-	-	1	6
Rubus pubescens	43	10	8	23	35	62	65	1	4	2	15	22
Coptis groenlandicum	30	5	8	26	4	53	35	1	3	-	12	5
Acer spicatum	27	2	8	36	19	31	31	-	2	1	3	1
Carex rosea	39	4	8	36	46	47	39	-	4	2	6	2
Viola pensylvanica	31	5	8	36	69	24	12	3	6	10	5	-
Athyrium filix-femina	62	7	8	36	81	82	73	1	2	4	11	11
Actaea rubra	35	1	8	42	54	29	35	-	1	3	1	-
Dryopteris spinulosa	46	5	8	42	38	58	62	-	5	1	7	9
Taxus canadensis	39	3	8	55	46	38	31	-	5	3	3	-
Nemopanthus mucronata	11	-	15	-	-	22	15	-	-	-	1	1
Dalibarda repens	13	2	15	7	-	29	4	3	-	-	4	1
Parthenocissus quinquefolia	33	3	15	16	42	31	58	1	-	2	3	7
Uvularia sessilifolia	18	2	15	19	15	20	15	4	1	1	3	-
Ranunculus abortivus	28	1	15	19	38	31	35	1	1	-	2	1
Viola incognita	39	6	15	23	35	56	50	1	2	1	13	7
Carex gracillima	24	1	15	23	42	22	19	1	1	2	1	3
Viburnum lentago	22	1	15	23	8	20	46	-	2	-	1	2
Aster cordifolius	22	1	15	29	15	20	27	2	3	1	1	1
Taraxacum officinale	27	2	15	29	4	36	42	2	4	-	2	3
Prenanthes altissima	36	4	15	39	73	31	19	-	2	8	5	1
Rubus idaeus	30	3	15	39	12	24	58	1	2	-	5	3
Rubus (raspberry)	31	3	15	39	12	24	62	1	2	-	5	3

			CONSTANCY					AVERAGE FREQUENCY				
			D	DM	M	WM	W	D	DM	M	WM	W
Sambucus pubens	35	1	15	42	54	29	31	-	1	3	1	-
Cornus alternifolia	41	2	15	45	73	40	23	-	3	5	1	1
Ribes cynosbati	45	2	15	52	73	40	35	4	4	3	2	1
Spiraea latifolia	22	3	23	-	12	33	39	1	-	1	7	3
Prenanthes alba	11	1	23	3	23	9	8	5	-	3	-	-
Rubus hispidus	17	4	23	7	4	31	15	6	1	-	9	4
Rubus (blackberry)	17	1	23	10	8	29	12	1	-	-	3	2
Pyrola elliptica	32	4	23	32	27	44	23	6	3	2	5	3
Galium triflorum	45	3	23	45	50	44	54	-	4	2	6	8
Carex pedunculata	43	8	23	48	77	35	27	3	16	11	5	4
Vaccinium angustifolium	6	2	31	-	-	7	8	12	-	-	2	1
Pyrus melanocarpa	8	2	31	7	-	11	4	10	1	-	2	-
Monotropa uniflora	22	-	31	26	23	27	8	1	1	-	1	-
Aster acuminatus	27	1	31	32	35	33	4	1	3	1	1	1
Dryopteris intermedia	60	7	31	61	85	69	39	-	5	7	13	5
Kalmia angustifolia	12	2	39	3	-	20	12	5	-	-	4	2
Cornus canadensis	21	4	39	7	-	42	15	5	1	-	7	4
Viburnum cassinoides	30	5	39	19	19	49	19	4	1	2	8	7
Rhus radicans	37	5	39	26	27	44	50	11	4	-	9	3
Fragaria virginiana	36	5	39	29	12	47	54	3	7	-	7	7
Lycopodium obscurum	36	4	39	32	35	56	8	2	2	4	8	1
Clintonia borealis	41	3	39	42	31	60	19	1	4	1	4	2
Carex arctata	42	3	39	45	54	42	27	1	3	1	5	2
Prunus virginiana	70	8	54	81	96	64	54	10	10	10	8	4
Trientalis borealis	49	10	62	45	27	64	46	20	12	2	13	7
Cypripedium acaule	28	-	69	13	-	29	8	3	-	-	-	-
Aralia nudicaulis	69	11	77	71	69	76	54	18	10	8	12	9
Maianthemum canadense	80	33	100	77	73	91	65	57	29	19	46	17
Rhus typhina	2	-	-	10	-	-	-	-	-	-	-	-
Solidago caesia X S. flexicaulis	1	-	-	7	-	-	-	-	-	-	-	-
Ribes sativum	1	-	-	7	-	-	-	-	-	-	-	-
Monotropa hypopithys	1	-	-	7	-	-	-	-	-	-	-	-
Leonorus cardiaca	1	-	-	7	-	-	-	-	-	-	-	-
Carex sprengelii	1	-	-	7	-	-	-	-	-	-	-	-
Carex sparganioides	1	-	-	7	-	-	-	-	1	-	-	-
Moneses uniflora	1	-	-	3	-	-	-	-	-	-	-	-

			CONSTANCY					AVERAGE FREQUENCY				
			D	DM	M	WM	W	D	DM	M	WM	W
Carex tetanica	1	-	-	3	-	-	-	-	-	-	-	-
Carex umbellata	1	-	-	3	-	-	-	-	-	-	-	-
Camptosorus rhizophyllus	1	-	-	3	-	-	-	-	-	-	-	-
Galium boreale	1	-	-	3	-	-	-	-	-	-	-	-
Linaria vulgaris	1	-	-	3	-	-	-	-	-	-	-	-
Corallorhiza striata	1	-	-	3	-	-	-	-	-	-	-	-
Viola sagittata	1	-	-	3	-	-	-	-	1	-	-	-
Lithospermum officinale	1	-	-	3	-	-	-	-	-	-	-	-
Monarda fistulosa	1	-	-	3	-	-	-	-	-	-	-	-
Nepata cataria	1	-	-	3	-	-	-	-	-	-	-	-
Pastinaca sätiva	1	-	-	3	-	-	-	-	-	-	-	-
Pyrola virens	1	-	-	3	-	-	-	-	-	-	-	-
Amelanchier humilis	1	-	-	3	-	-	-	-	1	-	-	-
Sanicula canadensis	1	-	-	3	-	-	-	-	-	-	-	-
Scrophularia lanceolata	1	-	-	3	-	-	-	-	-	-	-	-
Carex platyphylla	1	-	-	3	-	-	-	-	-	-	-	-
Dirca palustris	9	-	-	19	27	-	-	-	-	-	-	-
Carex plantaginea	11	1	-	13	42	-	-	-	1	2	-	-
Phryma leptostachya	4	-	-	10	12	-	-	-	-	-	-	-
Phlox divaricata	2	-	-	7	4	-	-	-	2	-	-	-
Chelidonium majus	2	-	-	7	4	-	-	-	-	-	-	-
Viola rostrata	2	-	-	7	4	-	-	-	-	-	-	-
Hystrix patula	2	-	-	7	4	-	-	-	-	-	-	-
Panax quinquefolius	4	-	-	3	19	-	-	-	-	-	-	-
Cypripedium calceolus	4	-	-	3	19	-	-	-	-	-	-	-
Polygonum cilinode	1	-	-	3	4	-	-	-	1	-	-	-
Symphytum officinale	1	-	-	3	4	-	-	-	-	-	-	-
Triosteum aurantiacum	1	-	-	3	4	-	-	-	-	-	-	-
Equisetum pratense	1	-	-	3	4	-	-	-	-	-	-	-
Galium circaezans	1	-	-	3	4	-	-	-	2	-	-	-
xDicentra canadensis	29	4	-	30	88	15	-	-	5	13	2	-
Caulophyllum thalictroides	22	3	-	29	69	11	-	-	2	11	1	-
Hydrophyllum virginianum	18	5	-	26	38	16	-	-	8	12	2	-

			CONSTANCY					AVERAGE FREQUENCY				
			D	DM	M	WM	W	D	DM	M	WM	W
Viburnum alnifolium	18	-	-	26	27	22	-	-	1	-	1	-
xClaytonia caroliniana	22	5	-	20	71	12	-	-	8	15	1	-
Polystichum acrostichoides	16	1	-	19	46	11	-	-	1	3	-	-
Dentaria diphylla	15	1	-	16	42	11	-	-	1	2	1	-
Osmorhiza longistylis	8	1	-	16	19	2	-	-	1	2	1	-
Dennstaedtia punctilobula	11	1	-	16	12	16	-	-	1	2	3	-
xDicentra cucullaria	13	2	-	15	29	12	-	-	-	8	2	-
Panax trifolius	14	1	-	13	35	16	-	-	1	1	3	-
Carex novae-angliae	8	-	-	10	15	16	-	-	-	-	-	-
Galium aparine	4	-	-	10	8	2	-	-	2	-	-	-
Desmodium glutinosum	4	-	-	7	12	2	-	-	-	1	-	-
Carex blanda	3	-	-	7	8	2	-	-	-	-	-	-
Geranium robertianum	4	-	-	7	8	2	-	-	1	-	-	-
Botrychium dissectum	4	-	-	7	4	4	-	-	-	-	-	-
Impatiens pallida	2	-	-	3	4	2	-	-	1	-	-	-
Bromus ciliolatus	2	-	-	3	4	2	-	-	-	-	-	-
Trillium erectum var. viridiflorum	5	-	-	3	4	11	-	-	-	-	-	-
Goodyera pubescens	1	-	-	3	-	2	-	-	-	-	-	-
Habenaria macrophylla	1	-	-	3	-	2	-	-	-	-	-	-
Asarum canadense	25	2	-	42	54	11	12	-	3	6	1	-
Tiarella cordifolia	35	5	-	39	54	36	31	-	4	9	6	5
Actaea pachypoda	25	1	-	36	58	13	12	-	2	2	1	-
Mitella diphylla	21	1	-	36	38	11	15	-	3	1	1	-
Streptopus roseus	27	1	-	36	38	36	8	-	2	2	1	1
Botrychium virginianum	27	1	-	32	73	18	8	-	1	2	1	-
Viola canadensis	14	2	-	19	46	2	4	-	1	7	-	1
Viola sororia	10	-	-	13	15	11	4	-	-	-	1	-
Adiantum pedatum	12	1	-	10	35	9	4	-	-	3	-	-
Viola pubescens	10	1	-	10	15	7	15	-	1	1	1	-
Carex eburnea	3	-	-	10	-	2	4	-	-	-	-	-
Cystopteris bulbifera	4	1	-	7	8	2	4	-	3	1	-	1
Cerastium vulgatum	3	-	-	7	-	2	4	-	-	-	1	-

			CONSTANCY					AVERAGE FREQUENCY				
			D	DM	M	WM	W	D	DM	M	WM	W
Cerastium vulgatum	3	-	-	7	-	2	4	-	-	-	1	-
Dryopteris goldiana	7	-	-	3	15	9	4	-	-	-	1	-
Festuca obtusa	4	-	-	3	12	-	4	-	-	-	-	-
Chrysanthemum leucanthemum	2	-	-	3	-	2	4	-	-	-	-	-
Prunus nigra	1	-	-	3	-	-	4	-	-	-	-	-
Salix discolor	2	-	-	3	-	-	8	-	-	-	-	-
Lilium michiganiense	2	-	-	3	-	2	4	-	-	-	-	-
Viola blanda	2	-	-	3	-	2	4	-	-	-	-	-
Mitella nuda	6	1	-	3	-	4	23	-	-	-	1	3
Carex stipata	8	1	-	3	-	4	35	-	-	-	-	4
Ranunculus recurvatus	5	-	-	3	-	7	12	-	-	-	-	-
Viola incognita var. Forbesii	6	1	-	3	-	13	4	-	-	-	2	1
Calamagrostis canadensis	15	1	-	3	-	24	35	-	-	-	-	4
Ilex verticillata	21	1	-	3	-	27	65	-	-	-	1	6
Circaea alpina	5	-	-	3	4	7	8	-	-	-	-	-
Viola renifolia	5	1	-	3	4	9	8	-	-	-	1	2
Lactuca canadensis	10	-	-	3	4	13	23	-	-	-	1	-
Erigeron philadelphicus	10	-	-	3	4	13	23	-	-	-	-	-
Clematis virginiana	10	-	-	3	4	11	27	-	-	-	-	2
Carex debilis	7	-	-	3	8	18	4	-	-	-	2	-
Menispermum canadense	6	-	-	3	8	11	4	-	-	1	1	-
Smilax herbacea	7	-	-	3	8	9	12	-	-	-	-	-
Viburnum trilobum	9	-	-	3	8	13	15	-	-	-	-	-
Carex brunnescens	9	-	-	3	15	13	12	-	-	-	1	1
Laportea canadensis	18	2	-	3	27	20	31	-	-	1	3	6
Carex intumescens	29	1	-	3	46	42	35	-	-	1	3	1
Rosa spp.	6	-	-	7	-	2	23	-	-	-	-	1
Hieracium scabrum	4	-	-	7	-	4	4	-	-	-	-	-
Trillium cernuum	4	-	-	7	-	4	8	-	-	-	-	-
Urtica dioica	5	-	-	7	-	4	12	-	-	-	1	-
Oxalis stricta	18	2	-	7	-	40	23	-	-	-	4	3
Solidago canadensis	11	1	-	7	4	18	15	-	-	-	1	-
Lycopodium annotinum	8	-	-	7	4	18	4	-	1	-	-	-

			Constancy					Average Frequency				
			D	DM	M	WM	W	D	DM	M	WM	W
Botrychium multifidum	6	-	-	7	8	7	8	-	-	-	-	-
Amphicarpa bracteata	10	1	-	7	19	9	12	-	-	1	1	1
Eupatorium rugosum	15	1	-	7	23	18	23	-	-	1	2	3
Solanum dulcamara	17	1	-	10	4	20	42	-	-	-	-	5
Viola cucullata	16	2	-	10	12	16	39	-	2	-	2	4
Ribes triste	14	-	-	10	15	16	23	-	-	-	-	1
Pteretis pensylvanica	18	1	-	10	15	24	27	-	1	-	2	1
Carex leptonervea	18	1	-	10	35	31	12	-	-	1	3	-
Rhamnus cathartica	9	-	-	13	4	13	8	-	-	-	1	-
Ribes americanum	18	1	-	13	4	22	39	-	-	1	1	2
Dryopteris disjuncta	22	1	-	13	27	31	23	-	-	-	2	1
Onoclea sensibilis	56	14	-	16	46	84	96	-	2	1	18	43
Prunella vulgaris	13	1	-	19	-	16	19	-	2	-	-	1
Dryopteris novaboracensis	20	1	-	19	23	29	15	-	-	2	3	1
Trillium undulatum	19	1	-	23	15	31	8	-	3	1	2	1
Aster lateriflorus	33	3	-	23	23	40	62	-	1	1	5	4
Brachyeletrum erectum	30	1	-	26	38	42	23	-	3	1	1	-
Arisaema atrorubens	43	4	-	29	58	44	65	-	-	5	7	6
Lycopodium lucidulum	27	2	-	36	27	36	19	-	3	1	2	1
Athyrium pycnocarpon	4	-	-	-	19	-	-	-	-	-	-	-
Carex disperma	2	-	-	-	8	-	-	-	-	-	-	-
Cypripedium calceolus var. pubescens	1	-	-	-	8	-	-	-	-	-	-	-
Botrychium lanceolatum	1	-	-	-	8	-	-	-	-	-	-	-
Saxifraga virginiensis	1	-	-	-	4	-	-	-	-	-	-	-
Lonicera oblongifolia	1	-	-	-	4	-	-	-	-	-	-	-
Lobelia inflata	1	-	-	-	4	-	-	-	-	-	-	-
Botrychium matricariae-folium	1	-	-	-	4	-	-	-	-	-	-	-
Carex laxiculmus	1	-	-	-	4	-	-	-	-	-	-	-
Athyrium thelypterioides	4	-	-	-	15	4	-	-	-	-	-	-
Cryptotaenia canadensis	4	-	-	-	12	7	-	-	-	-	-	-
Dryopteris phegopteris	6	-	-	-	12	13	-	-	-	-	1	-
Hamamelis virginianum	2	-	-	-	8	2	-	-	-	-	-	-

			CONSTANCY					AVERAGE FREQUENCY				
			D	DM	M	WM	W	D	DM	M	WM	W
Botrychium dissectum forma obliquum	4	-	-	-	8	7	-	-	-	-	-	-
Amelanchier weigandii	1	-	-	-	4	2	-	-	-	-	-	-
Poa languida	1	-	-	-	4	2	-	-	-	-	-	-
Oxalis montana	1	-	-	-	4	2	-	-	-	-	-	-
Staphylea trifoliata	2	-	-	-	4	4	-	-	-	-	-	-
Viola selkirkii	4	-	-	-	4	9	-	-	-	-	-	-
Carex radiata	3	-	-	-	4	4	4	-	-	-	-	-
Carex trisperma	3	-	-	-	4	4	4	-	-	-	-	-
Habenaria viridis	2	-	-	-	4	-	8	-	-	-	-	-
Acalypha rhomboidea	3	-	-	-	4	2	8	-	-	-	-	1
Echinocystis lobata	3	-	-	-	4	2	8	-	-	-	-	-
Viola pallens	4	-	-	-	4	7	8	-	-	-	1	-
Carex bromoides	4	1	-	-	4	7	8	-	-	-	-	3
Lactuca biennis	7	-	-	-	4	16	8	-	-	-	1	1
Ribes hirtellum	4	-	-	-	4	-	15	-	-	-	-	1
Carex tuckermanii	3	-	-	-	4	-	12	-	-	-	-	1
Cicuta maculata	10	1	-	-	4	11	31	-	-	-	1	2
Chelone glabra	15	1	-	-	4	18	16	-	-	-	-	3
Dryopteris cristata	17	1	-	-	4	24	46	-	-	-	1	1
Osmunda regalis	30	2	-	-	4	49	73	-	-	-	4	4
Orchis spectabilis	2	-	-	-	8	-	4	-	-	-	-	-
Cystopteris fragilis	3	-	-	-	8	-	8	-	-	-	-	-
Carex projecta	11	-	-	-	8	18	31	-	-	-	-	-
Carex tenera	4	-	-	-	12	-	8	-	-	-	-	-
Equisetum arvense	26	4	-	-	12	40	62	-	-	-	5	10
Glyceria striata	27	2	-	-	23	33	65	-	-	-	2	7
Impatiens capensis	32	8	-	-	42	38	69	-	-	4	13	19
Carex pallescens var. neogaea	1	-	-	-	-	2	-	-	-	-	-	-
Carex aurea	1	-	-	-	-	2	-	-	-	-	-	-
Panicum lanuginosum	1	-	-	-	-	2	-	-	-	-	-	-
Amelanchier bartramiana	1	-	-	-	-	2	-	-	-	-	-	-
Dryopteris hexagonoptera	1	-	-	-	-	2	-	-	-	-	-	-

			CONSTANCY					AVERAGE FREQUENCY				
			D	DM	M	WM	W	D	DM	M	WM	W
Aegopodium podograria	1	-	-	-	-	2	-	-	-	-	-	-
Arenaria lateriflora	1	-	-	-	-	2	-	-	-	-	-	-
Arabis divaricarpa	1	-	-	-	-	2	-	-	-	-	-	-
Epilobium leptophyllum	1	-	-	-	-	2	-	-	-	-	-	-
Epilobium angustifolium	1	-	-	-	-	2	-	-	-	-	-	-
Carex gracillescens	1	-	-	-	-	2	-	-	-	-	-	-
Carex granularis	1	-	-	-	-	2	-	-	-	-	-	-
Carex scabrata	1	-	-	-	-	2	-	-	-	-	-	-
Gentiana andrewsii	1	-	-	-	-	2	-	-	-	-	1	-
Gentiana lineare	1	-	-	-	-	2	-	-	-	-	-	-
Gerardia tenuifolia	1	-	-	-	-	2	-	-	-	-	-	-
Glyceria canadensis	1	-	-	-	-	2	-	-	-	-	-	-
Goodyera repens	1	-	-	-	-	2	-	-	-	-	1	-
Pyrus malus	1	-	-	-	-	2	-	-	-	-	-	-
Rhamnus frangula	1	-	-	-	-	2	-	-	-	-	-	-
Solidago gigantea	1	-	-	-	-	2	-	-	-	-	1	-
Tovara virginiana	1	-	-	-	-	2	-	-	-	-	-	-
Agrostis gigantea	1	-	-	-	-	2	-	-	-	-	-	-
Dentaria laciniata	1	-	-	-	-	2	-	-	-	-	-	-
Glyceria melicaria	1	-	-	-	-	2	-	-	-	-	-	-
Poa nemoralis	1	-	-	-	-	2	-	-	-	-	-	-
Potentilla simplex	1	-	-	-	-	2	-	-	-	-	-	-
Cardamine douglasii	1	-	-	-	-	2	-	-	-	-	-	-
Trifolium pratense	1	-	-	-	-	4	-	-	-	-	-	-
Carex amphibola var. turgida	1	-	-	-	-	4	-	-	-	-	-	-
Carex hirtifolia	1	-	-	-	-	4	-	-	-	-	-	-
Carex stricta	1	-	-	-	-	4	-	-	-	-	-	-
Cinna arundinacea	1	-	-	-	-	4	-	-	-	-	-	-
Solidago uliginosa	2	-	-	-	-	7	-	-	-	-	-	-
Panicum borealis	2	-	-	-	-	7	-	-	-	-	1	-
Liparis loesilii	2	-	-	-	-	7	-	-	-	-	-	-
xClaytonia virginica	2	-	-	-	-	8	-	-	-	-	1	-
Viola adunca	1	-	-	-	-	2	4	-	-	-	-	-

			CONSTANCY					AVERAGE FREQUENCY				
			D	DM	M	WM	W	D	DM	M	WM	W
Ambrosia artemisiifolia	2	-	-	-	-	2	4	-	-	-	-	-
Aster novae-angliae	1	-	-	-	-	2	4	-	-	-	-	-
Chamaedaphne calyculata	1	-	-	-	-	2	4	-	-	-	-	-
Erigeron annuus	1	-	-	-	-	2	4	-	-	-	-	-
Lonicera tartarica	1	-	-	-	-	2	4	-	-	-	-	-
Oenothera perennis	1	-	-	-	-	2	4	-	-	-	-	-
Myosotis laxa	1	-	-	-	-	2	4	-	-	-	-	-
Rudbeckia laciniata	1	-	-	-	-	2	4	-	-	-	-	-
Spiraea tomentosa	1	-	-	-	-	2	4	-	-	-	-	-
Carex typhina	1	-	-	-	-	2	4	-	-	-	-	-
Aster simplex	2	-	-	-	-	2	8	-	-	-	-	1
Poa alsodes	2	-	-	-	-	2	8	-	-	-	-	1
Veronica scutellata	2	-	-	-	-	2	8	-	-	-	-	-
Muhlenbergia mexicana	2	-	-	-	-	2	8	-	-	-	-	-
Carex grayii	2	-	-	-	-	2	8	-	-	-	-	-
Cirsium vulgare	3	-	-	-	-	2	12	-	-	-	-	-
Potentilla norvegica	3	-	-	-	-	2	12	-	-	-	-	-
Scutellaria epilobiifolia	3	-	-	-	-	2	12	-	-	-	-	-
Asclepias incarnata	3	-	-	-	-	2	12	-	-	-	-	-
Caltha palustris	3	-	-	-	-	2	12	-	-	-	-	-
Lythrum salicaria	4	-	-	-	-	2	15	-	-	-	-	2
Eupatorium perfoliatum	4	-	-	-	-	2	15	-	-	-	-	-
Carex lacustris	3	-	-	-	-	2	15	-	-	-	-	-
Sium suave	4	-	-	-	-	2	15	-	-	-	-	2
Eupatorium maculatum	5	-	-	-	-	2	23	-	-	-	-	1
Scutellaria lateriflora	8	1	-	-	-	2	42	-	-	-	-	3
Malaxis unifolia	2	-	-	-	-	4	4	-	-	-	-	-
Carex folliculata	2	-	-	-	-	4	4	-	-	-	-	-
Juncus effusus	2	-	-	-	-	4	4	-	-	-	-	-
Elymus virginicus	3	-	-	-	-	4	8	-	-	-	-	-
Geum macrophyllus	3	-	-	-	-	4	8	-	-	-	-	-
Ribes lacustre	3	-	-	-	-	4	8	-	-	-	-	-
Rhamnus alnifolia	3	-	-	-	-	4	8	-	-	-	-	-
Rubus occidentalis	3	-	-	-	-	4	8	-	-	-	-	-

			CONSTANCY					AVERAGE FREQUENCY				
			D	DM	M	WM	W	D	DM	M	WM	W
Dryopteris cristata var. clintoniana	3	-	-	-	-	4	8	-	-	-	-	-
Scirpus atrovirens	4	-	-	-	-	4	12	-	-	-	-	-
Agrostis palustris	2	-	-	-	-	4	12	-	-	-	-	-
Carex lupulina	4	-	-	-	-	4	15	-	-	-	-	2
Lycopus americanus	5	-	-	-	-	4	19	-	-	-	-	1
Lysimachia nummularia	5	1	-	-	-	4	19	-	-	-	2	3
Carex normalis	5	-	-	-	-	4	19	-	-	-	-	2
Smilacina stellata	3	-	-	-	-	7	4	-	-	-	-	-
Spiraea alba	4	-	-	-	-	7	12	-	-	-	-	-
Aster puniceus	6	1	-	-	-	7	19	-	-	-	1	1
Lysimachia thyrsiflora	8	-	-	-	-	7	31	-	-	-	-	2
Boehmeria cylindrica	12	3	-	-	-	7	54	-	-	-	1	12
Symplocarpus foetidus	4	2	-	-	-	9	4	-	-	-	5	1
Ribes glandulosum	6	-	-	-	-	9	19	-	-	-	-	1
Galium palustre	9	1	-	-	-	9	35	-	-	-	-	3
Lysimachia ciliata	7	-	-	-	-	11	19	-	-	-	1	1
Carex crinita	11	-	-	-	-	18	35	-	-	-	1	1
Alnus rugosa	15	1	-	-	-	18	54	-	-	-	1	4
Thalictrum polygamum	14	1	-	-	-	20	42	-	-	-	1	6
Cornus stolonifera	20	2	-	-	-	20	73	-	-	-	1	6
Dryopteris thelypteris	22	1	-	-	-	31	65	-	-	-	2	5
Iris versicolor	23	-	-	-	-	31	73	-	-	-	-	2
Lycopus uniflorus	27	4	-	-	-	42	77	-	-	-	5	12
Agropyron repens	1	-	-	-	-	-	4	-	-	-	-	-
Anemone canadensis	1	-	-	-	-	-	4	-	-	-	-	-
Actaea rubra f. neglecta	1	-	-	-	-	-	4	-	-	-	-	-
Berberis thurnbergii	1	-	-	-	-	-	4	-	-	-	-	-
Bidens vulgatum	1	-	-	-	-	-	4	-	-	-	-	-
Chrysosplenium americanum	1	-	-	-	-	-	4	-	-	-	-	1
Cichorium intybus	1	-	-	-	-	-	4	-	-	-	-	-
Cardamine bulbosum	1	-	-	-	-	-	4	-	-	-	-	-
Sedum purpureum	1	-	-	-	-	-	4	-	-	-	-	-
Dulichium arundinaceum	1	-	-	-	-	-	4	-	-	-	-	-

			CONSTANCY					AVERAGE FREQUENCY				
			D	DM	M	WM	W	D	DM	M	WM	W
Elymus canadensis	1	-	-	-	-	-	4	-	-	-	-	-
Equisetum fluviatile	1	-	-	-	-	-	4	-	-	-	-	-
Heracleum lanatum	1	-	-	-	-	-	4	-	-	-	-	-
Hypericum ellipticum	1	-	-	-	-	-	4	-	-	-	-	-
Lemna trisulca	1	-	-	-	-	-	4	-	-	-	-	1
Lycopus europeus	1	-	-	-	-	-	4	-	-	-	-	-
Lychnis flos-inculi	1	-	-	-	-	-	4	-	-	-	-	-
Melilotus alba	1	-	-	-	-	-	4	-	-	-	-	1
Mimulus ringens	1	-	-	-	-	-	4	-	-	-	-	-
Phalaris arundinacea	1	-	-	-	-	-	4	-	-	-	-	-
Phragmitis communis	1	-	-	-	-	-	4	-	-	-	-	1
Physostegia virginana	1	-	-	-	-	-	4	-	-	-	-	-
Polygamum arifolium	1	-	-	-	-	-	4	-	-	-	-	-
Ranunculus flabellaris	1	-	-	-	-	-	4	-	-	-	-	1
Ranunculus septentrionalis	1	-	-	-	-	-	4	-	-	-	-	-
Rumex orbiculatus	1	-	-	-	-	-	4	-	-	-	-	-
Rumex verticillatus	1	-	-	-	-	-	4	-	-	-	-	-
Selaginella apoda	1	-	-	-	-	-	4	-	-	-	-	-
Solidago nemoralis	1	-	-	-	-	-	4	-	-	-	-	-
Sonchus arvensis	1	-	-	-	-	-	4	-	-	-	-	-
Stachys palustris	1	-	-	-	-	-	4	-	-	-	-	-
Stellaria longifolia	1	-	-	-	-	-	4	-	-	-	-	-
Veratrum viride	1	-	-	-	-	-	4	-	-	-	-	-
Viola septentrionalis x V. cucullata	1	-	-	-	-	-	4	-	-	-	-	1
Carex comosa	1	-	-	-	-	-	4	-	-	-	-	-
Carex canescens	1	-	-	-	-	-	4	-	-	-	-	-
Carex pseudocyperus	1	-	-	-	-	-	4	-	-	-	-	-
Carex retrorsa	1	-	-	-	-	-	8	-	-	-	-	1
Carex tribuloides	1	-	-	-	-	-	8	-	-	-	-	-
Carex vesicaria	1	-	-	-	-	-	8	-	-	-	-	-
Cirsium arvense	1	-	-	-	-	-	8	-	-	-	-	-
Eleocharis obtusa	1	-	-	-	-	-	8	-	-	-	-	-
Cuscuta gronovii	1	-	-	-	-	-	8	-	-	-	-	-

			CONSTANCY					AVERAGE FREQUENCY				
			D	DM	M	WM	W	D	DM	M	WM	W
Glecoma hederacea	1	-	-	-	-	-	8	-	-	-	-	-
Lobelia cardinalis	1	-	-	-	-	-	8	-	-	-	-	-
Penthorum sedioides	1	-	-	-	-	-	8	-	-	-	-	-
Potentilla anserina	1	-	-	-	-	-	8	-	-	-	-	1
Rumes obtusifolius	1	-	-	-	-	-	8	-	-	-	-	-
Sagittaria latifolia	1	-	-	-	-	-	8	-	-	-	-	-
Typha latifolia	1	-	-	-	-	-	8	-	-	-	-	2
Scirpus pedicellatus	1	-	-	-	-	-	8	-	-	-	-	-
Solidago juncea	1	-	-	-	-	-	8	-	-	-	-	1
Typha angustifolia	1	-	-	-	-	-	8	-	-	-	-	-
Sparganium eurycarpum	1	-	-	-	-	-	8	-	-	-	-	-
Cardamine pensylvanica	1	-	-	-	-	-	8	-	-	-	-	1
Calla palustris	2	-	-	-	-	-	12	-	-	-	-	-
Galium asprellum	2	-	-	-	-	-	12	-	-	-	-	1
Habenaria psycodes	2	-	-	-	-	-	12	-	-	-	-	-
Hypericum virginicum	2	-	-	-	-	-	12	-	-	-	-	-
Geum allepicum	3	-	-	-	-	-	15	-	-	-	-	1
Lemna minor	3	1	-	-	-	-	15	-	-	-	-	7
Cephalanthus occidentalis	4	-	-	-	-	-	19	-	-	-	-	-
Cicuta bulbifera	4	-	-	-	-	-	19	-	-	-	-	1
Geum rivale	4	-	-	-	-	-	19	-	-	-	-	-
Leersia oryzoides	4	-	-	-	-	-	19	-	-	-	-	1
Lysimachia terrestris	4	-	-	-	-	-	19	-	-	-	-	2
Alisma triviale	4	-	-	-	-	-	23	-	-	-	-	1
Galium obtusum	4	1	-	-	-	-	23	-	-	-	-	6
Pilea pumila	5	1	-	-	-	-	27	-	-	-	-	4
Bidens frondosa	6	1	-	-	-	-	31	-	-	-	-	5
Mentha arvensis	6	-	-	-	-	-	35	-	-	-	-	1

x Values based on a sample of spring flora in 85 of the 141 stands.

Moisture Gradient Analysis:

As was shown for the arboreal elements, soil moisture is of importance in determining the composition and distribution of forest trees. Although much more influenced by microenvironment and local topographic variations than trees, the understory elements are to a degree also influenced by general stand soil moisture conditions.

The same stand moisture designations were used as a basis for determining the relationships of the 516 herbs and shrubs found in the 141 stands. Table 9 presents overall constancy, overall average frequency, and constancy and average frequency values along the moisture gradient for all understory components. The table has been organized to facilitate an understanding of the ecology of herbs and shrubs along the moisture gradient by ordering plants attaining ecological optima at the dry end of the moisture gradient, passing to plants with very broad amplitudes of tolerance and finally ending with those plants ecologically predominant at the wet end of the gradient. It can be seen that there is every combination of possible representation evident representing considerable variation in ecological representation. The representations of the 516 herbs and shrubs in the dry, dry-mesic, mesic, wet-mesic and wet segments are 185, 263, 227, 337 and 327 species respectively, indicating greatest representation in the wet-mesic. The high number of species within the wet segment includes 105 or 30% occurring in only one stand. Representation of plants occurring only once in a segment: in the dry it is 96 (52%), the dry-mesic 77 (29%), the mesic 99 (42%) and the wet-mesic 89 (27%). On the other hand, very few species have constancy values over 50. Within the 5 segments, in order from dry to wet, 14 (8%), 10 (4%), 26 (11%), 17 (6%), and 25 (8%) occur with a constancy greater than 50, respectively.

If the average number of species per stand per moisture segment is calculated, one obtains the number of prevalent species of that segment; Within the dry, dry-mesic, mesic, wet-mesic, and wet segments there are 33, 45, 51, 53 and 56 prevalent species respectively. Within each segment these include those prevalent species mentioned above and include 31, 32, 32, 35 and 31 levels of constancy respectively. The 117 prevalent species of all moisture segments in decreasing order of constancy are arranged in Table 10. This gives a clearer picture of the ecological importance of these major understory components across the whole moisture gradient. It is somewhat deficient in that it does not include certain high values of these species in other segments which would indicate their broader ecological amplitude. Those species having average frequencies of 5 or more are also included in Table 10.

In addition to the spring vernals, the families Liliaceae, Gramineae and Compositae and the genera Carex and Viola which will be discussed later, selections have been made from the large number of additional species, and their patterns along the moisture gradient have been presented graphically.

Table 10:

The constancy values of 117 prevalent herbs and shrubs, as well as average frequency for those species with a value of 5 or more, for all moisture segments.

THE CONSTANCY VALUES OF 117 PREVALENT HERBS AND SHRUBS, AS WELL AS AVERAGE FREQUENCY FOR THOSE SPECIES WITH A VALUE OF 5 OR MORE, FOR ALL MOISTURE SEGMENTS

	CONSTANCY					AVERAGE FREQUENCY				
	D	DM	M	WM	W	D	DM	M	WM	W
Diervilla lonicera	85	-	-	-	-	11	-	-	-	-
Gaultheria procumbens	77	-	-	-	-	32	-	-	-	-
Cypripedium acaule	69	-	-	-	-	-	-	-	-	-
Chimaphila umbellata	62	-	-	-	-	-	-	-	-	-
Aster macrophyllus	54	-	-	-	-	-	5	-	-	-
Vaccinium myrtilloides	54	-	-	-	-	26	-	-	-	-
Kalmia angustifolia	39	-	-	-	-	5	-	-	-	-
Lycopodium clavatum	39	-	-	-	-	-	-	-	-	-
Oryzopsis asperifolia	39	-	-	-	-	7	-	-	-	-
Monotropa uniflora	31	-	-	-	-	-	-	-	-	-
Vaccinium angustifolium	31	-	-	-	-	12	-	-	-	-
Linnaea borealis	31	-	-	-	-	-	-	-	-	-
Carex pensylvanica	62	42	-	-	-	19	9	-	-	-
Lonicera canadensis	31	48	-	-	-	-	-	-	-	-
Corylus cornuta	54	45	46	-	-	11	5	-	-	-
Dryopteris marginalis	31	42	50	-	-	-	-	-	-	-
Smilacina racemosa	31	58	96	-	-	-	-	11	-	-
Pteridium aquilinum	85	48	-	42	-	28	6	-	5	-
Aster acuminatus	31	32	35	33	-	-	-	-	-	-
Mitchella repens	39	52	-	42	-	8	-	-	-	-
Clintonia borealis	39	42	-	60	-	-	-	-	-	-
Lycopodium obscurum	39	32	35	56	-	-	-	-	8	-
Cornus canadensis	39	-	-	42	-	-	-	-	7	-
Viburnum cassinoides	39	-	-	49	-	-	-	-	8	7
Carex arctata	39	45	54	42	-	-	-	-	-	-
Polygonatum pubescens	54	81	89	36	-	-	10	13	-	-
Maianthemum canadense	100	77	73	91	65	57	29	19	45	17
Aralia nudicaulis	77	71	69	76	54	18	10	8	12	9

	CONSTANCY					AVERAGE FREQUENCY				
	D	DM	M	WM	W	D	DM	M	WM	W
Trientalis borealis	62	45	-	64	46	20	12	-	13	7
Prunus virginiana	54	81	96	64	54	10	10	9	8	-
Dryopteris intermedia	31	61	85	69	39	-	5	7	13	-
Rhus radicans	39	-	-	44	50	11	-	-	9	-
Fragaria virginiana	39	-	-	47	54	-	7	-	7	7
Lycopodium complanatum	-	32	-	-	-	-	-	-	-	-
Osmorhiza claytoni	-	48	58	-	-	-	7	11	-	-
Trillium grandiflorum	-	48	77	-	-	-	9	25	-	-
Carex pedunculata	-	48	77	-	-	-	16	11	-	-
Solidago flexicaulis	-	45	54	-	-	-	7	-	-	-
Asarum canadense	-	42	54	-	-	-	-	6	-	-
Prenanthes altissima	-	39	73	-	-	-	-	8	5	-
Uvularia grandiflora	-	36	65	-	-	7	-	11	-	-
Viola pensylvanica	-	36	69	-	-	-	6	10	5	-
xDicentra canadensis	-	30	88	-	-	-	5	13	-	-
xErythronium americanum	-	65	94	54	-	15	39	64	18	-
Taxus canadensis	-	55	40	38	-	-	5	-	-	-
Cornus alternifolia	-	45	73	40	-	-	-	-	-	-
Trillium erectum	-	45	100	42	-	-	-	16	-	-
Tiarella cordifolia	-	39	54	36	-	-	-	9	6	-
Streptopus roseus	-	36	38	36	-	-	-	-	-	-
Lycopodium lucidulum	-	36	-	36	-	-	-	-	-	-
Epipactis helleborine	-	32	46	22	-	-	-	-	-	-
Botrychium virginianum	-	32	73	18	-	-	-	-	-	-
Pyrola elliptica	-	32	-	44	-	6	-	-	5	-
Medeola virginiana	-	32	-	51	-	-	-	-	-	-
Ribes cynosbati	-	52	73	40	35	-	-	-	-	-
Sambucus pubens	-	42	54	-	31	-	-	-	-	-
Actaea rubra	-	42	54	-	35	-	-	-	-	-
Acer spicatum	-	36	-	-	31	-	-	-	-	-
Carex rosea	-	36	46	47	39	-	-	-	6	-
Galium triflorum	-	45	50	44	54	-	-	-	6	8

	CONSTANCY					AVERAGE FREQUENCY				
	D	DM	M	WM	W	D	DM	M	WM	W
Dryopteris spinulosa	-	42	38	58	62	-	-	-	7	-
Rubus idaeus	-	39	-	-	58	-	-	-	5	-
Athyrium filix-femina	-	36	81	82	73	-	-	-	11	11
xClaytonia caroliniana	-	-	71	-	-	-	8	15	-	-
Caulophyllum thalictroides	-	-	69	-	-	-	-	11	-	-
Polystichum acrostichoides	-	-	46	-	-	-	-	-	-	-
Carex gracillima	-	-	42	-	-	-	-	-	-	-
Viola canadensis	-	-	46	-	-	-	-	7	-	-
Dentaria diphylla	-	-	42	-	-	-	-	-	-	-
Carex plantaginea	-	-	42	-	-	-	-	-	-	-
Hydrophyllum virginianum	-	-	38	-	-	-	8	12	-	-
Panax trifolius	-	-	35	-	-	-	-	-	-	-
Mitella diphylla	-	36	38	-	-	-	-	-	-	-
Hepatica acutiloba	-	36	46	-	-	-	6	8	-	-
Actaea pachypoda	-	36	58	-	-	-	-	-	-	-
Circaea quadrisulcata	-	-	58	40	31	-	-	-	6	-
Carex intumescens	-	-	46	42	35	-	-	-	-	-
Parthenocissus quinquefolia	-	-	42	-	58	-	-	-	-	7
Arisaema atrorubens	-	-	58	44	65	-	-	-	7	6
Onoclea sensibilis	-	-	46	84	96	-	-	-	18	43
Brachyeletrum erectum	-	-	38	42	-	-	-	-	-	-
Osmunda cinnamomea	-	-	-	60	42	-	-	-	19	7
Coptis groenlandicum	-	-	-	56	35	-	-	-	12	5
Viola incognita	-	-	-	56	50	-	-	-	13	7
Spiraea latifolia	-	-	-	33	39	-	-	-	7	-
Solidago rugosa	-	-	-	36	42	-	-	-	-	-
Aster lateriflorus	-	-	-	40	62	-	-	-	-	-
Impatiens capensis	-	-	-	38	69	-	-	-	13	19
Equisetum arvense	-	-	-	40	62	-	-	-	5	10
Lycopus uniflorus	-	-	-	42	77	-	-	-	5	12
Osmunda regalis	-	-	-	49	73	-	-	-	-	-
Rubus pubescens	-	-	-	62	65	-	-	-	15	22

	CONSTANCY					AVERAGE FREQUENCY				
	D	DM	M	WM	W	D	DM	M	WM	W
Calamogrostis canadensis	-	-	-	-	35	-	-	-	-	-
Mentha arvensis	-	-	-	-	35	-	-	-	-	-
Carex crinita	-	-	-	-	35	-	-	-	-	-
Carex stipata	-	-	-	-	35	-	-	-	-	-
Ranunculus abortivus	-	-	-	-	35	-	-	-	-	-
Ribes americanum	-	-	-	-	39	-	-	-	-	-
Viola cucullata	-	-	-	-	39	-	-	-	-	-
Sambucus canadensis	-	-	-	-	39	-	-	-	-	-
Geum canadense	-	-	-	-	39	-	-	-	-	-
Thalictrum polygamum	-	-	-	-	42	-	-	-	-	6
Solanum dulcamara	-	-	-	-	42	-	-	-	-	-
Taraxacum officinale	-	-	-	-	42	-	-	-	-	-
Scutellaria lateriflora	-	-	-	-	42	-	-	-	-	-
Dryopteris cristata	-	-	-	-	46	-	-	-	-	-
Viburnum lentago	-	-	-	-	46	-	-	-	-	-
Chelone glabra	-	-	-	-	46	-	-	-	-	-
Vitis riparia	-	-	-	-	54	-	-	-	-	6
Boehmeria cylindrica	-	-	-	-	54	-	-	-	-	12
Alnus rugosa	-	-	-	-	54	-	-	-	-	-
Glyceria striata	-	-	-	-	65	-	-	-	-	7
Dryopteris thelypteris	-	-	-	-	65	-	-	-	-	-
Ilex verticillata	-	-	-	-	65	-	-	-	-	6
Cornus stolonifera	-	-	-	-	73	-	-	-	-	-
Iris versicolor	-	-	-	-	73	-	-	-	-	-
Pyrus melanocarpa	-	-	-	-	-	10	-	-	-	-
Hieracium vulgatum	-	-	-	-	-	9	-	-	-	-
Polypodium virginianum	-	-	-	-	-	5	-	-	-	-
Poa pratensis	-	-	-	-	-	6	-	-	-	-
Danthonia spicata	-	-	-	-	-	6	-	-	-	-
Thalictrum dioicum	-	-	-	-	-	-	6	-	-	-

	CONSTANCY					AVERAGE FREQUENCY				
	D	DM	M	WM	W	D	DM	M	WM	W
xDicentra cucullaria	-	-	-	-	-	-	-	7	-	-
Rubus (raspberry)	-	-	-	-	-	-	-	-	5	-
Rubus hispidus	-	-	-	-	-	-	-	-	9	-
Laportea canadensis	-	-	-	-	-	-	-	-	-	6
Lemna minor	-	-	-	-	-	-	-	-	-	7

x Values based on a sample of spring flora in 85 of the 141 stands.

One hundred and ninety-nine species are restricted to one moisture segment; 27 to the dry, 25 to the dry-mesic, 12 to the mesic, 32 to the wet-mesic and 103 to the wet segment. Seventy-nine species have broad amplitudes of tolerance and are found across the entire moisture gradient. Figures 13 - 22 present the ecological distribution patterns of 73 herb and shrub species. Various species' relationships have been compared on the same graph in an effort to illustrate that two species of the same genus may be predominant in different ecological situations. As an example, species such as Uvularia grandiflora, Trillium erectum, Dryopteris spinulosa and Sambucus pubens are of greater ecological importance than their close relatives Uvularia sessilifolia, Trillium grandiflorum, Dryopteris cristata and Sambucus canadensis. Certain species, Maianthemum canadense, Aralia nudicaulis, Onoclea sensibilis and Prunus virginiana, which have high average frequency, have been graphed along the moisture gradient and constancy relationships are also shown. As mentioned by Maycock and Curtis (1960), herbs like Maianthemum canadense, which occur with wide ecological tolerance and at high levels of importance along the moisture gradient, have little indicator value with respect to sociological and environmental conditions.

Spring Ephemerals:

These herbs have a limited above-ground growing period at the beginning of the season. They are essentially sun-loving plants, and grow in the period before the trees leaf out and overshadow them. These plants thus pass through their life cycle quite rapidly and then, for the balance of the year, remain dormant in the form of underground bulbs, corms or tubers. The ephemerals present in the forests of the study region include Erythronium americanum, Dicentra canadensis, D. cucullaria, Claytonia caroliniana and C. virginica. Other spring plants respond in a somewhat similar manner as vernals. Allium tricoccum, Sanguinaria canadensis, Hepatica acutiloba and Panax trifolius are all spring plants which, in certain respects, can be considered to have ecological relations similar to the true ephemerals.

The latest date suitable for the recording of spring ephemerals, during the period of study, was June 12. This terminated a period of approximately two months from when Claytonia caroliniana and Erythronium americanum were collected in a sugar bush which still had a one-foot snow coverage. Corms of Dicentra canadensis and D. cucullaria and bublets of Erythronium americanum have been found later in the season and have been recorded on the presence lists. Of the 141 stands, 85 were checked for spring flora. Thirty-eight of these had no vernals present. Erythronium americanum has a constancy of 52 and is the eighth most prevalent species within the study region. Claytonia caroliniana, C. virginica, Dicentra canadensis and D. cucullaria have a constancy in 85 stands of 22, 2, 29 and 13 respectively. Allium tricoccum, Sanguinaria canadensis, Panax trifolius and Hepatica acutiloba have constancy values in 141 stands of 11, 18, 14 and 18 respectively.

Along the moisture gradient, vernals predominate in more mature stands on rich loam soils, dominated by Sugar Maple and of mesic soil moisture. Six of the 13 dry stands were checked for spring ephemerals. Erythronium americanum was the only vernal present in one stand an Allium tricoccum was also present in that stand. Twenty of 31 dry-mesic stands were checked and vernals were found in 12 stands. Erythronium americanum, Dicentra canadensis, D. cucullaria and Claytonia caroliniana have constancy values of 65, 30, 15, and 20 and average frequency values of 39, 5, 0, and 8 respectively. Nineteen of 28 mesic stands were checked at the beginning of the growing period and quantitative records for ephemerals were taken in 16 stands. Erythronium americanum, Dicentra canadensis, D. cucullaria and Claytonia caroliniana were present with constancy values of 94, 88, 29, and 71 and average frequency of 64, 13, 7, and 15 respectively. In three stands, corms were found as late as September 3. Of the 43 wet-mesic stands, 13 of 24 stands checked had spring species. Claytonia virginica, a rare southern plant, was found with a constancy of 8 and an average frequency of only 1. Erythronium americanum, Dicentra canadensis, D. cucullaria and Claytonia caroliniana have constancy values of 54, 15, 12, and 12 and average frequency of 18, 2, 2, and 1 respectively. Only Erythronium americanum was found in one stand of 15 of the 26 wet stands checked. Most of the wet sites were inundated throughout the spring period and into early summer. Figure 18 shows the distribution and importance along the moisture gradient of the spring ephemerals. All except Claytonia virginica attain ecological optima within mesic moisture conditions. The predominant spring flowering species shown with the vernals also attain optimum importance within the mesic segment, although *Uvularia grandiflora*, *U. sessilifolia*, *Trillium erectum*, *T. grandiflorum* and *Sanguinaria canadensis* have broader tolerance.

Liliaceae:

Most of the herbs in this family bloom in the spring, and some of its members have already been considered in the preceding section on spring ephemerals. The family is represented by 13 genera and 18 species, most of which are well distributed throughout the study region. Eight species are among the 49 prevalent species of all stands. These are *Maianthemum canadense* (80), *Polygonatum pubescens* (53), *Erythronium americanum* (52), *Trillium erectum* (46), *Clintonia borealis* (41), *Smilacina racemosa* (41), *Trillium grandiflorum* (35), and *Medeola virginiana* (30). Other important species are *Uvularia grandiflora* (28), *Trillium undulatum* (19), and *Uvularia sessilifolia* (18). Except for *Trillium cernuum*, *Trillium erectum* var. *viridiflorum*, *Smilax herbacea*, *Lilium michiganiense*, *Veratrum viride*, and *Smilacina stellata*, all species have broad amplitudes of tolerance and are of similar relative importance within all segments of the moisture gradient, and especially so within mesic and sub-mesic segments. Within the dry segment, 4 of the 13 species present were also prevalent. Within dry-mesic, mesic and wet-mesic segments, 10 of 17, 9 of 15 and 7 of 18 species present respectively were prevalent. *Maianthemum canadense* was the only one of 15 species present in the wet segment that was also prevalent. It was the only species to attain prevalence in all

5 segments and to occur with an average frequency of at least 5 across the moisture gradient. Eight species had average frequency values greater than 5 in at least one segment. The mesic segment had the highest number of species of greatest importance, with 7 of 13 species having higher frequency values there. These quantitative values not only provide precise information on the occurrence of specific plants but collectively emphasize the great ecological significance of members of this family in these forests.

Carex:

This genus is of interest due to the high species represented. Some of these have broad amplitudes of ecological tolerance; others are quite restricted or rare. The large numbers collected are representative of forest sedges within the study region and are of considerable taxonomic interest. Fifty-seven species of Carex were recorded present within the forests in which quantitative data were collected. Of these, Carex pedunculata, C. arctata and C. rosea were among the 49 prevalent species, with overall constancy values of 43, 42 and 39 respectively. Twenty-four species were only encountered once and 29 species had constancy values between 2 and 25. Carex intumescens had a constancy value of 29 and may be considered to be of decided ecological importance, along with the other 3 major species.

The distribution patterns of the different species of Carex are well illustrated in Figure 19. Only Carex backii and C. tonsa are restricted to the dry forest sites, while C. tetanica, C. umbellata, C. platyphylla, C. sparganioides, and C. sprengelii are restricted to dry-mesic stands. Carex laxiculmus and C. disperma are restricted to sites with mesic moisture conditions. In moister and extremely wet forest sites, rare occurrences of C. gracillescens, C. granularis, C. scabrata, C. hirtifolia, C. stricta and C. amphibola, and of C. retrorsa, C. tribuloides, C. vesicaria, C. comosa, C. canescens and C. pseudocyperus respectively were noted. Altogether 14, 25, 29, 35 and 32 species of Carex were found in the dry, dry-mesic, mesic, wet-mesic and wet forests of which 2, 4, 7, 3 and 4 respectively were prevalent species. This shows in effect that the wet lowland and bottomland stands have the richest sedge flora and that although fewer species did occur within the mesic segment, these occurred with greater importance than did the larger number of species which occurred sporadically within wet-mesic forests. Throughout the moisture gradient, 10 species were among the prevalent species in at least one segment.

Carex pensylvanica was among the prevalent species within the dry and dry-mesic forests with constancy values of 62 and 42 respectively, and with average frequency values of 18 and 9 respectively. Carex rosea was a prevalent species in the dry-mesic, mesic, wet-mesic and wet segments with constancy values of 36, 43, 47 and 39 respectively. Carex gracillima and C. deweyana were prevalent within the mesic segment with constancy values of 42 and 38 respectively. Carex pedunculata has constancy values of 48 and 77 within dry-mesic and mesic sites. Carex arctata within dry, dry-mesic and wet-mesic sites has constancy values of 39, 45, 54 and 42 respectively. These 2 latter species are also prevalent within those segments. These 6 species of Carex, and including Carex laxiflora, have broad amplitudes of tolerance across the whole moisture gradient. Other species attaining prevalence in various segments are Carex plantaginea (42 in mesic), C. intumescens (46, 42, 35 in mesic, wet-mesic and wet respectively), C. stipata (35 in wet) and C. crinita (35 in wet). Thirty-two species have average frequency values, but only Carex pensylvanica, C. rosea and C. pedunculata have values greater than 5.

Gramineae:

Twenty-four genera and 42 species of grasses were, with few exceptions, quite scattered throughout the forests studied and never occurred in significant levels. Of the 42 species, Brachyeletrum erectum was the most prevalent grass with a constancy of 30. Twenty-one species occurred in just one stand. Glyceria striata, Calamagrostis canadensis, Schizachne purpurascens, Poa pratensis, and Poa compressa are next in importance with constancy values of 27, 15, 10, 8, and 4 respectively. Analyzed for occurrence along the soil moisture gradient, there are 16, 15, 14, 26, and 22 grass species within dry, dry-mesic, mesic, wet-mesic, and wet segments respectively.

The grasses show an affinity for moist soil conditions. The stable nature of the mature sugar maple forests prevents them from attaining high levels of influence there. Only Oryzopsis racemosa and Brachyeletrum erectum have any importance values within the mesic segment with average frequency values of 2 and 1 respectively. No grasses are prevalent within the mesic forests. Oryzopsis asperifolia is prevalent on drier-site moisture conditions with a constancy of 39. Five species have quantitative values there, and of these Oryzopsis asperifolia and Danthonia spicata have average frequency values of 7 and 6 respectively. There are no prevalent grasses within the dry-mesic segment. Under moister conditions, Brachyeletrum erectum and Glyceria striata have constancy values of 44 and 65 in wet-mesic and wet segments respectively. Table lists constancy and average frequency values for all species. Dactylis glomerata, Panicum linearifolium, P. latifolia, P. tsugetorum and Phleum pratense are restricted to dry moisture conditions. Agrostis gigantea, Cinna arundinacea, Glyceria canadensis, Glyceria melicaria, Panicum boreale and Poa nemoralis occur on moister sites. Agropyron repens, Elymus canadensis, Leersia virginica, L. oryzoides, Phalaris arundinacea, Phragmites communis, and Sphenopholis intermedia thrive only under wet-soil moisture conditions.

Figure 20 presents the amplitudes of ecological tolerance of 8 grass species, including those attaining optima within restricted segments as well as those having broad amplitudes across the whole moisture gradient.

Compositae:

Of the 19 genera and 49 species of Compositae encountered, a greater majority are late-summer and fall flowering. Among spring bloomers are Taraxacum officinale, Antennaria spp. and Erigeron philadelphicus. Summer-flowering composites are Prenanthes spp., Lactuca biennis and L. canadensis. Most Solidago and Aster flower in late summer and fall. About 40 percent of the composites are represented in only one or two stands sampled within the study region. Prenanthes altissima and Aster lateriflorus are the most ubiquitous of the Compositae and have constancy values of 36 and 33 respectively. Of subsequent importance, though not prevalent, are Aster acuminatus, Taraxacum officinale, Solidago flexicaulis, S. rugosa and Aster cordifolius with constancy values of 27, 27, 26, 22 and 22 respectively.

Throughout the moisture series 19, 21, 18, 34 and 41 of 49 species of composites were encountered in dry, dry-mesic, mesic, wet-mesic and wet sites respectively. If considered from the point of view of numbers of species, composites have an affinity for moister habitats, although Solidago hispida, Solidago flexicaulis x S. caesia, and Hieracium vulgatum are restricted to drier habitats. Solidago gigantea and S. uliginosa are found where wetter soil conditions prevail. Nine species, of which Bidens frondosa and Solidago juncea are most significant, are restricted to wet sites. On the driest sites, Aster acuminatus and A. macrophyllus are prevalent with constancy values of 31 and 54 respectively, while Solidago hispida, Hieracium vulgatum, H. aurantiacum, Prenanthes alba, P. altissima and Taraxacum officinale attain values of 23, 15, 15, 23, 15 and 15 respectively. Within the dry-mesic segment Solidago flexicaulis, Prenanthes altissima and Aster acuminatus are prevalent with constancy values of 45, 39 and 32. Aster cordifolius, Taraxacum officinale, Aster macrophyllus and A. lateriflorus are also of importance.

On sites of mesic moisture conditions, only 18 species of Compositae were encountered and of these the more important and widespread were Prenanthes altissima and Solidago flexicaulis, both prevalent species with constancy values of 73 and 54 respectively. Aster acuminatus, A. lateriflorus, Prenanthes alba, and Erigeron strigosus also contribute to the understory cover. At the wet end of the gradient, Aster lateriflorus was prevalent and has constancy values of 40 and 62 in wet-mesic and wet sites respectively. Solidago rugosa is also important in contributing to the vegetational pattern of these sites. Aster acuminatus, Taraxacum officinale, Prenanthes altissima and Aster umbellatus have constancy values on wet-mesic sites of 33, 36, 31 and 31 respectively. On most of the wet sites, Bidens frondosa, Aster cordifolius, Eupatorium rugosum, Erigeron philadelphicus and Lactuca canadensis thrive well and achieve some importance with constancy values of 31, 27, 23, 23, and 23 respectively.

Thirty-three species have significant quantitative values. Only

5 however have average frequency over 5 percent. Hieracium vulgatum, with an affinity for the driest conditions, has a value of 9. Solidago flexicaulis and Aster macrophyllus have frequency values of 7 and 5 for dry-mesic sites. Prenanthes altissima attains an average frequency of 8 and 5 within mesic and wet-mesic segments. Bidens frondosa, restricted to the wettest conditions, has a frequency value of 5.

Figure 21 provides a visual record of some of the more representative composites, where some have adapted to specific moisture conditions and where others have wide preference of distribution along the soil moisture gradient.

Viola:

The genus Viola is second largest in number of represented species. Of the 18 present, Viola incognita and V. pensylvanica are the most widespread with constancy values of 39 and 31 respectively. Viola cucullata, V. canadensis, V. conspersa, V. pubescens, and V. sororia are also of significance in indicating environmental preferences even though they are of more restricted distribution.

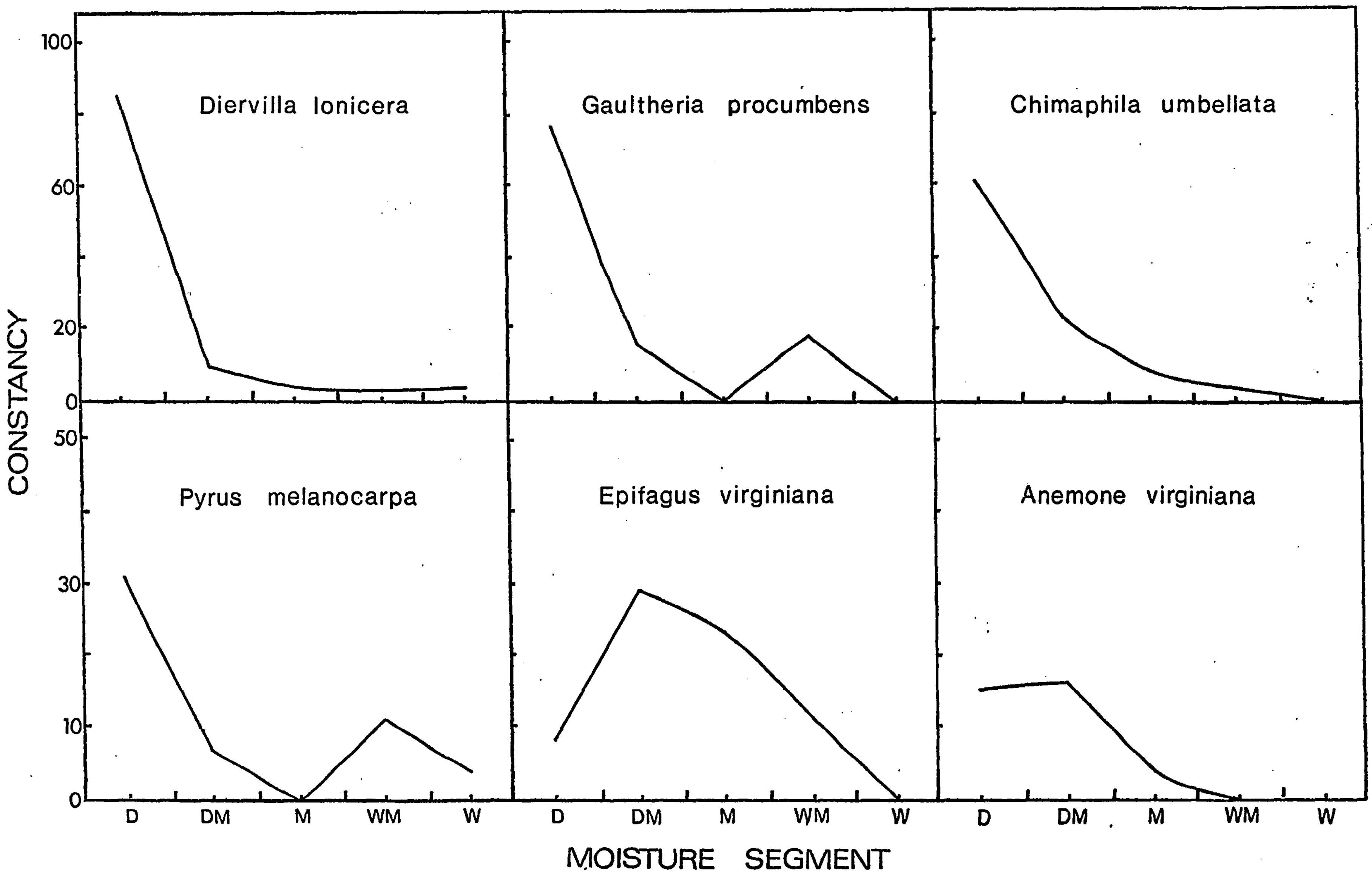
Along the moisture gradient 4, 14, 12, 15, and 14 species of Viola are present in dry, dry-mesic, mesic, wet-mesic and wet sites respectively. Only 4 species occur on the driest sites, and only Viola pensylvanica, V. incognita and V. canadensis are found with significant levels of importance within these conditions. These same species have constancy values of 36, 23, and 19 in dry-mesic sites and 69, 35, and 46 respectively under mesic conditions. Viola pensylvanica, V. incognita and V. cucullata are found with a constancy of 24, 56 and 16 respectively in wet-mesic sites, while under wet soil moisture conditions the latter are the more important species with constancy values of 50 and 39.

Although 16 species attain average frequency values within at least one specific soil moisture category, only Viola pensylvanica, V. canadensis and V. incognita are capable of attaining average frequency values of 5 or more. The former has frequency values of 6 and 10 in dry-mesic and mesic sites; Viola canadensis has an average frequency of 7 in mesic sites, while V. incognita attains frequency values of 13 and 7 in wet-mesic and wet sites.

Figure 22 presents the amplitudes of ecological tolerance of several species of the genus Viola.

Figure 13:

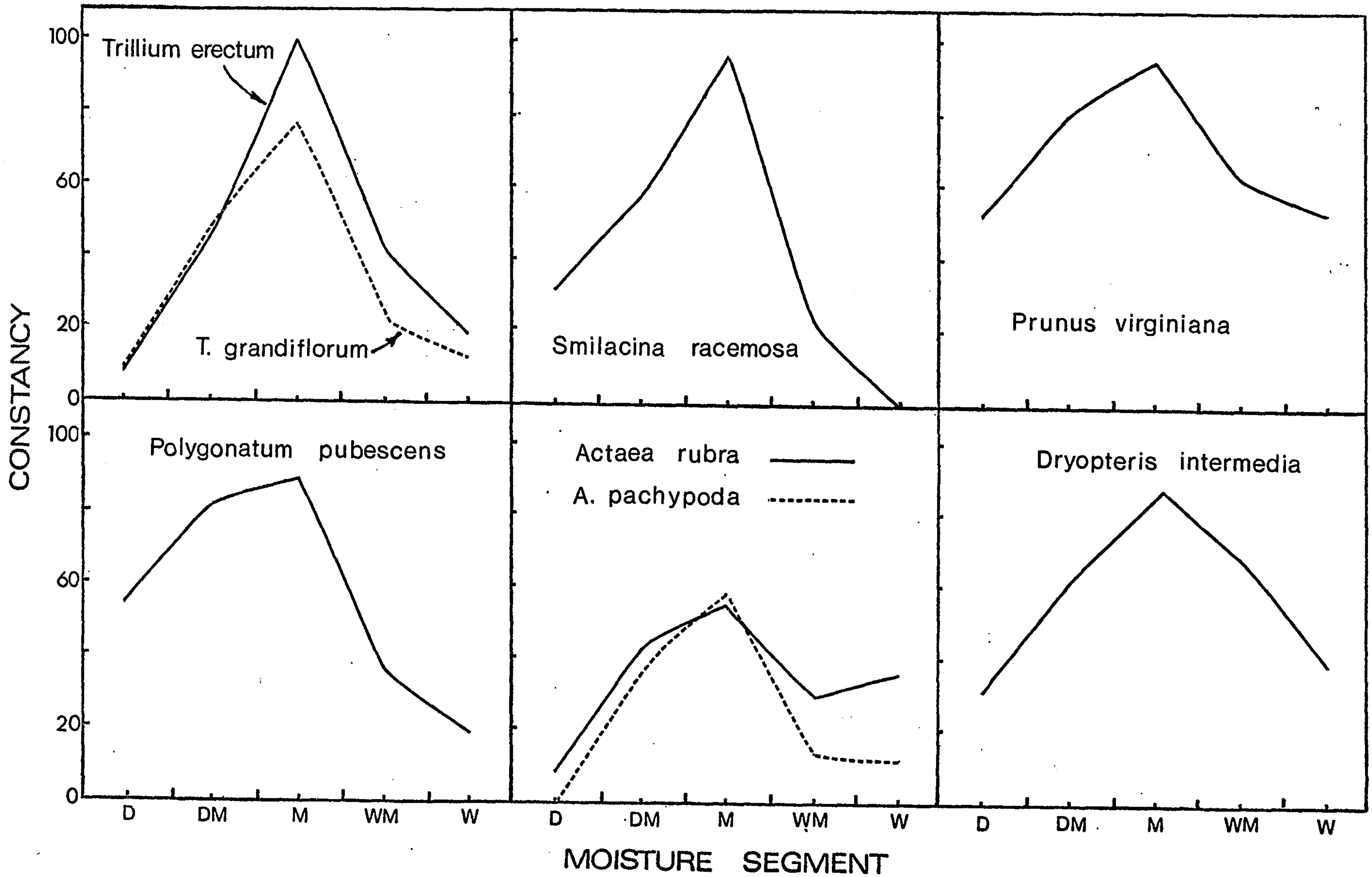
Shrub and herb species which attain optimum constancy values in the dry and dry-mesic segments of the moisture gradient.



Diervilla lonicera
Gaultheria procumbens
Chimaphila umbellata
Pyrus melanocarpa
Epifagus virginiana
Anemone virginiana
CONSTANCY
100
60
20
0
50
30
10
0
D
DM
M
WM
W
D
DM
M
WM
W
D
DM
M
WM
W
MOISTURE SEGMENT

Figure 14:

Shrub and herb species which attain optimum constancy values in the mesic segment of the moisture gradient.



CONSTANCY
100
60
20
0
Trillium erectum
T. grandiflorum
Smilacina racemosa
Prunus virginiana
Polygonatum pubescens
Actaea rubra
A. pachypoda
Dryopteris intermedia
D
DM
M
WM
W
MOISTURE SEGMENT

Figure 15:

Herb species which attain optimum constancy values in the wet-mesic or wet segments of the moisture gradient.

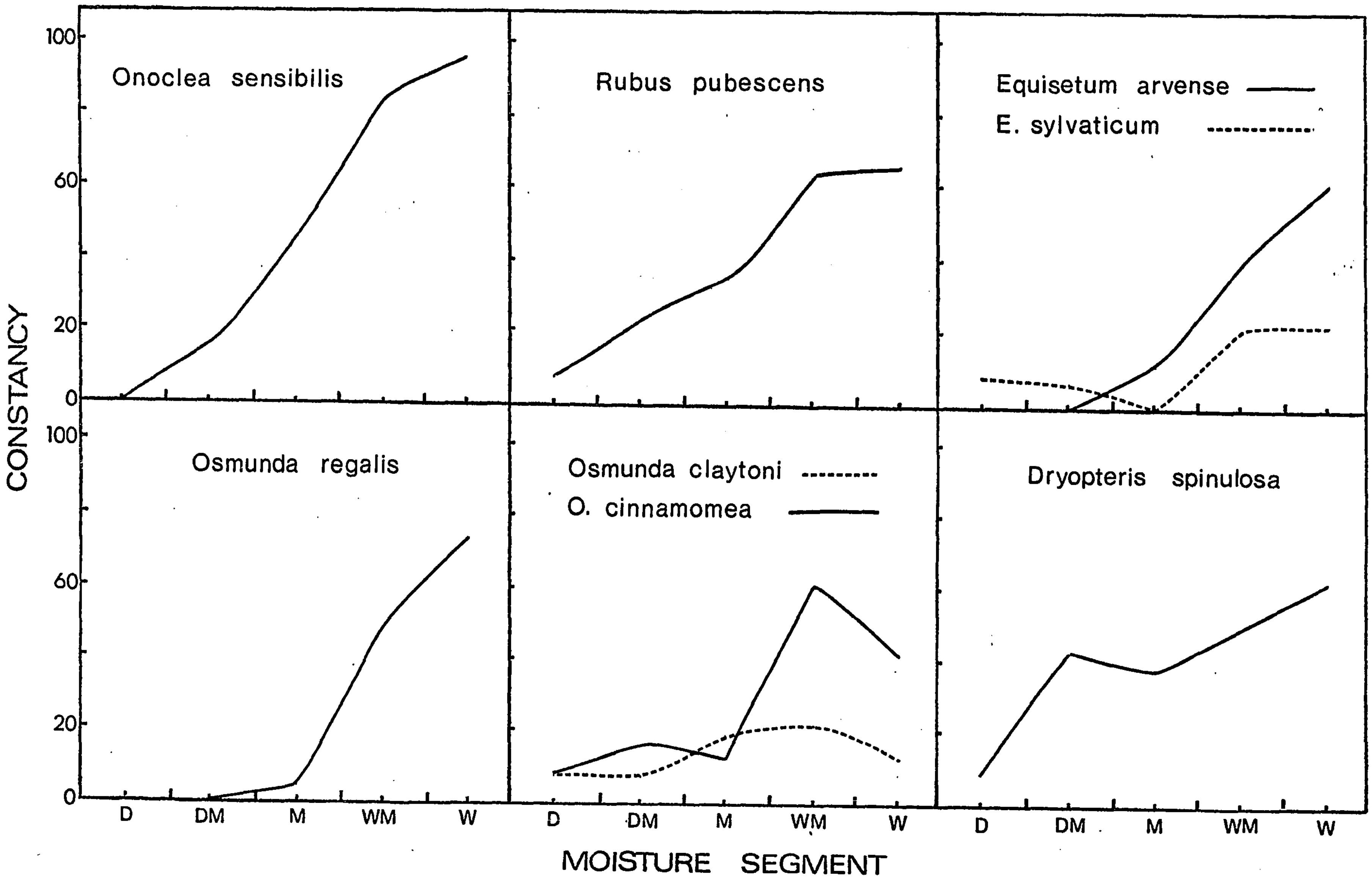
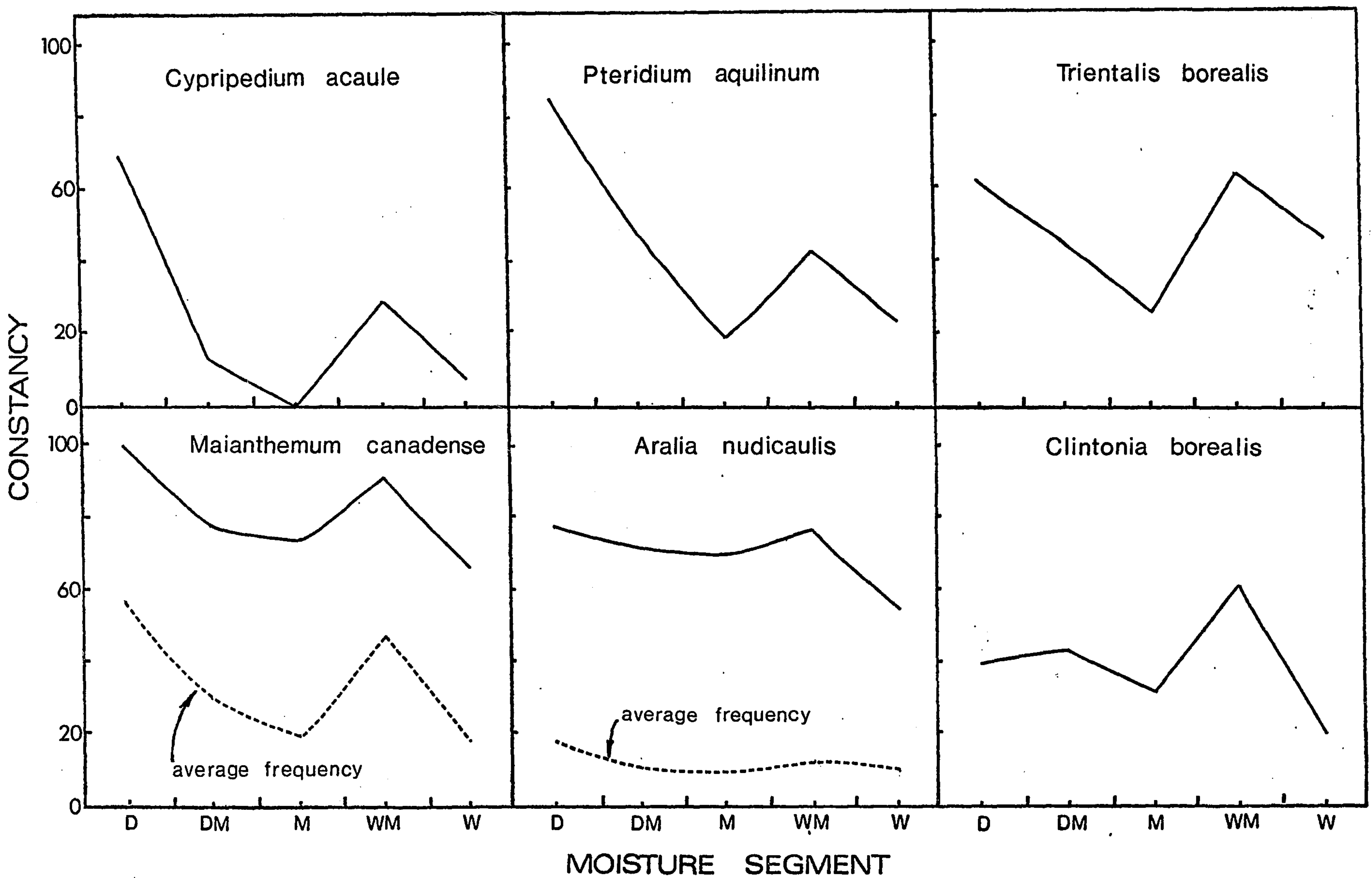

Onoclea sensibilis
Rubus pubescens
Equisetum arvense
E. sylvaticum
Osmunda regalis
Osmunda claytoni
O. cinnamomea
Dryopteris spinulosa
CONSTANCY
100
60
20
0
D
DM
M
WM
W
MOISTURE SEGMENT

Figure 16:

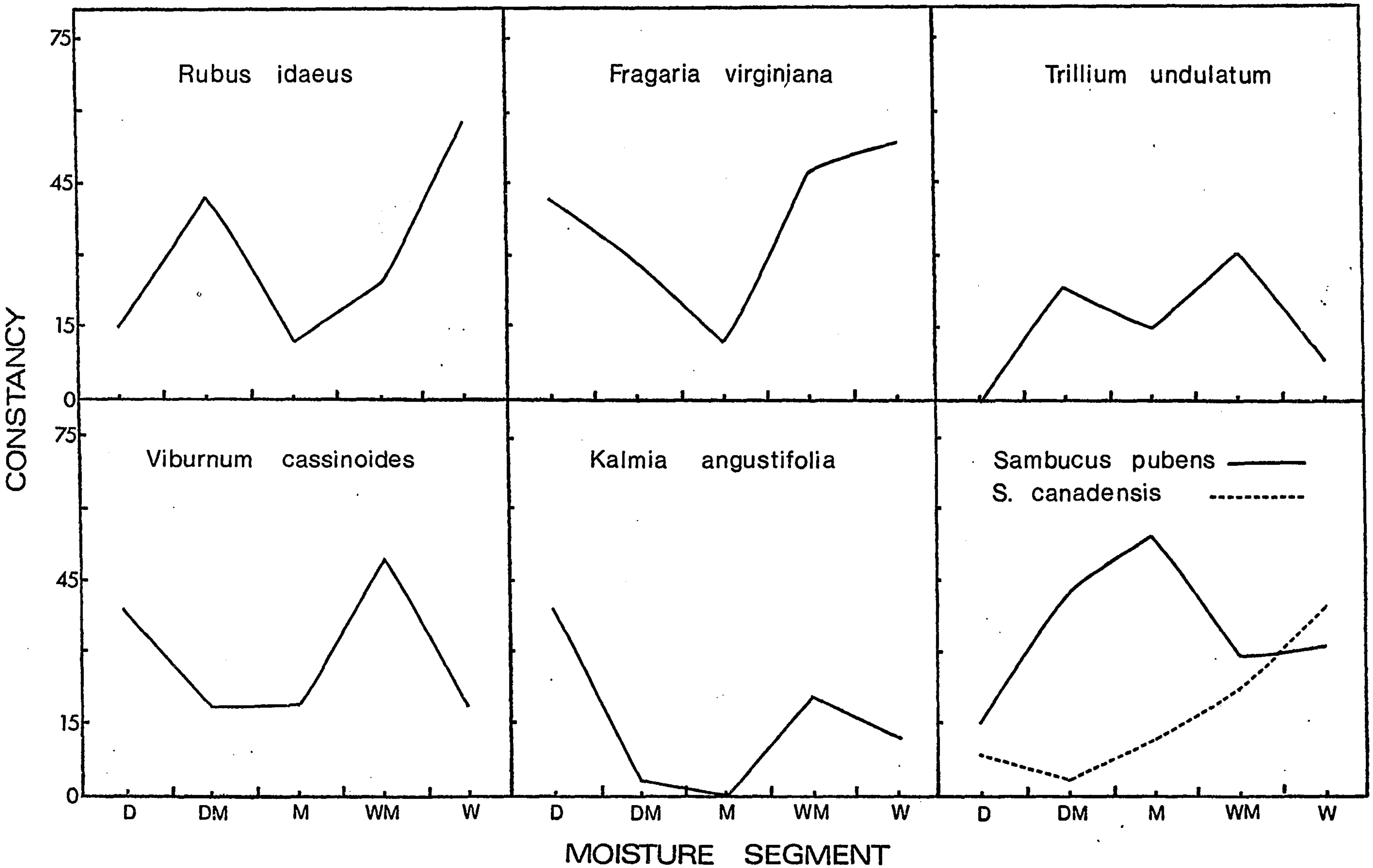
Graphs based on constancy values, showing various distribution patterns of herbs, particularly bimodal relationships, along the moisture gradient.



Cypripedium acaule
Pteridium aquilinum
Trientalis borealis
Maianthemum canadense
Aralia nudicaulis
Clintonia borealis
average frequency
average frequency
CONSTANCY
100
60
20
0
100
60
20
0
D
DM
M
WM
W
D
DM
M
WM
W
D
DM
M
WM
W
MOISTURE SEGMENT

Figure 17:

Graphs based on constancy values, showing various distribution patterns for herbs and shrubs, particularly bimodal relationships, along the moisture gradient.

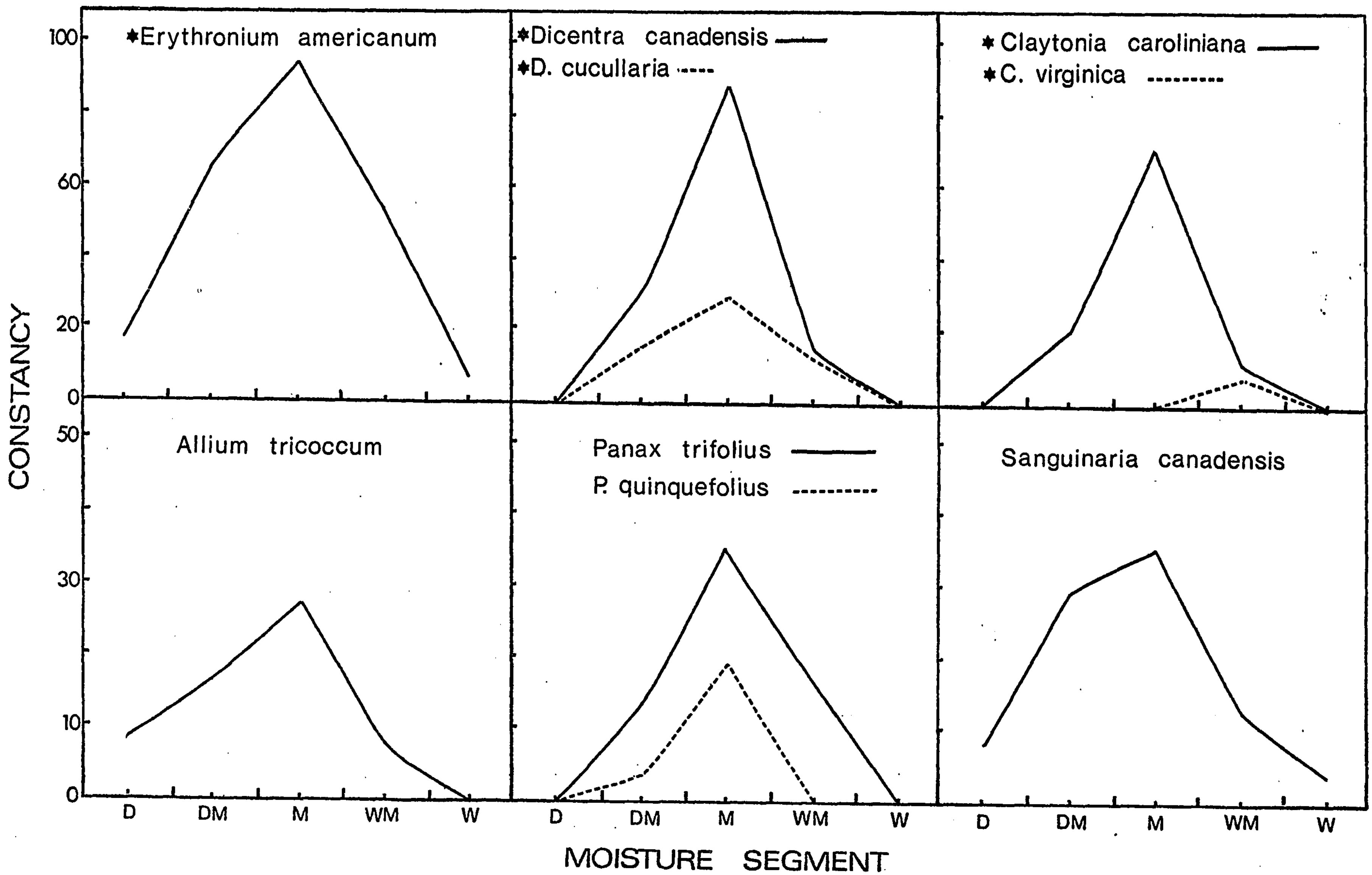


Rubus idaeus
Fragaria virginjana
Trillium undulatum
Viburnum cassinoides
Kalmia angustifolia
Sambucus pubens
S. canadensis
CONSTANCY
75
45
15
0
D
DM
M
WM
W
MOISTURE SEGMENT

Figure 18:

Graphs based on constancy of vernal herbs along the moisture gradient. The majority of such species attain optimum occurrence in mesic forests.

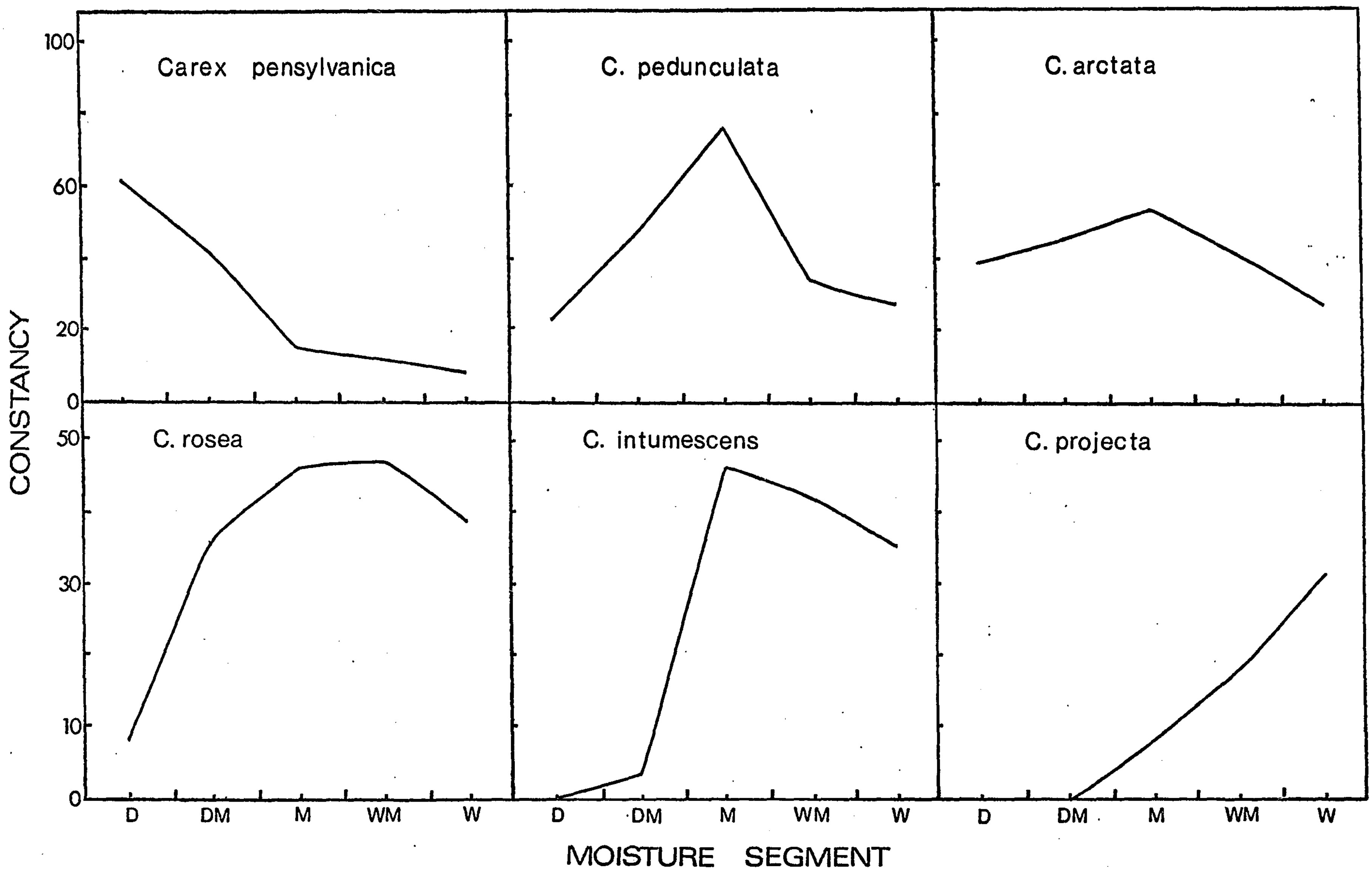
* Calculations based only on a sample of spring flora in 85 of 141 stands (see text)



*Erythronium americanum
*Dicentra canadensis
*D. cucullaria
*Claytonia caroliniana
*C. virginica
Allium tricoccum
Panax trifolius
P. quinquefolius
Sanguinaria canadensis
CONSTANCY
100
60
20
0
50
30
10
0
D
DM
M
WM
W
MOISTURE SEGMENT

Figure 19:

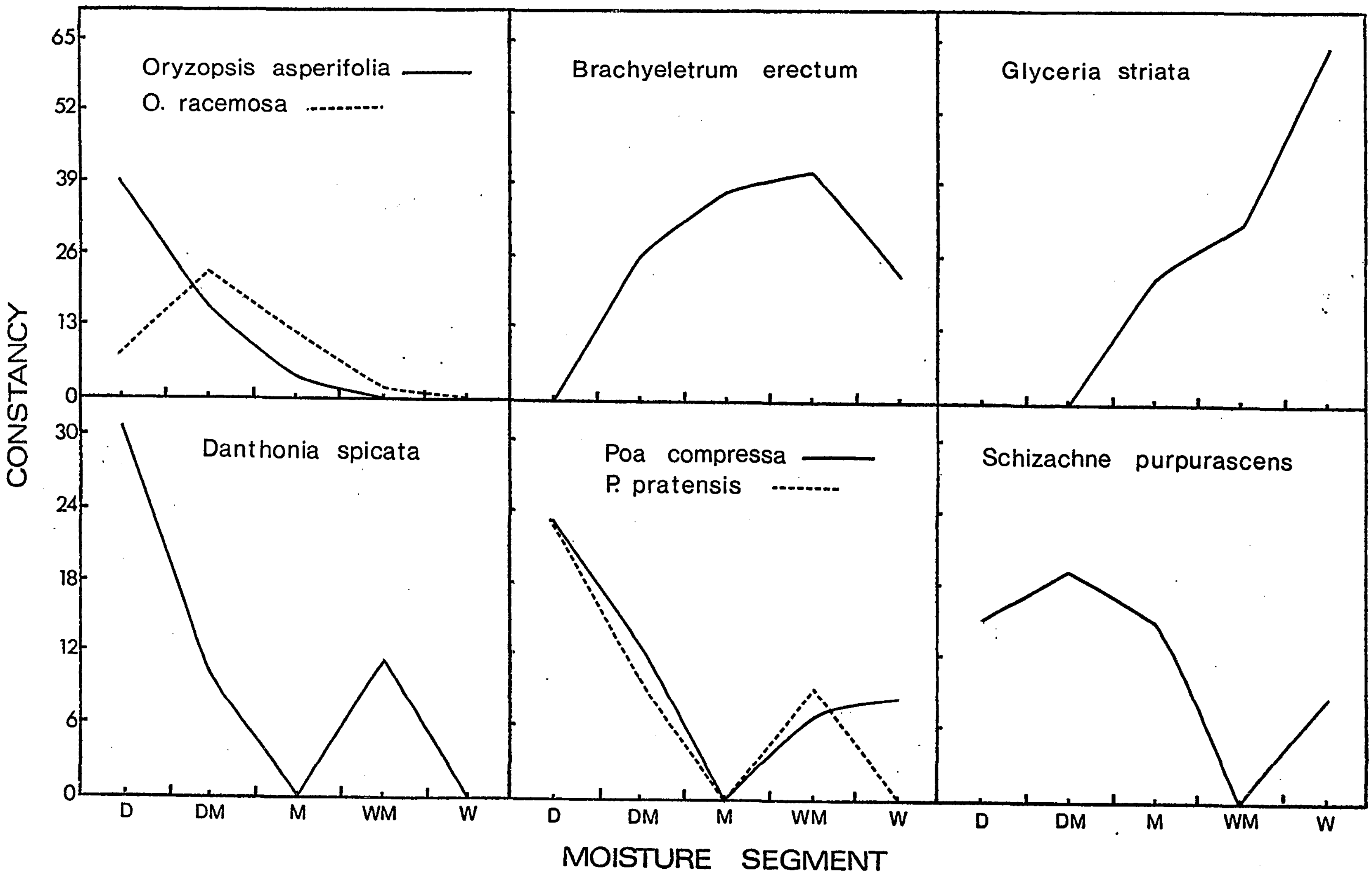
Constancy curves along the moisture gradient for 6 species of the genus *Carex*.



Carex pensylvanica
C. pedunculata
C. arctata
C. rosea
C. intumescens
C. projecta
CONSTANCY
100
60
20
0
50
30
10
0
D
DM
M
WM
W
MOISTURE SEGMENT

Figure 20:

Constancy curves along the moisture gradient for various species of the family Gramineae.



CONSTANCY
65
52
39
26
13
0
30
24
18
12
6
0
Oryzopsis asperifolia
O. racemosa
Brachyeletrum erectum
Glyceria striata
Danthonia spicata
Poa compressa
P. pratensis
Schizachne purpurascens
D
DM
M
WM
W
MOISTURE SEGMENT

Figure 21:

Constancy curves along the moisture gradient for various species of the family Compositae.

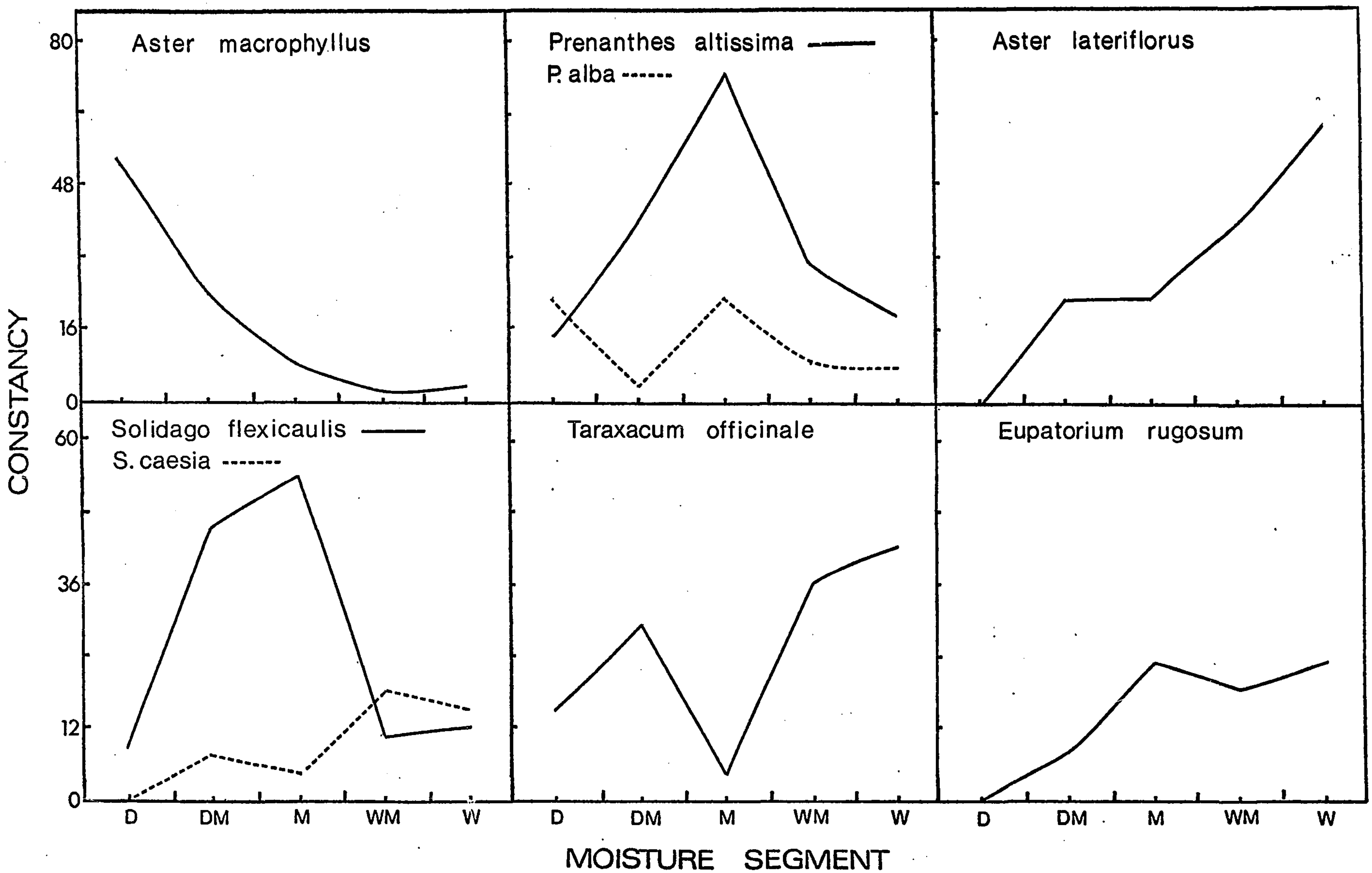
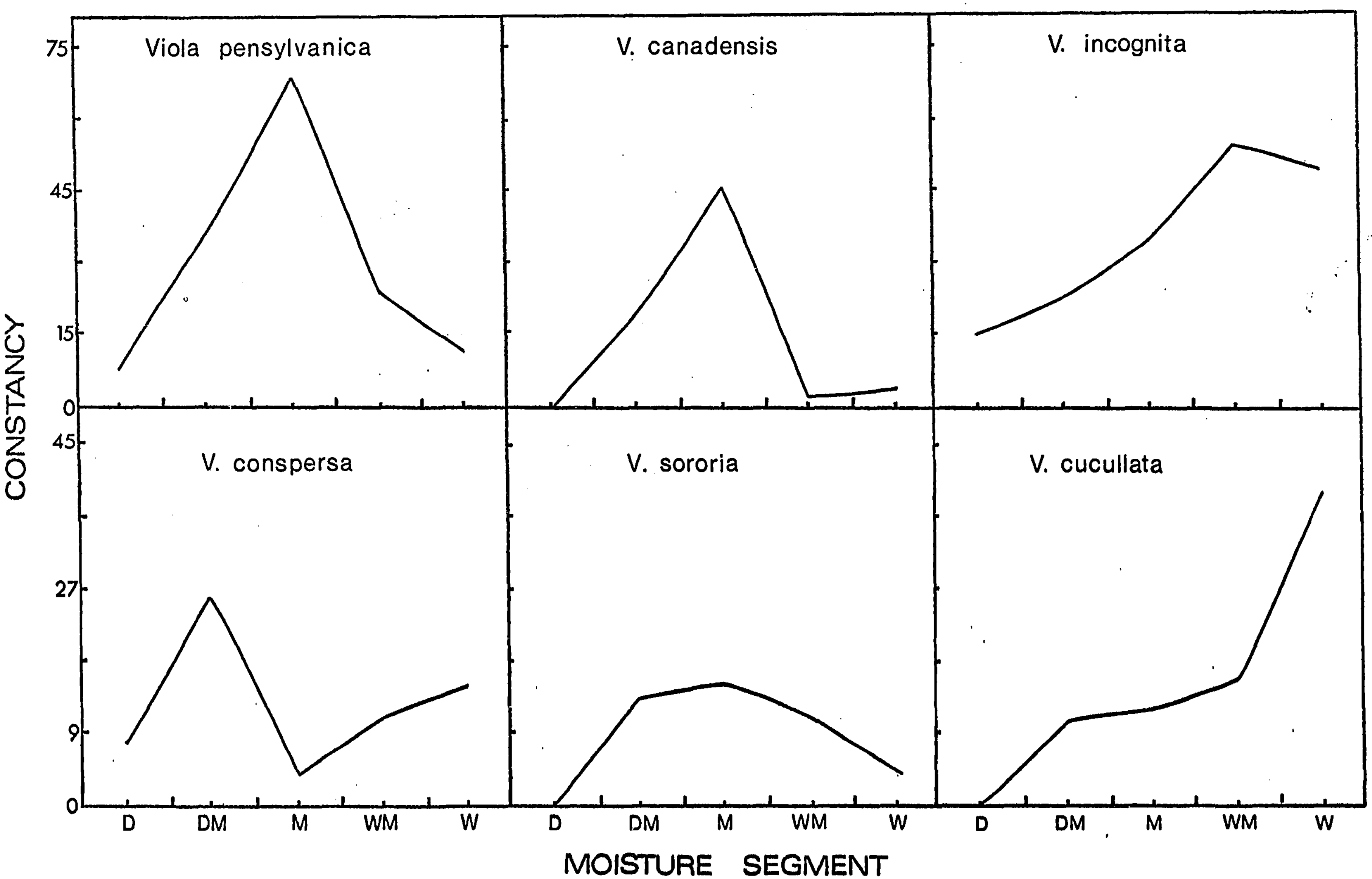

Aster macrophyllus
Prenanthes altissima
P. alba
Aster lateriflorus
Solidago flexicaulis
S. caesia
Taraxacum officinale
Eupatorium rugosum
CONSTANCY
80
48
16
0
60
36
12
0
D
DM
M
WM
W
D
DM
M
WM
W
D
DM
M
WM
W
MOISTURE SEGMENT

Figure 22:

Constancy curves along the moisture gradient for 6 species of the genus Viola.



Viola pensylvanica
V. canadensis
V. incognita
V. conspersa
V. sororia
V. cucullata
CONSTANCY
75
45
15
0
45
27
9
0
D
DM
M
WM
W
MOISTURE SEGMENT

SUMMARY OF ENVIRONMENTAL RELATIONSHIPS

Table 11 presents a summary of the analysis of samples of the A_1 soil layer collected in 113 stands. Certain significant trends are indicated in the various moisture categories. Variation between individual stands in a specific moisture segment may be considerable and provide an indication of the influences which other environmental factors or processes may have in effecting changes in soil conditions. Each stand is affected to a different degree by such factors as leaching, erosion, slope run-off, accumulation of plant and animal detritus, etc.

The values for average water retaining capacities (WRC) are relatively high for all segments. There are apparent differences between drier and wetter stands, with the dry and dry-mesic stands averaging 225 whereas the average for stands in the wet-mesic and wet is 248. There is an apparent discrepancy between the mesic stands which appear to have consistently lower average water retaining capacities. The only explanation for this situation is in terms of the problems associated with collecting samples of A_1 in the field. In drier stands the A_1 layer is very thin and it is extremely difficult to obtain mineral soil without adulteration by the adjacent humus layer. On the other hand, mesic stands have deep A_1 layers and the humus can be easily cleared and mineral samples can be cleanly taken. Thus, water-retaining capacity values and their influence on soil moisture must be carefully considered in terms of the depth of overlying humus. An interesting situation exists between lowland and bottomland stands. The lowland forests have an average WRC value of 339 (12 stands), with a range varying from 119 to 584 percent. Bottomland forests, on the other hand, have a much lower average of 110 percent (10 stands), with a range of 63-170 percent. This would indicate greater accumulation of organic matter in lowland stands and probably a more rapid turnover in the bottomlands.

The pH values show only slight trends along the moisture gradient. Individual variations are more noteworthy. For 113 stands, pH ranges from 4.0 to 7.3 with averages of 4.5, 4.8, 5.1, 5.0 and 5.5 for D, DM, M, WM and W stands, respectively. In 12 lowland stands, pH ranges from 5.3 to 6.4, whereas in 9 bottomlands values range from 5.3 to 7.3.

The total organic matter content (%C) in the A_1 soil layer is uniform for D, DM, WM and W with averages of 20, 23, 23 and 23, respectively. The lower organic content of 15 percent for Mesic segment, corresponds with the lower WRC for stands of the same segment. Total nitrogen varies from a low of 0.69 in the dry to a high of 1.32 percent in the Wet. The nitrogen content thus shows a tendency to increase with pH.

Of the remaining mineral constituents, Na, Ca, Mg and perhaps K increase from drier to wetter habitats. P has higher values on drier sites than at the wet end of the soil moisture gradient.

Table 11:

Summary of analysis of the A_1 soil layer, averaged for the 5 segments of the moisture gradient.

SUMMARY OF ANALYSIS OF THE A_1 SOIL LAYER, AVERAGED
FOR THE 5 SEGMENTS OF THE MOISTURE GRADIENT

	D	DM	M	WM	W
WRC	225	226	159	264	232
WRC Range	79 - 416	71 - 548	83 - 398	65 - 568	63 - 584
pH	4.5	4.8	5.1	5.0	5.5
pH Range	4.0 - 6.4	4.3 - 7.0	4.2 - 6.8	4.5 - 6.4	4.9 - 7.3
%C	20.16	22.95	14.79	23.12	22.55
%N	0.69	1.05	0.83	1.22	1.32
P ppm.	62	45	35	36	34
Mn ppm.	54	46	60	30	45
H ppm.	293	311	151	323	135
K ppm.	282	261	234	271	288
Na ppm.	46	93	90	107	220
Ca ppm.	1,609	4,014	3,414	3,760	8,538
Mg ppm.	154	385	317	402	494

DISCUSSION

General Considerations:

In accumulating qualitative and quantitative data for 141 forest stands, our prime concern has been in studying the organization of the forest community and the relationships of their composition and structure to environmental features. A rich flora was encountered including 54 arboreal species and 516 understory elements.

Certain trees were found to be of major influence. Acer rubrum, Ulmus americana, Acer saccharum, Betula lutea, Tilia americana and Fraxinus americana have over 50% presence values. Other trees considered to be prevalent — the "topmost species counted off to a number equal to the species density of the community" (Curtis, 1959) — are Tsuga canadensis, Fagus grandifolia, Betula papyrifera, Ostrya virginiana and Abies balsamea. Of these 11 species, the most important elements, based on a Density-Frequency-Dominance Index, are Acer rubrum and Acer saccharum followed by Ulmus americana, Acer saccharinum, Pinus strobus, Betula populifolia, Tsuga canadensis, Fagus grandifolia, Populus tremuloides and Tilia americana.

The predominant environmental feature influencing the distribution of trees, herbs and shrubs within the forest complex is soil moisture. This overriding feature prevailing today has been affected by topography and soil structure due to the sorting and depositing effect of glacial and post-glacial action, climate and the post-glacial vegetational history of the study region. The data presented in Table 5 and Figures 3 to 8 show that certain tree species are found with a broad amplitude of ecological tolerance across a moisture gradient of 5 defined categories. *Acer saccharum*, *Pinus strobus*, *Betula papyrifera*, *Tilia americana*, *Abies balsamea*, *Fraxinus americana*, *Acer rubrum* and *Ulmus americana* are included here. These species nevertheless attain an optimum degree of importance on sites of specific moisture, as do other arboreal elements which have narrower amplitudes of tolerance. In this latter category one finds *Pinus resinosa*, *Ostrya virginiana*, *Fagus grandifolia*, *Betula populifolia*, *Populus tremuloides*, *Thuja occidentalis*, *Fraxinus pennsylvanica*, *Acer saccharinum* and *Quercus bicolor*.

Field observation throughout the study region presents widely varying aspects of different vegetation types. One realizes that certain development patterns relate these different vegetation types in a successional sequence.

One can imagine the sequences of the past: a barren land, spotted with innumerable lakes, following abandonment by glacial ice. Both plants and animals migrate from unglaciated areas and establish themselves. Establishment, growth, reproduction and competition take place until communities begin to mature and to stabilize. Somewhat later the natural cover has again been removed for agriculture, for lumbering operations and settlement, and areas are then later abandoned. The degree of clearance and past usage favors the re-establishment of particular vegetation series. Invariably weeds, particularly annuals, invade the abandoned soils. Different species and groups of species are found on rich farmlands, on abandoned pastures, on fields strewn with erratics or bedrock, or on shorelines inundated in spring and fall. On these sites prepared by pioneering species, perennial herbs germinate, and later shrubs and arboreal seedlings become established. The light-requiring poplars and birches result in the deposition of humus, but competition for space and intolerance to shade result in their replacement by arboreal elements which thrive on soils richer in humus and nutrients and with optimum soil moisture.

A progressive amelioration of the soil is thus seen to take place along this successional sequence. On the heavier soils of the hydrosere these processes result in drying, increased aeration and improved drainage. On the sands of the xerosere there is an improvement in the water-retaining capacities of the substrate. Each dominant or group of dominants holds place and gives character to the habitat and community until effectively replaced by the next dominant. Eventually a period of little visible change is attained, a stable climax forest with pronounced shade-enduring capacity, governed by the actual climatic conditions and being representative of them. The dominant members are able to reproduce themselves indefinitely under the actual climatic, edaphic, biotic and other abiotic conditions.

Certain studies (Dansereau, 1946) had already initiated research on the successional tendencies prevailing within the Quebec Lowlands. Both Dansereau (1946, 1959) and Grandtner (1966) present and discuss the basic vegetational patterns. The former over-emphasizes the contribution of the more stable mesic communities, while under-estimating the importance of the communities of the hydrosere. The latter, in presenting an extensively general picture and including types corresponding to complexes of the present study, nevertheless accentuates on small details. Halliday (1937), in a very general study, presents no successional patterns and, as will become evident, underrates the role and importance of *Acer rubrum*. With the completion of the present project, more quantitative data has been added, showing the close and continuing relationships of different arboreal elements which, while making up the different facets of forest communities, nevertheless tend toward relative stability under prevailing conditions.

Over half of the stands of the present study were located on wet-mesic and wet sites. Included here are bottomlands, particularly flood-plains, and lowlands on heavy, impervious clays and hardpans. Within wet lowland depressions and bottomlands *Ulmus americana* (constancy 85; average importance value 58), *Acer saccharinum* (65;73), *Acer rubrum* (77;36), and *Fraxinus pennsylvanica* (65;13) are the more important elements contributing to the overall composition of this segment of forest communities. One may also include Fraxinus nigra, Betula populifolia, Salix nigra and Populus tremuloides. The flood-plain forest supports a successional community of Salix nigra, Ulmus americana, Fraxinus nigra and Acer rubrum leading to relatively stable conditions where Acer saccharinum dominates. In certain instances Quercus bicolor and Ulmus americana may dominate this forest community.

Ulmus americana is a dominating element of wet lowland communities. Salix nigra, Betula populifolia and Populus tremuloides are important as initiators of the successional sequence for the prevailing moisture conditions. These latter have high constancy values with low average frequency except in those situations where they dominate certain sites.

In wet situations the herb layer may be quite prolific or sparse, the latter occurring when inundation prolongs into the growing season. Onoclea sensibilis, Rubus pubescens, Impatiens capensis, Maianthemum canadense, Lycopus uniflorus, Athyrium filix-femina, Boehmeria cylindrica, Equisetum arvense, Dryopteria spinulosa are the more important elements. In bottomland sites one mainly finds Onoclea sensibilis, Impatiens capensis, Lysimachia nummularia, Ariaeama atrorubens, Cornus stolonifera, Parthenocissus quinquefolia, Laportea canadensis, Boehmeria cylindrica, Rhus radicans and Lycopus uniflorus.

Where wet-mesic conditions exist, the community tends to be relatively stable and the contributing elements more flexible. Bottomlands may persist on second-level terraces or on high flood levels. Here one finds *Quercus macrocarpa*, *Ulmus americana* and *Carya cordiformis* as dominating elements. A great variety of sites exist where the more important components are *Acer rubrum* (82;72), *Betula populifolia* (49;32), *Tsuga canadensis* (49;25), *Ulmus americana* (58;20), *Populus tremuloides* (40;23) and *Thuja occidentalis* (42;18). *Acer rubrum*, which dominates 15 stands here, although not so widespread, does attain maximum importance on these sites of slower drainage. It occurs to varying degrees with other important components such as *Betula populifolia*, *Populus tremuloides*, *Ulmus americana*, *Fraxinus americana*, *Fraxinus nigra*, *Fraxinus pennsylvanica*, *Betula lutea*, *Thuja occidentalis* and *Tsuga canadensis*.

Populus tremuloides and *Betula populifolia* initiate succession of abandoned fields, pastures, water-logged sites, alder swales and willow carrs. *Ulmus americana* is present in the various facets of the successional sequence in situations of moister soils with less mineralization, such as found in pastures. With higher values of *Ulmus americana*, one finds little or no *Acer rubrum*, whereas *Betula populifolia* and *Populus tremuloides* are not encountered. Where one has a decreasing occurrence of *Betula populifolia* and *Populus tremuloides*, there is a gradual increase of *Acer rubrum* with certain representation of *Fraxinus americana*, *F. pennsylvanica*, *Betula lutea*, *Thuja occidentalis* and *Picea glauca*. *Pinus strobus* occurs with *Betula populifolia*, *Populus tremuloides*, *Acer rubrum*, Betula papyrifera, Tsuga canadensis and Abies balsamea. Acer saccharum is fairly well represented, although of less influence. In all instances there is a higher representation of Acer rubrum. One also finds Fagus grandifolia, Tilia americana and Betula lutea, while in local and usually more southern sites Acer nigrum, Ostrya virginiana, Carya cordiformis, Juglans cinerea and Prunus serotina are common. Twelve understory elements of higher relative frequency include Maianthemum canadense, Onoclea sensibilis, Erythronium americanum, Rubus pubescens, Aralia nudicaulis, Athyrium filix-femina, Dryopteris intermedia, Trientalis borealis, Viola incognita, Coptis groenlandicum, Osmunda cinnamomea and Prunus virginiana.

Bog succession within the hydrosere indicates a tendency for development from Boreal Forest elements to a forest of a more deciduous nature starting with Picea mariana and Betula papyrifera and, after long duration, perhaps leading to a forest in which Abies balsamea, Acer rubrum, Betula lutea, Tilia americana and Tsuga canadensis are found to be major components.

It is more difficult for plants to establish themselves on xeroseric sites, such as sandy ridges, old dune systems and limestone outcrop. Analysis of the data for dry stands shows the importance of Pinus strobus, Quercus rubra, Pinus resinosa and Acer rubrum. Other species which contribute to the composition of these communities are Tsuga canadensis, Acer saccharum, Populus grandidentata, Betula papyrifera, Ostrya virginiana, Quercus alba and Betula populifolia. Populus tremuloides and Prunus spp. have a certain degree of importance in occupying disturbed sites. Pinus strobus and P. resinosa were fairly well represented in a majority of stands. Both species were closely associated, although there was a larger occurrence of Pinus strobus. Where white pine dominated, it usually occurred with Pinus resinosa, Quercus rubra, Acer rubrum and Populus grandidentata. Betula papyrifera was more frequent in stands where Pinus resinosa dominated. Pinus resinosa did not occur in any stand dominated by Quercus rubra, but there was a higher representation of Acer saccharum and Ostrya virginiana. In these same stands the higher importance of Acer saccharum, Carya cordiformis, C. ovata and Tilia americana may be related to a certain maturing of the soil in the sense that there was a definite accumulation of humus and its incorporation into the A_1 layer, as shown by its increased thickness.

Table 6 shows that Prunus serotina, Tsuga canadensis, Betula papyrifera, Abies balsamea, Betula populifolia and Acer rubrum have a positive ratio of relative density of saplings to relative density of trees. Although nothing definite can be reliably interpreted from these figures, there does seem to exist a tendency for an increase of importance of these species in any successional tendencies within this segment.

The more important understory components here are Maianthemum canadense, Gaultheria procumbens, Pteridium aquilinum, Vaccinium myrtilloides, Aralia nudicaulis, Trientalis borealis, Carex pennsylvanica, Diervilla lonicera, Corylus cornuta and Prunus virginiana.

On dry-mesic sites the more important trees, based on constancy and average importance values, are Acer saccharum (77;65), Acer rubrum (55;41), Fagus grandifolia (58;30), Ostrya virginiana (68;18), Pinus strobus (36;29), Fraxinus americana (68;12), Tsuga canadensis (58;14) Tilia americana (65;10) and Quercus rubra (52;12). In stands dominated by Acer saccharum one usually finds in decreasing order of importance Ostrya virginiana, Tilia americana, Fraxinus americana, Tsuga canadensis, Fagus grandifolia and Quercus rubra. No Acer rubrum is found in any of these stands. Where Acer rubrum dominates, Quercus rubra is usually replaced by Betula lutea and Betula papyrifera, while in stands dominated by Pinus strobus one finds Acer rubrum, Ulmus americana, Tsuga canadensis and Quercus rubra. In these stands there is no occurrence of Tilia americana or of Betula lutea. In general, where one has a decrease in the importance of Acer saccharum or Fagus grandifolia, there is usually an increase in importance of Acer rubrum. Betula populifolia and Populus tremuloides do not contribute extensively to the successional tendencies and are usually replaced in this function by Betula papyrifera, Betula lutea, Prunus serotina, Prunus pennsylvanica and Populus grandidentata.

There are not a large number of understory elements within these soil conditions. One nevertheless is bound to find Erythronium americanum, Maianthemum canadense , Polygonatum pubescens, Prunus virginiana, Carex pedunculata, Aralia nudicalis and Trientalis borealis.

Terminal forest stages are situated on well-drained sites where there has been a maximum development and build-up of the soils. There is no excess of either cold or heat, dryness or wetness. The resources are thus considered used to a maximum and the arboreal stratum serves as a climatic regulator for the understory herbs and shrubs.

The major dominant of these forests is Acer saccharum (constancy 100; average importance 119). One usually finds with varying degree of importance Acer rubrum (65;42), Tilia americana (96;28), Fagus grandifolia (92;24), Fraxinus americana (81;11) and Ostrya virginiana (92;9). Climate affects the distribution of some elements in relation to Acer saccharum. In the northern parts of the region one will find with larger occurrence and greater importance Tsuga canadensis, Betula lutea and Acer rubrum; while in the southern parts Juglans cinerea, Carya cordiformis, C. ovata, Quercus alba and Prunus serotina. Halliday (1937) based his discussions on these distribution patterns.

Although Acer saccharum dominates 19 of 26 mesic stands, other arboreal species have attained dominance on these optimum moisture conditions. Acer rubrum dominates 3 stands with very high importance, while in these stands Betula lutea, Tilia americana and Fagus grandifolia have but a minor contribution. Tilia americana, Tsuga canadensis and Fagus grandifolia each dominate one stand and have as co-dominants Acer saccharum, Fagus grandifolia and Acer rubrum. Acer saccharum has its lowest importance for mesic segments in a stand dominated by Quercus rubra with the presence of Prunus serotina, Acer rubrum, Fagus grandifolia, Fraxinus americana and Acer saccharum. The overall tendency is for the gradual decrease of all components with the increase in constancy and importance of Acer saccharum.

Dansereau (1959) has stated that the Laurentian sugar maple grove:

> "...is the climatic climax association for the St. Lawrence Lowlands, and for much of the Appalachian and Laurentian Uplands below 1,000 feet. It does not contain any conifers; sugar maple is very strongly dominant over beech to the point of forming a veritable consociation. .... The herbaceous layer is characteristically sparse in summer."

Theoretically, all facets of the different vegetation types encountered can be shown to tend toward a potential steady state -- the climax. This can rarely, if ever, be attained. Allowing for a reasonably long period of stability, destruction of even a small portion of the canopy creates a different microclimate in so far as light and moisture conditions are concerned. For this reason one usually finds different types of climax situations. A single climatic climax, which is considered to be in equilibrium with the general climate, is "a theoretical community towards which all successional development in a given region is tending. It is realized when physical conditions of the substrate are not so extreme as to modify the effects of the prevailing regional climate" (Odum, 1971). There may also exist a number of edaphic climaxes. These are modified by local conditions of the substrate and where topography, soil, water, fire or other disturbances are such that the climatic climax cannot develop. Here come to mind stands along the gradient where Pinus strobus, Quercus rubra, Acer saccharinum, Quercus bicolor, Ulmus americana and Acer rubrum dominate within local conditions of moisture.

In so far as the theoretical climatic climax of the study region is concerned:

> "The stabilizing and purifying influence of the sugar maple ... is thus occasionally interrupted locally or generally, with a resultant resurgence of less well-adapted trees. The forest is never stable but rather exists in a state of dynamic equilibrium, compounded by the opposing forces of a supertolerant sugar maple, on the one hand and a particular group of vigorous but less tolerant species, aided by external agents of destruction, on the other." (Curtis, 1959)

Tilia americana, Fagus grandifolia, Ostrya virginiana, Fraxinus americana and Betula lutea attain percent presence over 80 under mesic conditions, while not surpassing an average importance of 28 compared to the average importance of 119 for Acer saccharum.

As for a destruction of the natural sugar maple grove, a major problem was encountered during sampling and is related to the long period of exploitation for maple sugar production of mesic upland forests dominated by sugar maple. The management of most sugar bushes involves the removal of tree species other than sugar maple and of most saplings. The central bush completely "dominated" by Acer saccharum nevertheless has, in most instances, a buffer zone to adjacent fields and pastures where one finds a remnant of the natural bush, dominated by Acer saccharum, with scattered occurrence of Fagus grandifolia, Quercus rubra, Ulmus americana or Quercus rubra.

The data was also analyzed for stands where Acer saccharum and any conifers occurred together. In all, 44 stands were counted. Acer saccharum was not important in 4 dry stands where Pinus strobus dominated. There was an increase in the importance of sugar maple in 16 dry-mesic stands related to a gradual decrease of white pine. While in the dry stands there was also an occurrence of Tsuga canadensis and Pinus resinosa, in the dry-mesic Abies balsamea, Picea glauca, Tsuga canadensis and Thuja occidentalis contributed slightly. Sugar maple is not so important in 10 wet-mesic stands. Here Thuja occidentalis and Tsuga canadensis are the important conifers, increasing in importance as sugar maple decreases. Tsuga canadensis, the only conifer present in at least 14 mesic stands, attains a very small degree of importance in a stand where Acer saccharum does not dominate. Pinus strobus, Abies balsamea and Picea glauca have scattered occurrence of no relevant importance. No conifers are encountered in stands where Acer saccharum has any importance over 221. Only Tsuga canadensis is present to any degree in more stable forest communities in both dry and dry-mesic conditions. This may bear relation to the Pine-Hemlock Forest of Nichols (1935).

The scattered occurrence of individuals of white pine may be explained by the fact that white pine, an early successional species, has a life expectancy of many centuries. As a result, one comes upon mature forests of 80 to 90 feet, with scattered individuals towering over this forest at 100 to 150 feet.

> "Barring catastrophy, the white pines gradually die out, and probably would be entirely gone within 600 years under natural conditions leaving a climax mesic forest which would gradually increase in sugar maple dominance. Uninterrupted succession of this sort must have been very rare in presettlement times, since the time period of 800 to 1000 years necessary from initial stand to final forest is so long that the chances of having no catastrophy are practically nil." (Curtis, 1959)

Along the same lines of thought, Oosting (1956) mentions Pinus strobus as dominating on certain sites of more favorable moisture conditions, where it remains for long periods as sub-climax. Its long life and relatively low numbers suggest that this species is regarded as a relict within the climax.

The understory of mesic hardwoods is rich and varied. At least 18 herb species are widespread within this particular community. Here, one may include certain spring vernals: Erythronium americanum, Dicentra canadensis and Claytonia caroliniana as well as Trillium grandiflorum, Trillium erectum, Maianthemum canadense, Polygonatum pubescens, Smilacina racemosa, Prunus virginiana, Carex pedunculata, Caulophyllus thalictroides, Uvularia grandiflora, Viola pensylvanica, Osmorhiza claytoni, Dryopteris intermedia, Prenanthes altissima and Aralia nudicaulis.

The information which has been gathered has been examined with particular interest in so far as the overall contribution of certain important elements to the forest community. Betula populifolia and Populus tremuloides are dominating elements in successional sequences, especially on moist sites.

Stands of Betula populifolia, or old field birch, are commonly restricted to the Central St. Lawrence Plain. An early invader of sandy fields and sites of immature soils of slow and irregular drainage, it occurs predominantly in wetter sites and in peaty areas where drainage has improved. Betula populifolia occurred in 45 stands. Most commonly occurring with it were Acer rubrum, Abies balsamea, Populus tremuloides, Pinus strobus, Betula papyrifera, Tsuga canadensis and Prunus serotina. In early stages of development, old field birch will completely dominate with scattered individuals of Abies balsamea, Prunus pensylvanica, P. serotina, Populus tremuloides or Acer rubrum. As the site matures, a gradual increase of Acer rubrum and Populus tremuloides will replace Betula populifolia. In wet areas Ulmus americana replaces Acer rubrum. Where Acer rubrum has attained dominance Betula populifolia loses all importance and one finds Abies balsamea, Pinus strobus, Betula papyrifera, with Tsuga canadensis attaining a certain degree of importance. On drier sites Betula populifolia, although occurring frequently, is nevertheless not so important as on wetter sites.

The occurrence of Populus tremuloides and Betula populifolia is closely related. The importance of one over the other depends, to a large extent, on the particular site conditions. In 40 stands the more important trees to be found with Populus tremuloides are Acer rubrum, Betula populifolia, Abies balsamea and Betula papyrifera. As with old field birch, the poplar contributes to the initiation of successional trends. A maturing of the site brings about a gradual increase of Acer rubrum and Ulmus americana. On dry-mesic sites, dominated by Populus tremuloides, Pinus strobus and Tilia americana will replace Ulmus americana and Betula lutea.

Ulmus americana has an overall constancy of 58, and an average importance of 20. It occurs most frequently with Acer rubrum, Fraxinus americana, Tilia americana, Acer saccharum and Betula lutea. It attains its greatest importance under moister conditions. In wet-mesic sites one encounters it in the presence of Acer rubrum, Betula lutea, Fraxinus nigra, F. pennsylvanica and Acer saccharinum. A decrease of Ulmus americana is usually accompanied by an increase in importance of Acer rubrum and Betula lutea, while an increase is related to a decrease of Acer saccharinum and Tilia americana. In drier situations one finds Fraxinus americana, Tilia americana, Acer saccharum and Ostrya virginiana occurring with Ulmus americana, a decrease of the latter usually accompanied by an increase of Fraxinus americana.

The relationship of Ulmus americana and Fraxinus spp. was interesting to analyze, in that both are related in their occurrence. Fraxinus americana occurs alone in 15 of 94 stands; Ulmus americana in 14; and Fraxinus nigra in 2 stands. Numerous combinations exist for these 3 elements and for Fraxinus pennsylvanica, depending on the degree of importance of any one over the others. In this way Fraxinus americana is the more important in 34 stands, Fraxinus nigra in 5, F. pennsylvanica in 7, whereas Ulmus americana is the more important element in 47 stands. In most cases there is one or more of the other species present. Related to the soil moisture gradient, Fraxinus americana is more important in drier and in mesic sites. Ulmus americana, Fraxinus pennsylvanica and F. nigra are more influential in wet and in wet-mesic conditions.

The contribution of Acer rubrum has been indirectly shown while discussing all facets of the forest communities encountered. It is of widespread occurrence, has a high relative importance and has a broad amplitude of ecological tolerance. Its importance has been underestimated by most researchers. Along with Acer saccharum and Ulmus americana it dominates and is influential in the development of numerous forest communities of the St. Lawrence Lowlands.

Geographical Relationships:

The present study contributes to a larger project involving the phytosociology of all forest regions of Ontario and Quebec. Major facets of these forests have been studied by Maycock (1963), Davies (1968) and Bouchard (1970). Other relevant studies have been accomplished by Walther (1963), Daly (1965), Lambert (1968) and Warder (1970). All have compiled extensive qualitative and quantitative data showing the composition, structure and ecological relationships of all forest types existing within the southern regions of Quebec and Ontario. The forest vegetation of the Central St. Lawrence Lowlands can be compared phytosociologically and floristically with the Paleozoic Northern Conifer-Hardwoods of S.E. Ontario (Davies, 1968) and with the Appalachian Foothills region (Bouchard, 1970).

The St. Lawrence Lowlands lie south of the Canadian Shield and stretch from Lakes Erie and Huron to Anticosti Island. The Western and Central sections are separated by the Frontenac Axis, a projection of the Canadian Shield between Kingston and Prescott. The Western Lowlands form a contact zone with the Deciduous Forest of Extreme S. Ontario at the northern limits of Soper's Carolinian zone (1949). Its northern limits are along the Paleozoic-Precambrian contact running from Georgian Bay to Kingston. The Appalachian Foothills or Eastern Quebec Highlands lie south-east of Logan's Fault and in relation to the present study are mainly areas over 450 feet in altitude.

Within the Western Lowlands for 131 stands studied, 62 trees were found to make up all major phases of the forest continuum, while within 94 Upland stands 40 arboreal elements were encountered with a marked absence of all southern species and a marked tendency to borealness. The Central Lowlands form a meeting ground with various elements of southern or boreal affinity contributing to their composition. To the south-west, the arboreal flora is decidedly richer in species composition. Juniperus virginiana, Quercus velutina, Juglans nigra, Quercus meuhlenbergii and Sassafras albidum occur here and not in the other two regions. Pinus banksiana, Pyrus americana, and Populus deltoides, although present in the Central Lowlands, attain greater importance further south. Not occurring within the Western Lowlands are Pinus rigida, Picea rubens, Betula populifolia, Picea mariana and Pyrus malus. In the Appalachian Uplands elements of southern affinity usually occurring on drier sites, Quercus alba, Ulmus thomasi, Quercus rubra, Carya ovata and C. cordiformis, are not found. Neither are species of moister sites: Quercus macrocarpa, Q. bicolor, Celtis occidentalis, Populus deltoides and Acer nigrum. Crataegus spp., Carpinus caroliniana and Alnus rugosa never become mature trees. Table 12 shows the constancy and average importance values for all trees occurring within the three regions. A total of 36 trees are present across all regions.

In the Western Lowlands the most widespread trees are Ulmus americana, Fraxinus americana, Acer saccharum, Tilia americana, Ostrya virginiana and Prunus serotina with constancy values of 75, 69, 67, 61,

Table 12:

Constancy and average importance values for tree species occurring within Western St. Lawrence Lowlands (WL), Central Lowlands (CL), and/or Appalachian Highlands (AH).

CONSTANCY AND AVERAGE IMPORTANCE VALUES FOR TREE SPECIES OCCURRING WITHIN WESTERN ST. LAWRENCE LOWLANDS (WL), CENTRAL LOWLANDS (CL), AND/OR APPALACHIAN HIGHLANDS (AH)

	CONSTANCY			AVERAGE IMPORTANCE		
	WL	CL	AH	WL	CL	AH
Juniperus virginiana	5	-	-	1.5	-	-
Pinus banksiana	3	-	-	0.4	-	-
Quercus velutina	3	-	-	0.9	-	-
Juglans nigra	2	-	-	0.1	-	-
Quercus muehlenbergii	2	-	-	0.1	-	-
Sassafras albidum	1	-	-	0.1	-	-
Acer nigrum	15	9	-	2.9	0.9	-
Quercus alba	10	4	-	4.2	0.9	-
Alnus rugosa	2	1	-	-	-	-
Populus deltoides	3	3	-	0.1	-	-
Celtis occidentalis	1	1	-	-	0.1	-
Pyrus aucuparia	1	1	-	-	-	-
Quercus bicolor	1	8	-	0.1	2.0	-
Amelanchier arborea	5	9	-	0.1	-	-
Carya ovata	7	10	-	3.2	1.2	-
Quercus macrocarpa	8	18	-	2.3	2.6	-
Carya cordiformis	20	28	-	0.9	3.9	-
Ulmus americana	75	60	33	24.8	20.5	9.0
Fraxinus americana	69	53	34	6.7	8.3	2.9
Tilia americana	61	54	21	6.9	11.3	1.4
Ostrya virginiana	55	42	24	4.0	6.7	1.5
Tsuga canadensis	48	45	32	10.5	13.7	16.6
Fraxinus nigra	34	31	30	4.1	4.5	4.2
Populus balsamifera	19	10	9	4.8	1.1	6.0
Ulmus thomasi	14	5	1	2.8	1.4	-
Pinus resinosa	11	6	6	3.0	3.9	7.9
Prunus virginiana	7	2	2	0.2	-	-

	CONSTANCY			AVERAGE IMPORTANCE		
	WL	CL	AH	WL	CL	AH
Acer negundo	4	1	2	2.6	-	1.5
Salix nigra	14	4	8	5.3	3.2	1.4
Thuja occidentalis	49	30	36	28.6	9.1	19.7
Prunus serotina	53	33	38	1.7	2.1	3.3
Pinus strobus	28	33	20	10.3	16.1	11.0
Quercus rubra	29	31	6	13.3	9.9	2.2
Fraxinus pennsylvanica	23	25	2	3.0	6.0	0.2
Acer saccharinum	20	22	2	18.0	17.0	1.1
Juglans cinerea	10	19	4	0.4	1.0	0.3
Carpinus caroliniana	8	17	1	0.1	0.1	-
Ulmus rubra	12	14	1	0.7	1.4	0.3
Crataegus spp.	8	9	1	0.1	0.1	-
Larix laricina	5	9	3	0.4	1.9	0.1
Picea glauca	17	29	26	1.3	1.8	2.3
Salix spp.	-	4	-	-	0.5	-
Pyrus americana	-	2	-	-	-	-
Pinus rigida	-	1	-	-	2.1	-
Acer spicatum	1	-	3	-	-	0.2
Pyrus decora	1	1	12	0.6	-	0.6
Populus tremuloides	31	28	38	14.7	10.6	16.1
Betula papyrifera	45	44	59	9.7	3.9	16.8
Acer saccharum	67	57	76	73.5	38.6	72.1
Amelanchier spp.	13	13	20	0.3	0.2	0.2
Fagus grandifolia	45	45	52	14.4	12.4	12.7
Populus grandidentata	15	18	20	3.5	1.8	2.6
Prunus pensylvanica	1	23	28	-	1.3	1.6
Acer pensylvanicum	3	16	43	-	0.3	2.1
Abies balsamea	32	37	68	2.6	4.8	16.4
Acer rubrum	36	70	76	5.7	48.2	25.3
Betula lutea	47	54	88	5.6	5.0	29.5
Betula populifolia	-	32	19	-	15.2	4.3
Picea mariana	-	4	2	-	0.4	-
Picea rubens	-	6	58	-	0.7	5.4

55 and 53. The most important are Acer saccharum, Thuja occidentalis and Ulmus americana with average importance values of 74, 29 and 25. In the Quebec Highlands Betula lutea, Acer saccharum, Betula papyrifera, Picea rubens and Fagus grandifolia are most widespread with constancies of 88, 76, 59, 58 and 52. The most important elements are Acer saccharum, Betula lutea, Acer rubrum and Thuja occidentalis with average values of 72, 30, 25 and 20.

An index of similarity (Curtis, 1959) was applied to both constancy and average importance values of trees present in all three regions. Using the formula 2w/a + b these values were compared to those in the other regions and a coefficient of correlation, an index of similarity, was derived. This formula takes the sum of quantitative measures for each entity respectively (a, b) with w the sum of the lower values of each measure; 2w being the degree of coincidence between the 2 sets of measures. A value of 1 represents 2 quantitatively identical measurements, a value of 0 represents no similarity whatsoever. In this way, based on occurrence, the similarity between Western and Central Lowlands is 0.82, between the Central Lowlands and Highlands is 0.71, while between the Western Lowlands and Highlands a similarity of 0.63 in the occurrence of species exists. Based on average importance of tree species, Western and Central Lowlands have a degree of similarity of 0.68, with a similarity of 0.59 between Central Lowlands and Highlands; and, surprisingly enough, between the Western Lowlands and Highlands, the similarity is 0.68.

Table 13 presents the average importance values of all trees in all three regions along the moisture gradient. Figure 23 presents the distribution patterns of some of the more important trees. Some general tendencies manifest themselves. Trees which attain a limit -- whether climatic or altitudinal -- within one region usually tend to have a narrow range of tolerance toward one segment of the moisture gradient. In this group are species of meridional affinity and which reach their northern limit within south-western Ontario. There are also those species which, although occurring throughout all regions, are limited by edaphic factors to one segment of the moisture gradient.

Acer saccharum, one of the more important trees within all regions, is not so important within the Central Lowlands as it is within the other two. Mention has already been made concerning the problem of sampling the stands dominated by *Acer saccharum*. Nevertheless, throughout the regions it dominates on mesic sites. *Fraxinus americana* and *Ulmus americana* are definitely lowland types. Both have fair occurrence at the moisture end, although *Fraxinus americana* has a greater importance within the drier end. *Ulmus americana* is important within wet-mesic and wet segments. *Acer rubrum*, having a wide distribution with altitude and latitude, is most important within the Central Lowlands. Here it reaches an optimum within the wet-mesic segment, while in the Uplands it reaches an optimum in both dry-mesic and wet-mesic segments. In all regions it has a wide amplitude of tolerance.

Table 13:

The average importance values for all trees occurring within one or all regions, along the moisture gradient. (WL - Western Lowlands; CL - Central Lowlands; AH - Appalachian Highlands).
* - denotes all values of 0.4 and less

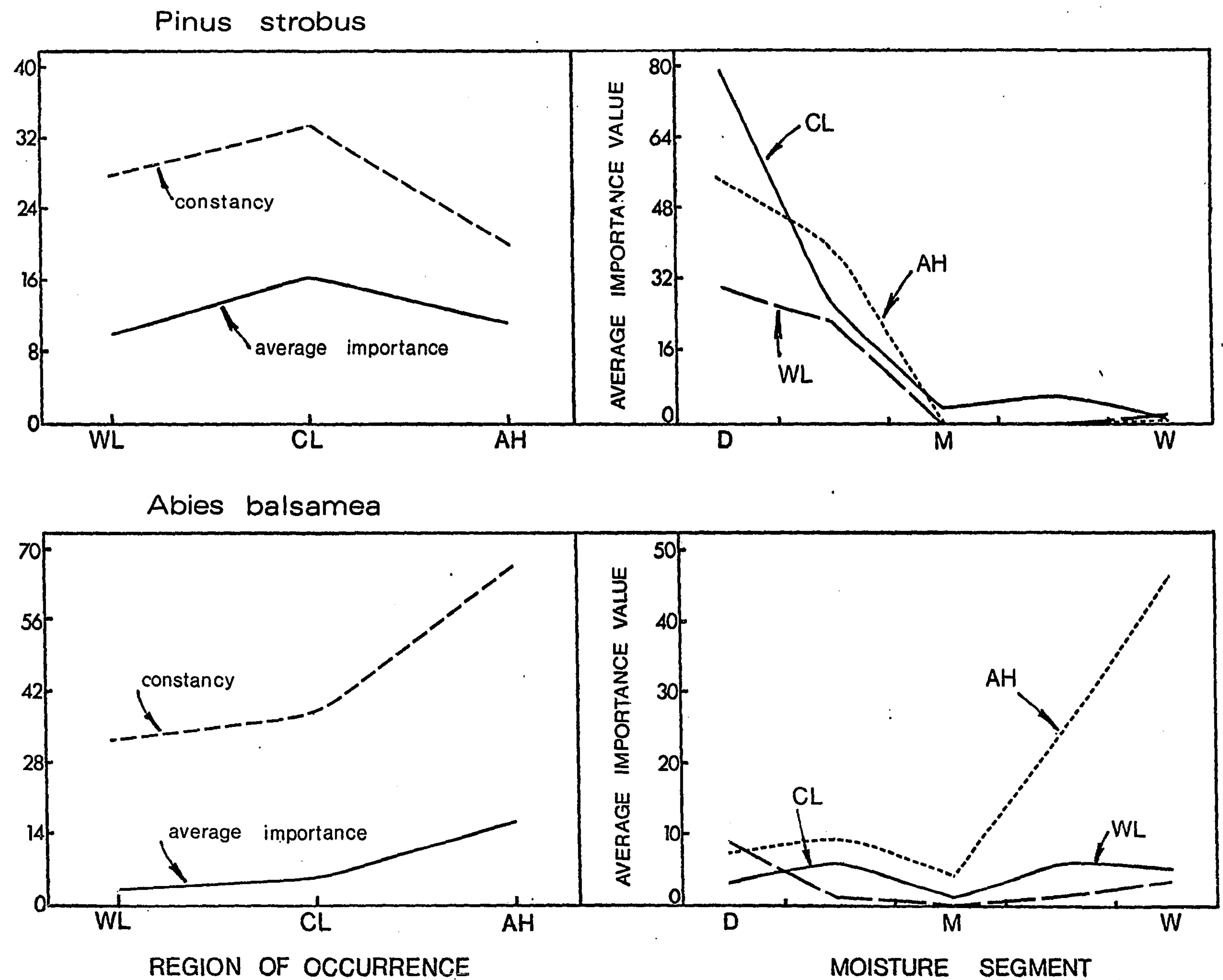
THE AVERAGE IMPORTANCE VALUES FOR ALL TREES OCCURRING
WITHIN ONE OR ALL REGIONS ALONG THE MOISTURE GRADIENT

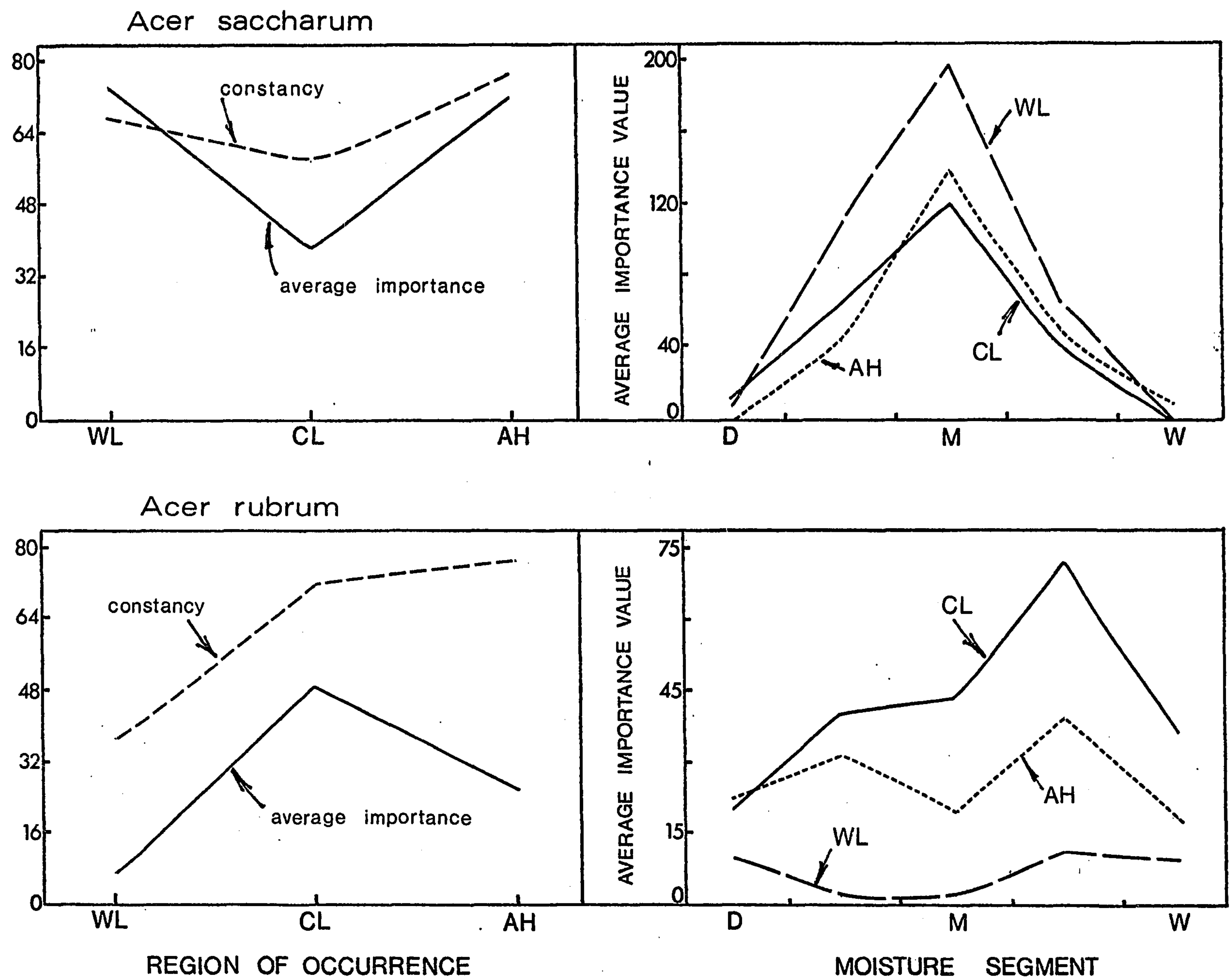
	DRY			DRY MESIC			MESIC			WET MESIC			WET		
	WL	CL	AH	WL	CL	AH	WL	CL	AH	WL	CL	AH	WL	CL	AH
Juniperus virginiana	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus velutina	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinus banksiana	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sassafras albidum	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus muhlenbergii	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinus rigida	-	23	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinus resinosa	18	43	180	1	-	-	-	-	-	-	-	-	-	-	-
Quercus alba	16	9	-	7	*	-	*	-	-	1	-	-	-	-	-
Quercus rubra	59	45	-	16	12	10	*	9	-	1	6	-	-	-	-
Carya ovata	13	2	-	5	1	-	*	1	-	*	2	-	-	-	-
Populus grandidentata	12	8	1	7	2	8	*	2	2	-	1	-	-	-	-
Acer pennsylvanicum	*	-	-	-	1	*	-	*	5	*	*	*	-	-	-
Thuja occidentalis	42	-	-	17	8	4	1	21	*	44	5	29	40	8	73
Pinus strobus	29	29	54	22	29	41	*	2	-	*	6	-	2	1	1
Populus tremuloides	25	1	-	3	6	17	*	-	11	2	25	40	25	10	7
Betula papyrifera	21	6	12	13	8	31	1	1	16	4	4	13	10	1	7
Abies balsamea	9	3	7	1	6	9	-	1	4	1	6	23	3	5	46
Acer rubrum	9	20	23	2	41	32	2	42	14	10	72	39	9	36	18
Picea glauca	7	-	8	*	2	*	-	1	-	1	3	4	1	1	7
Acer saccharum	6	10	-	107	65	43	196	119	139	69	4	49	1	-	9
Quercus macrocarpa	4	9	-	1	2	-	-	*	-	2	4	-	*	1	-
Ostrya virginiana	2	9	-	10	18	*	4	9	4	4	1	-	*	-	*
Populus balsamifera	2	-	-	*	-	1	-	-	-	5	2	10	15	3	22
Fraxinus americana	2	2	-	11	12	2	7	11	3	12	9	3	2	4	4
Amelanchier spp.	1	1	-	*	*	1	*	-	*	*	*	*	*	-	*
Prunus scrotina	1	*	-	6	1	5	4	7	2	1	2	7	1	-	1
Tsuga canadensis	1	11	-	16	14	51	13	9	2	14	35	26	8	*	4
Fagus grandifolia	*	1	-	31	30	4	30	24	29	11	5	4	-	-	*
Carya cordiformis	*	4	-	1	5	-	1	8	-	3	2	-	*	-	-

	DRY			DRY MESIC			MESIC			WET MESIC			WET		
	WL	CL	AH	WL	CL	AH	WL	CL	AH	WL	CL	AH	WL	CL	AH
Prunus virginiana	*	-	-	-	-	-	-	-	-	1	*	*	*	*	-
Juglans cinerea	*	-	-	*	2	-	*	2	*	2	*	-	*	-	1
Ulmus thomasi	*	2	-	*	5	-	1	-	-	2	*	-	9	-	-
Tilia americana	*	1	-	9	10	*	8	28	3	17	11	*	2	2	1
Celtis occidentalis	*	-	-	-	-	-	-	-	-	-	*	-	-	-	-
Crataegus spp.	*	-	-	*	-	-	-	-	-	-	*	-	*	*	-
Ulmus americana	*	1	-	9	7	1	22	9	2	45	20	5	42	58	38
Fraxinus pennsylvanica	*	-	-	-	1	-	-	*	-	2	2	1	11	24	-
Larix laricina	*	-	-	-	1	-	-	-	-	*	3	*	2	6	*
Ulmus rubra	-	*	-	1	2	-	1	3	-	2	1	-	*	-	1
Picea rubens	-	2	15	-	*	11	-	-	4	-	1	3	-	*	1
Betula populifolia	-	7	-	-	2	14	-	-	*	-	32	*	-	21	7
Picea mariana	-	-	-	-	-	1	-	-	-	-	*	-	-	2	-
Acer nigrum	-	-	-	1	*	-	10	2	-	5	2	-	-	-	-
Betula lutea	-	-	-	3	4	12	2	6	51	12	8	23	9	2	21
Carpinus caroliniana	-	-	-	*	*	-	-	*	-	*	-	-	*	*	-
Prunus pensylvanica	-	-	-	*	2	1	-	1	3	-	2	2	-	1	1
Fraxinus nigra	-	-	-	-	*	-	*	2	*	3	6	9	14	13	17
Pyrus malus	-	-	-	-	-	*	-	-	-	-	-	-	-	-	-
Juglans nigra	-	-	-	-	-	-	*	-	-	*	-	-	-	-	-
Acer saccharinum	-	-	-	-	-	-	-	*	-	5	11	6	67	73	*
Acer spicatum	-	-	-	-	-	-	-	-	*	-	-	-	*	-	*
Sorbus decora	-	-	-	-	-	-	-	-	1	*	-	1	-	-	-
Pyrus aucuparia	-	-	-	-	-	-	-	-	-	*	-	-	-	-	-
Quercus bicolor	-	-	-	-	-	-	-	-	-	5	1	-	-	10	-
Salix nigra	-	-	-	-	-	-	-	-	-	-	*	1	21	17	7
Acer negundo	-	-	-	-	-	-	-	-	-	-	-	-	10	-	5
Populus deltoides	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Alnus rugosa	-	-	-	-	-	-	-	-	-	-	-	-	*	*	-

Figure 23:

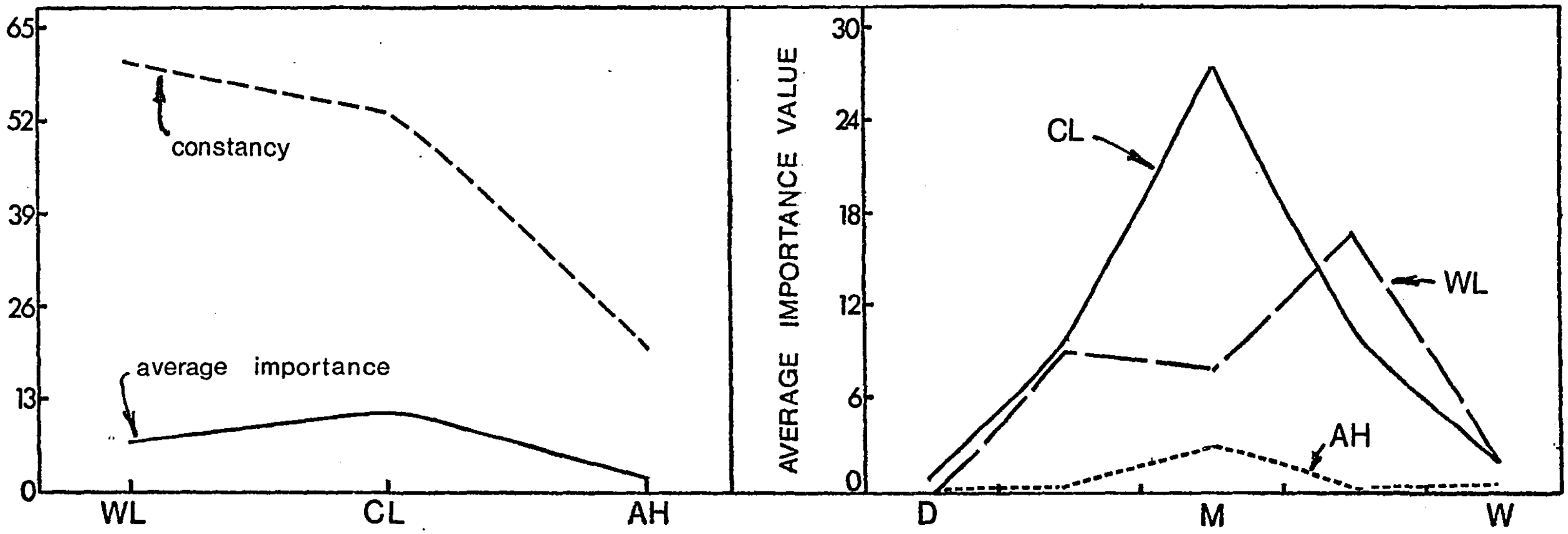
The constancy and average importance values of 8 important trees within the Western St. Lawrence Lowlands (WL), Central Lowlands (CL), and Appalachian Highlands (AH), as well as the importance values of these same species along the moisture gradient.


Pinus strobus
40
32
24
16
8
0
constancy
average importance
WL
CL
AH
AVERAGE IMPORTANCE VALUE
80
64
48
32
16
0
CL
AH
WL
D
M
W
Abies balsamea
70
56
42
28
14
0
constancy
average importance
WL
CL
AH
AVERAGE IMPORTANCE VALUE
50
40
30
20
10
0
AH
CL
WL
D
M
W
REGION OF OCCURRENCE
MOISTURE SEGMENT

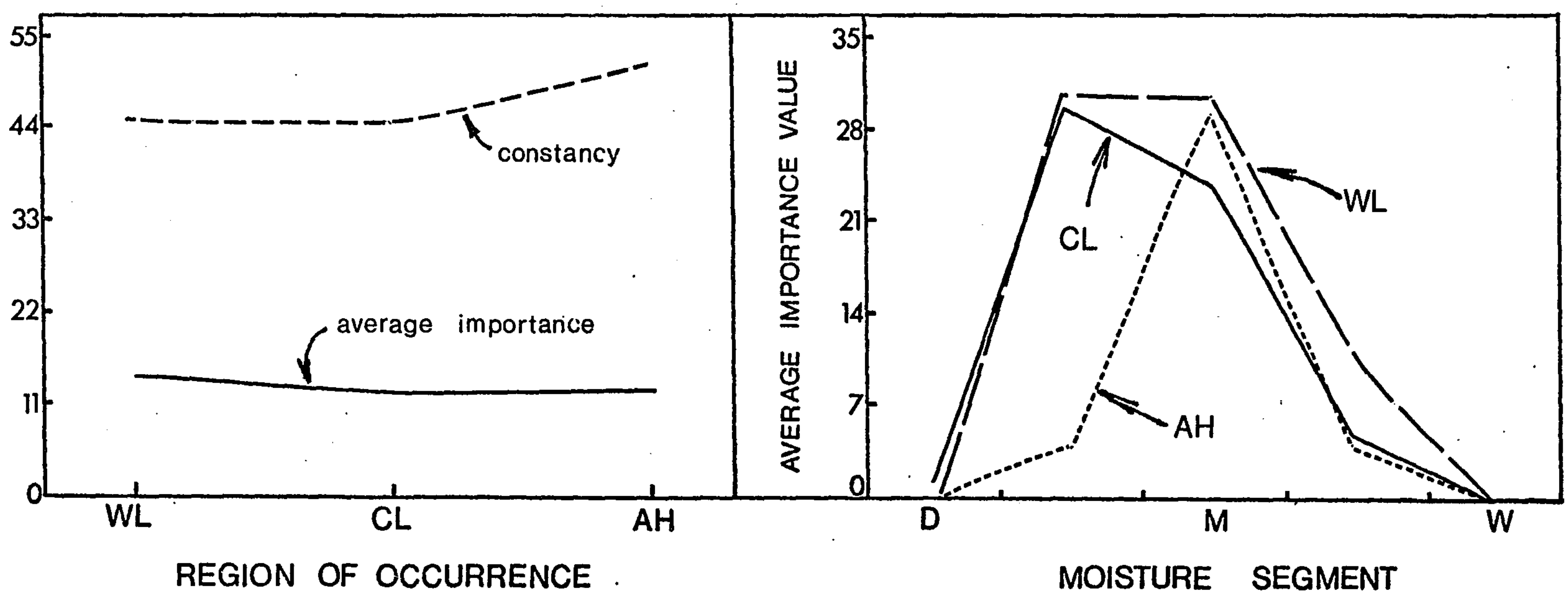


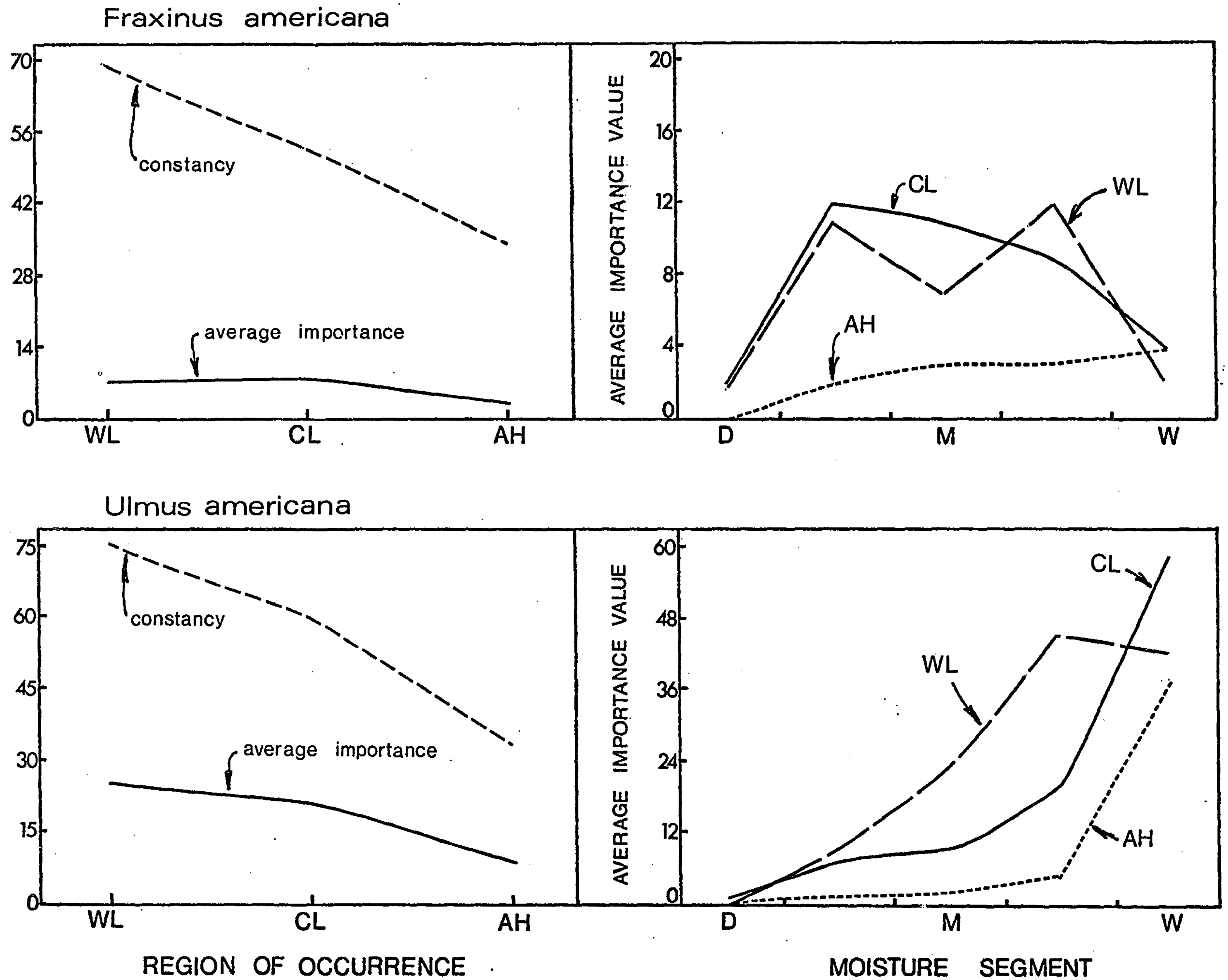
Acer saccharum
80
64
48
32
16
0
constancy
average importance
WL
CL
AH
AVERAGE IMPORTANCE VALUE
200
120
40
0
WL
AH
CL
D
M
W
Acer rubrum
80
64
48
32
16
0
constancy
average importance
WL
CL
AH
AVERAGE IMPORTANCE VALUE
75
45
15
0
CL
AH
WL
D
M
W
REGION OF OCCURRENCE
MOISTURE SEGMENT

Tilia americana



Fagus grandifolia




Fraxinus americana
70
56
42
28
14
0
constancy
average importance
WL
CL
AH
AVERAGE IMPORTANCE VALUE
20
16
12
8
4
0
CL
WL
AH
D
M
W
Ulmus americana
75
60
45
30
15
0
constancy
average importance
WL
CL
AH
AVERAGE IMPORTANCE VALUE
60
48
36
24
12
0
CL
WL
AH
D
M
W
REGION OF OCCURRENCE
MOISTURE SEGMENT

The forests of the three regions are essentially mixed forests and, as such, some mention should be made of the coniferous elements which, as with hardwoods, have boreal or meridional affinities. Juniperus virginiana and Pinus banksiana occur only within the Western Lowlands although scattered individuals of the latter have been found near contact zones with the Canadian Shield in the Central Lowlands. Tsuga canadensis and Thuja occidentalis are more widespread in western Ontario as forest elements, although Thuja is the only conifer with a higher average importance within these western regions. Pinus strobus has constancy values of 28, 33 and 20 within south-western, northern and Uplands regions. Its average importance values are 10, 16 and 11 in these same regions. Tsuga canadensis, with presence values of 48, 45 and 32, has an increasing importance with altitude of 11, 14 and 17 respectively. Abies balsamea, definitely of boreal affinity, increases in both constancy and importance from south to north with constancy values of 32, 37 and 68 and average importance values of 3, 5 and 16 for south-western, northern and foothills regions respectively.

The index of similarity was applied to all moisture segments of Western and Central Lowlands. The dry-mesic segments were most similar with a value of 0.71. Other values were 0.63, 0.60, 0.51 and 0.46 for wet, mesic, dry and wet-mesic segments. This low value for wet-mesic sites is probably due to the greater number and variety of lowland and bottomland stands encountered in the Central Lowlands.

The Index of Regional Influence (IRI), derived by Maycock (1963) and subsequently used by Davies (1968), gives the ecological importance of individual tree species within specific study regions. This index is determined for each species by summing average importance values for all soil moisture segments and calculating each species as a percentage of the total average importance values for all species in all moisture segments. The most important species within the Western Lowlands are *Acer saccharum*, *Thuja occidentalis*, *Ulmus americana*, *Quercus rubra*, *Populus tremuloides* and *Fagus grandifolia* with IRI values of 24.96, 9.48, 7.84, 5.02, 4.86 and 4.75 respectively. Within the Central Lowlands *Acer rubrum* is the most important with 14.05, followed by *Acer saccharum*, *Pinus strobus*, *Ulmus americana*, *Acer saccharinum*, *Quercus rubra* and *Betula populifolia* with values of 12.63, 7.78, 6.34, 5.65, 4.70 and 4.21. In the Uplands *Acer saccharum*, *Pinus resinosa*, *Acer rubrum*, *Thuja occidentalis*, *Betula lutea* and *Pinus strobus* attain major importance with IRI values of 15.89, 12.07, 8.80, 7.14, 7.12 and 6.40. With an increase of latitude and altitude, there seem to be more species contributing to the general make-up of the regional vegetation. The influence of conifers gains more importance in the northern forests. In the Western Lowlands, *Thuja occidentalis* is second in influence with an IRI value of 9.48, while *Pinus strobus* (3.59) and *Tsuga canadensis* (3.40) make minor contributions. *Pinus strobus* (7.78) is third in influence in the Central Lowlands, while *Tsuga canadensis* (3.90), *Pinus resinosa* (2.83), *Thuja occidentalis* (2.81) and *Abies balsamea* (1.48) are of lesser importance. For the Highlands, the influence of conifers is more noticeable and widespread. One can include here Pinus resinosa (IRI - 12.07), Thuja occidentalis (7.14), Pinus strobus (6.40), Abies balsamea (5.97) and Tsuga canadensis (5.57).

The analysis of herbs and shrubs has been one of a floristic comparison based on the total percent presence, and of the application of the Index of Similarity. For the three regions 487, 516 and 356 herb and shrub species were encountered in the Western and Central Lowlands and Highlands respectively. Because of its situation on several major migration routes, and especially because of predominance of wetter sites facilitating migration, a larger number of herbs and shrubs are found within the Central Lowlands, a large number occurring only once for the whole region. Table 14 presents constancy values for all herb and shrub species found within any or all of the regions studied. Within the Western Lowlands 96 species (20%) occur with a constancy of 1 as compared to 189 (36%) for the Central Lowlands and 81 (22%) for the Appalachian Highlands.

Table 14:

Constancy values of shrub and herb species occurring within Western Lowlands (WL), Central Lowlands (CL), and/or Appalachian Highlands (AH).

CONSTANCY VALUES FOR ALL HERB AND SHRUB SPECIES OCCURRING WITHIN THE WESTERN ST.LAWRENCE LOWLANDS (WL), THE CENTRAL LOWLANDS (CL), AND/OR THE APPALACHIAN HIGHLANDS

	Constancy		
	WL	CL	AH
Ranunculs fascicularis	15	-	-
Mentha arvensis	14	-	-
Juniperus communis	13	-	-
Polygala paucifolia	13	-	-
Lonicera hirsuta	12	-	-
Shepherdia canadensis	12	-	-
Agropyron trachycaulum	11	-	-
Lindera benzoin	8	-	-
Melica smithii	8	-	-
Smilax hispida	8	-	-
Podophyllum peltatum	7	-	-
Pedicularis canadensis	6	-	-
Galium lanceolatum	6	-	-
Carex flava	5	-	-
Carex hystricina	4	-	-
Cynoglossum officinale	4	-	-
Rhus aromatica	4	-	-
Salix humilis	4	-	-
Arabis glabra	3	-	-
Asplenium trichomanes	3	-	-
Aster azureus	3	-	-
Ceanothus americanus	3	-	-
Conopholis americana	3	-	-
Euonymus obovatus	3	-	-
Galium pilosum	3	-	-
Helianthum divaricatus	3	-	-
Hepatica americana	3	-	-
Hieracium floribundum	3	-	-
Lilium philadelphicum	3	-	-
Malaxis brachypoda	3	-	-
Nasturtium officinale	3	-	-
Polygala senega	3	-	-
Ranunculus repens	3	-	-
Saponaria officinalis	3	-	-
Solidago squarrosa	3	-	-
Stellaria longifolia	3	-	-
Asclepias syriaca	2	-	-
Carex digitalis	2	-	-
Carex foenea	2	-	-
Carex cephalophae	2	-	-
Carex cristatella	2	-	-
Ceonathus ovatus	2	-	-
Cerastium arvense	2	-	-
Clematis verticillaris	2	-	-
Goodyera oblongifolia	2	-	-
Hackelia virginiana	2	-	-
Lithospermum croceum	2	-	-
Penstemon hirsutus	2	-	-
Phyllitis scolopendrium	2	-	-
Prunus pensylvanica	2	-	-
Rudbeckia serotina	2	-	-
Smilax ecirrhata	2	-	-
Veronica anagallis-aquatica	2	-	-
Agropyron caninum	1	-	-
Alliaria officinalis	1	-	-
Allium canadense	1	-	-
Allysum allysoides	1	-	-
Angelica atropurpures	1	-	-
Arabis lyrata	1	-	-
Arenaria serpyllifolia	1	-	-
Asclepias exaltata	1	-	-
Aster sagittifolius	1	-	-
Carex lurida	1	-	-
Carex muhlenbergii	1	-	-
Carex vulpinoidea	1	-	-
Cornus florida	1	-	-
Cypripedium reginae	1	-	-
Epilobium hirsutum	1	-	-
Euphorbia corallata	1	-	-
Habenaria unalascensis	1	-	-
Hedysarum alpinum	1	-	-
Helenium autumnale	1	-	-
Houstonea canadensis	1	-	-
Lepidium campestre	1	-	-
Lonicera japonica	1	-	-
Lupinus pelennis	1	-	-
Medicago lupulina	1	-	-
Melilotus officinalis	1	-	-
Mertensia paniculata	1	-	-
Ophioglossum vulgatum	1	-	-
Panicum xanthophysum	1	-	-
Polygala polygama	1	-	-
Polygonum punctatum	1	-	-
Polygonum ilinode	1	-	-
Polymnia canadensis	1	-	-
Ranunculus gmelini	1	-	-
Ranunculus pensylvanicus	1	-	-
Ranunculus rhomboidus	1	-	-
Rhus glabra	1	-	-
Rumex crispus	1	-	-
Salix lucida	1	-	-
Salix rigida	1	-	-
Smilacina trifolia	1	-	-
Stellaria media	1	-	-
Tragopogon pratensis	1	-	-

	Constancy WL	CL	AH		Constancy WL	CL	AH
Verbena urticifolia	1	-	-	Mimulus ringens	3	1	-
Veronica serpylifolia	1	-	-	Pyrola virens	3	1	-
Zygadenus glaucus	1	-	-	Carex sparganioides	3	1	-
Geranium robertianum	47	4	-	Dentaria laciniata	3	1	-
Solanum dulcamara	47	17	-	Potentilla simplex	3	1	-
Trillium grandiflorum	47	35	-	Phlox divaricata	3	2	-
Viola pubescens	29	10	-	Rhus typhina	3	2	-
Thalictrum dioicum	24	11	-	Salix discolor	3	2	-
Ribes americanum	23	18	-	Arabis divaricarpa	2	1	-
Lonicera dioica	23	10	-	Aster novae-angliae	2	1	-
Solidago caesia	22	14	-	Convolvulus spithaneus	2	1	-
Aquilegia canadensis	17	2	-	Corallorhiza striata	2	1	-
Lycopus americanus	17	5	-	Lobelia cardinalis	2	1	-
Hystrix patula	16	2	-	Prunus nigra	2	1	-
Anemone virginiana	16	6	-	Symphoricarpos alba	2	1	-
Galium obtusum	13	4	-	Tovara virginiana	2	1	-
Xanthoxylum americanum	12	6	-	Carex tetanica	2	1	-
Rhamnus cathartica	12	9	-	Osmorhiza longistylis	8	8	-
Anemone canadensis	10	1	-	Cerastium vulgatum	3	3	-
Sium suave	10	4	-	Hamamelis virginiana	2	2	-
Waldsteinia fragarioides	10	4	-	Veronica scutellata	2	2	-
Pyrola asarifolia	9	3	-	Agropyron repens	1	1	-
Cornus racemosa	8	1	-	Arenaria lateriflora	1	1	-
Solidago juncea	8	1	-	Comptosorus rhizophyllus	1	1	-
Carex eburnea	8	3	-	Cuscuta gronovii	1	1	-
Phryma leptostachya	8	4	-	Cypripedium calceolus var. pubescens	1	1	-
Carex lupulina	8	4	-				
Carex tenera	8	4	-	Epilobium leptophyllum	1	1	-
Arctostaphylos uva-ursi	7	1	-	Galium boreale	1	1	-
Comandra richardsiana	7	1	-	Lithospermum officinale	1	1	-
Viburnum rafinesquianum	7	1	-	Lycopodium tristachyum	1	1	-
Carex hitchcockiana	7	3	-	Melilotus alba	1	1	-
Carex aurea	6	1	-	Panicum latifolia	1	1	-
Eupatorium perfoliatum	6	4	-	Penthorum sedioides	1	1	-
Galium aparine	6	4	-	Rumex acetosella	1	1	-
Barbarea vulgaris	5	1	-	Solidago gigantea	1	1	-
Geranium maculatum	5	1	-	Solidago nemoralis	1	1	-
Linaria vulgaris	5	1	-	Sonchus arvensis	1	1	-
Typha latifolia	5	1	-	Carex laxiculmus	1	1	-
Carex retrorsa	5	1	-	Carex sprengelii	1	1	-
Triosteum aurantiacum	5	1	-	Carex umbellata	1	1	-
Ambrosia artemisiifolia	5	2	-	Cinna arundinacea	1	1	-
Solidago hispida	5	2	-	Poa nemoralis	1	1	-
Carex lacustris	5	3	-	Chelidonium majus	1	2	-
Ribes hirtellum	5	4	-	Juncus effusus	1	2	-
Monarda fistulosa	4	1	-	Lilium michiganiense	1	2	-
Nepeta cataria	4	1	-	Liparis loeselii	1	2	-
Carex platyphylla	4	1	-	Solidago uliginosa	1	2	-
Erigeron strigosus	4	2	-	Verbascum thapsus	1	2	-
Orchis spectabilis	4	2	-	Carex blanda	1	3	-
Rhamnus alnifolia	4	3	-	Carex tuvkermanii	1	3	-

	Constancy		
	WL	CL	AH
Scutellaria epilobiifolia	2	3	-
Asclepias incarnata	2	3	-
Alisma triviale	1	4	-
Athyrium pycnocarpon	1	4	-
Cephalanthus occidentalis	1	4	-
Desmodium glutinosum	1	4	-
Hieracium florentinum	1	4	-
Panax quinque folius	2	4	-
Salix bebbiana	3	5	-
Carex peckii	1	6	-
Menispermum canadense	3	6	-
Carex convoluta	4	7	-
Viburnum acerifolium	6	7	-
Oryzopsis racemosa	1	8	-
Carex albursina	8	9	-
Cicuta maculata	7	10	-
Prenanthes alba	2	11	-
Sanicula gregaria	1	12	-
Rubus (blackberry)	9	17	-
Mitella diphylla	14	21	-
Carex laxiflora	11	25	-
Ribes cynosbati	73	45	16
Taraxacum officinale	55	27	18
Dryopteris spinulosa	54	46	21
Epipactis helleborine	52	25	25
Carex pedunculata	52	43	22
Rhus radicans	51	37	5
Aster lateriflorus	48	33	12
Vitis riparia	45	28	3
Circaea quadrisulcata	45	34	8
Parthenocissus quinquefolia	44	33	5
Ranunculus abortivus	43	28	9
Fragaria virginiana	43	36	23
Equisetum arvense	42	26	12
Caulophyllum thalictroides	38	22	19
Impatiens capensis	36	32	31
Geum canadense	35	25	3
Asarum canadense	35	25	12
Poa compressa	33	4	1
Oryzopsis asperifolia	32	8	7
Cornus stolonifera	31	20	4
Dryopteris marginalis	28	27	22
Hydrophyllum virginianum	27	18	2
Prunella vulgaris	27	13	12
Ranunculus recurvatus	26	5	5
Carex plantaginea	26	11	5
Erigeron philadelphicus	25	10	2
Cystopteris bulbifera	23	4	3
Adiantum pedatum	22	12	12
Viola canadensis	21	14	7

	Constancy		
	WL	CL	AH
Hepatica acutiloba	21	18	2
Sambucus canadensis	21	18	9
Viola conspersa	20	13	4
Epilobium glandulosum	19	6	4
Laportea canadensis	19	18	5
Arctium minus	18	4	3
Sanguinaria canadensis	18	18	2
Celastrus scandens	17	9	1
Smilax herbacea	16	7	4
Agrimonia gryposepala	16	9	1
Ranunculus acris	16	11	7
Cypripedium calceolus	13	4	4
Rosa spp.	13	6	2
Lysimachia ciliata	13	7	4
Carex stipata	13	8	8
Fragaria vesca	12	2	2
Cornus rugosa	12	3	1
Smilacina stellata	12	3	2
Satureja vulgaris	11	1	1
Lactuca canadensis	10	10	5
Carex hirtifolia	9	1	1
Cystopteris fragilis	8	3	3
Carex normalis	8	5	3
Pilea pumila	8	5	4
Bidens frondosa	8	6	4
Dryopteris goldiana	8	7	1
Hypericum perforatum	7	3	2
Equisetum scirpoides	7	-	1
Leonorus cardiaca	6	1	1
Chrysanthemum leucanthemum	6	2	1
Spiraea alba	6	4	2
Antennaria spp.	6	6	2
Galium circaezans	5	1	1
Urtica dioica	5	5	1
Poa saltuensis	4	-	1
Dactylis glomerata	4	1	1
Elymus virginicus	4	3	1
Echinocystis lobata	4	3	3
Glechonia hederacea	3	1	1
Erigeron annuus	3	1	1
Carex scabrata	2	1	1
Myosotis scirpoides	3	-	1
Lonicera tartarica	2	1	1
Phleum pratense	2	1	2
Anaphalis mar	4	2	4
Festuca obtusa	5	4	5
Corallorhiza maculata	10	4	10
Ribes triste	16	14	16
Polygonatum pubescens	66	53	64
Arisaema atrorubens	64	43	58

	Constancy		
	WL	CL	AH
Glyceria striata	55	27	39
Actaea pachypoda	52	25	30
Rubus idaeus	49	30	44
Viola pensylvanica	41	31	36
Aster macrophyllus	34	13	15
Solidago flexicaulis	29	26	27
Solidago canadensis	28	11	16
Aralia racemosa	27	16	18
Apocynum androsaemifolium	25	8	9
Dentaria diphylla	23	15	18
Veronica officinale	21	5	11
Allium tricoccum	18	11	12
Eupatorium maculatum	17	5	8
Scutellaria lateriflora	17	8	10
Achillea millefolium	17	9	16
Carex communis	16	12	15
Melampyrum lineare	11	1	4
Caltha palustris	8	3	4
Ranunculus septentrionalis	7	1	4
Rumex obtusifolium	6	1	3
Epilobium angustifolium	6	1	4
Impatiens pallida	5	2	3
Trifolium pratense	1	1	1
Botrychium matricariaefolium	1	1	1
Pyrola rotundifolia	1	2	1
Gaylussacia baccata	3	3	3
Carex radiata	2	3	1
Viccia cracca	3	4	1
Symplocarpus foetidus	3	4	3
Lysimachia nummularia	3	5	2
Lysimachia terrestris	1	4	1
Agrostis perennans	1	5	1
Botrychium multifidum	1	6	2
Rubus odoratus	7	8	1
Danthonia spicata	4	8	3
Dirca palustris	8	9	5
Equisetum hyemale	6	9	2
Schizachne purpurascens	7	10	1
Amphicarpa bracteata	5	10	1
Carex crinita	6	11	9
Sanicula marilandica	11	12	8
Chimaphila umbellata	7	13	11
Eupatorium rugosum	13	15	11
Chelone glabra	9	15	14
Calamagrostis canadensis	8	15	7
Epifagus virginiana	8	15	8
Alnus rugosa	3	15	11
Viola cucullata	10	16	8
Gaultheria procumbens	4	16	7
Pteretis pensylvanica	7	18	12
Ilex verticillata	8	21	5
Dryopteris thelypteris	15	22	4
Viburnum lentago	12	22	3
Aster cordifolius	5	22	18
Iris versicolor	8	23	2
Lycopodium complanatum	2	23	14
Carex gracillima	16	24	18
Lycopus uniflorus	26	27	13
Uvularia grandiflora	23	28	4
Carex pensylvanica	18	28	11
Cypripedium acaule	2	28	16
Dicentra canadensis	7	29	20
Brachyeletrum erectum	9	30	21
Osmunda regalis	7	30	7
Carex rosea	37	39	4
Pteridium aquilinum	28	39	26
Onoclea sensibilis	38	56	37
Cardamine pensylvanica	2	1	4
Deschampsia flexuosa	4	1	5
Habenaria viridis	3	2	10
Linnaea borealis	12	6	13
Carex disperma	5	2	15
Habenaria psycodes	3	2	15
Mitella nuda	15	6	20
Athyrium thelypterioides	7	4	20
Viola septentrionalis	7	6	20
Aster puniceus	21	6	22
Dryopteris cristata	14	17	23
Diervilla lonicera	22	12	24
Circaea alpina	19	5	27
Poa pratense	22	8	33
Carex deweyana	25	21	37
Botrychium virginianum	36	27	44
Carex leptonervea	19	18	46
Dryopteris disjuncta	23	22	50
Viola selkirkii	13	4	50
Cinna latifolia	7	6	52
Viola renifolia	15	5	56
Oxalis montana	7	1	58
Smilacina racemosa	62	41	63
Galium triflorum	46	45	63
Sambucus pubens	49	35	65
Tiarella cordifolia	43	35	69
Viola blanda	1	2	3
Moneses uniflora	1	1	3
Carex trisperma	2	3	5
Geum macrophyllum	1	3	5
Vaccinium angustifolium	6	6	7
Milium effusum	1	4	7
Hieracium scabrum	2	4	8
Bromus ciliolatus	2	2	8

	Constancy		
	WL	CL	AH
Galium asprellum	2	2	8
Poa palustris	1	4	8
Pyrola secunda	7	8	9
Carex bromoides	2	4	9
Poa alsodes	1	2	11
Viburnum trilobum	8	9	12
Clematis virginiana	6	10	12
Polypodium virginianum	4	5	12
Ribes lacustre	1	3	12
Carex novae-angliae	1	8	13
Ribes glandulosum	6	6	14
Lycopodium clavatum	2	11	14
Vaccinium myrtilloides	3	14	15
Lactuca biennis	2	7	15
Carex projecta	5	11	18
Galeopsis tetrahit	1	1	18
Galium palustre	1	9	19
Hieracium aurantiacum	3	8	22
Lycopodium annotinum	1	8	22
Polystichum acrostichoides	15	16	25
Dicentra cucullaria	2	13	26
Thalictrum polygamum	11	14	27
Aster umbellatus	8	14	27
Carex brunnescens	7	9	27
Solidago rugosa	4	22	31
Osmorhiza claytoni	12	32	33
Cornus canadensis	12	21	35
Mitchella repens	18	34	40
Coptis groenlandicum	9	30	40
Lycopodium obscurum	4	36	42
Pyrola elliptica	14	32	43
Taxus canadensis	25	39	45
Medeola virginiana	7	30	45
Dryopteris novaborascensis	2	20	47
Rubus pubescens	36	43	53
Actaea rubra	28	35	53
Viburnum alnifolium	9	18	54
Osmunda claytoniana	9	15	54
Trillium undulatum	2	19	57
Erythronium americanum	8	52	60
Dryopteris phegopteris	1	6	63
Carex intumescens	22	29	64
Corylus cornuta	23	35	65
Cornus alternifolia	28	41	66
Lycopodium lucidulum	9	27	66
Carex arctata	35	42	67
Prenanthes altissima	21	36	67
Streptopus roseus	22	27	70
Aster acuminatus	3	27	75
Prunus virginiana	61	70	76
Trientalis borealis	23	49	77
Aralia nudicaulis	48	69	78
Clintonia borealis	19	41	80
Acer spicatum	19	27	82
Trillium erectum	4	46	82
Viola incognita	29	39	88
Dryopteris intermedia	48	60	89
Maianthemum canadense	70	80	93
Athyrium filix-femina	51	62	93
Poa trivialis	2	-	1
Senecio pauperculus	4	-	3
Habenaria hyperborea	8	-	4
Campanula rotundifolia	3	-	3
Berberis vulgaris	1	-	1
Apocynum cannabinum	1	-	1
Urtica procera	1	-	1
Selaginella rupestris	1	-	1
Carex castanea	1	-	1
Anemone quinquefolia	1	-	2
Pyrola virens	1	-	2
Habenaria obtusata	1	-	2
Plantago major	1	-	2
Lapsana communis	1	-	2
Prenanthes trifoliata	1	-	3
Habenaria orbiculata	1	-	3
Listera convallarioides	1	-	3
Carex leptalea	1	-	3
Epigaea repens	1	-	4
Petasitis palmatus	1	-	4
Luzula acuminata	1	-	4
Senecio aureus	1	-	10
Hydrocotyle americana	3	-	13
Actaea rubra f. neglecta	-	1	-
Aegopodium podograria	-	1	-
Bidens vulgatum	-	1	-
Cardamine bulbosum	-	1	-
Cardamine douglasii	-	1	-
Chamaedaphne calyculata	-	1	-
Cichorium intybus	-	1	-
Cirsium arvense	-	1	-
Comptonia peregrina	-	1	-
Corydalis sempervirens	-	1	-
Eleocharis obtusa	-	1	-
Equisetum fluviatile	-	1	-
Gentiana lineare	-	1	-
Gerardia tenuifolia	-	1	-
Glyceria canadensis	-	1	-
Heracleum lanatum	-	1	-
Houstonia caerulea	-	1	-
Hypericum ellipticum	-	1	-

	Constancy WL	CL	AH
Juncus bufonius	-	1	-
Lathyrus ochroleucus	-	1	-
Lemna trisulca	-	1	-
Lonicera oblongifolia	-	1	-
Lychnis flos-inculi	-	1	-
Lycopus europeus	-	1	-
Myosotis laxa	-	1	-
Oenethera perennis	-	1	-
Pastinacea sativa	-	1	-
Phalaris arundinacea	-	1	-
Phragmites commune	-	1	-
Physostegia virginiana	-	1	-
Polygonum arifolium	-	1	-
Potentilla anserina	-	1	-
Pyrus malus	-	1	-
Ranunculus flabellaris	-	1	-
Rhamnus frangula	-	1	-
Ribes sativum	-	1	-
Rubus allegheniensis	-	1	-
Rudbeckia laciniata	-	1	-
Rumex orbiculatus	-	1	-
Rumex verticillatus	-	1	-
Sagittaria latifolia	-	1	-
Sanicula trifoliata	-	1	-
Scirpus pedicellatus	-	1	-
Scirpus verecundus	-	1	-
Scrophularia lanceolata	-	1	-
Selaginella apoda	-	1	-
Solidago caesia X S. flexicaulis	-	1	-
Spiraea tomentosa	-	1	-
Spiranthes cernua	-	1	-
Symphytum officinale	-	1	-
Typha angustifolia	-	1	-
Carex amphibola	-	1	-
Carex comosa	-	1	-
Carex gracillescens	-	1	-
Carex granularis	-	1	-
Carex pseudocyperus	-	1	-
Carex tonsa	-	1	-
Carex tribuloides	-	1	-
Carex typhina	-	1	-
Carex vesicaria	-	1	-
Carex stricta	-	1	-
Agrostis gigantea	-	1	-
Amelanchier sanguinea	-	1	-
Amelanchier weigandii	-	1	-
Amelanchier humilis	-	1	-
Amelanchier bartramiana	-	1	-
Dryopteris hexagonoptera	-	1	-

	Constancy WL	CL	AH
Dulichium arundinacea	-	1	-
Panicum lanuginosum	-	1	-
Panicum tsugetorum	-	1	-
Poa languida	-	1	-
Sparganium eurycarpum	-	1	-
Stellaria longifolia	-	1	-
Sedum purpureum	-	1	-
Viola adunca	-	1	-
Viola sagittata	-	1	-
Aster simplex	-	2	-
Calla palustris	-	2	-
Claytonia virginica	-	2	-
Hypericum virginicum	-	2	-
Leersia virginica	-	2	-
Salix petiolaris	-	2	-
Staphylea trifoliata	-	2	-
Carex backii	-	2	-
Carex folliculata	-	2	-
Carex grayii	-	2	-
Panicum boreale	-	2	-
Viola rostrata	-	2	-
Acalypha rhomboidea	-	3	-
Dryopteris cristata var. clintoniana	-	3	-
Lemna minor	-	3	-
Potentilla norvegica	-	3	-
Rubus occidentalis	-	3	-
Amelanchier spicata	-	3	-
Botrychium dissectum forma obliqua	-	4	-
Cicuta bulbifera	-	4	-
Leerzia oryzoides	-	4	-
Lythrum salicaria	-	4	-
Scirpus atrovirens	-	4	-
Trifolium repens	-	4	-
Trillium erectum var. viridiflorum	-	5	-
Viola incognita var. forbesii	-	6	-
Viola sororia	-	10	-
Viburnum cassinoides	-	30	25
Spiraea latifolia	-	22	10
Oxalis stricta	-	18	9
Rubus hispida	-	17	1
Boehmeria cylindrica	-	12	1
Kalmia angustifolia	-	12	9
Pyrus melanocarpa	-	8	3
Mentha arvensis	-	6	5
Trillium cernuum	-	4	1
Cryptotaenia canadensis	-	4	3

	Constancy		
	WL	CL	AH
Geum allepicum	-	3	1
Cirsium vulgare	-	3	1
Muhlenbergii mexicana	-	2	1
Hieracium vulgatum	-	2	1
Osmunda cinnamomea	-	33	33
Lonicera canadensis	-	30	71
Claytonia caroliniana	-	22	38
Monotropa uniflora	-	22	42
Uvularia sessilifolia	-	18	23
Panax trifolium	-	14	16
Equisetum sylvaticum	-	13	15
Dalibarda repens	-	13	18
Nemopanthus mucronata	-	11	13
Dennstaedtia punctilobula	-	11	55
Carex debilis	-	7	25
Viola pallens	-	4	18
Botrychium dissectum	-	4	4
Ledum groenlandicum	-	3	4
Goodyera tesselata	-	2	4
Zizia aurea	-	2	4
Malaxis unifolia	-	2	3
Agrostis palustris	-	2	3
Veratrum viride	-	1	14
Polygonum cilinode	-	1	5
Monotropa hypopithys	-	1	3
Equisetum pratense	-	1	3
Saxifraga virginiensis	-	1	3
Spiranthes lacera	-	1	3
Goodyera repens	-	1	2
Lobelia inflata	-	1	1
Glyceria melicaria	-	1	1
Panicum linearifolium	-	1	1
Elymus canadensis	-	1	1
Goodyera pubescens	-	1	1
Gentiana andrewsii	-	1	1
Habenaria hookeri	-	1	1
Habenaria macrophylla	-	1	1
Viola septentrionalis X V. cucullata	-	1	1
Botrychium lanceolatum	-	1	1
Carex pallescens	-	1	1
Carex cannescens	-	1	1
Berberis thurnbergii	-	1	1

	Constancy		
	WL	CL	AH
Stachys palustris	-	1	1
Aster johannensis	-	-	1
Woodsia ilvensis	-	-	1
Botrychium simplex	-	-	1
Viburnum edule	-	-	1
Stellaria longipes	-	-	1
Daphne mesereum	-	-	1
Stellaria calycantha	-	-	1
Solidago graminiifolia	-	-	1
Polygonum sagittatum	-	-	1
Plogonum hydropiper	-	-	1
Panicum xanthophysum	-	-	1
Muhlenbergii frondosa	-	-	1
Luzula campestris	-	-	1
Lonicera oblongifolia	-	-	1
Listera cordata	-	-	1
Hesperis matronalis	-	-	1
Carex swanii	-	-	1
Carex prasina	-	-	1
Geum lacianatum	-	-	1
Gnaphalium macounii	-	-	1
Habenaria dilatata	-	-	1
Heracleum maximum	-	-	1
Circaea canadensis	-	-	2
Agrimonia striata	-	-	2
Rhododendron canadense	-	-	2
Agrostis scabra	-	-	2
Carex deflexa	-	-	2
Solidago puberula	-	-	3
Rubus canadensis	-	-	3
Alnus crispa var. mollis	-	-	4
Polystichum braunii	-	-	4
Juniperus communis var. depressa	-	-	4
Cirsium muticum	-	-	4
Gaultheria hispidula	-	-	4
Festuca rubra	-	-	5
Streptopus amplexicaulis	-	-	8
Senecia robbinsii	-	-	9
Corallorhiza trifida	-	-	9
Viola rotundifolia	-	-	11
Solidago macrophylla	-	-	14

SUMMARY

Quantitative data for the tree, shrub and herb strata were collected in 141 Northern Conifer-Hardwood stands randomly selected throughout south-eastern Ontario and south-western Quebec.

A major concern in the analysis was to determine the relationship and distribution of all species to certain edaphic and environmental features. Successional trends were analyzed for the occurrence and importance of contributing arboreal elements to the various facets of vegetational types. Being continuous with the Western Lowlands on the one hand, and proximal to the Appalachian Highlands region on the other, indices of similarity and regional influence were applied.

Relative frequency-relative density-dominance values were calculated for all tree species and incorporated into an Importance Value Index, by summing all three values mentioned. Constancy and average importance values were also calculated, as were constancy and average frequency values for the shrub and herb stratum.

Soil moisture is shown to be the overriding environmental factor influencing the distribution and importance of all species encountered, and especially so of the tree elements. All stands were, as such, distributed along a predetermined moisture gradient while assembling data in the field. Constancy and average importance values for trees and constancy and average frequency values for herbs and shrubs were averaged for each of the five moisture categories.

The majority of species, when graphed to illustrate their performance on the moisture gradient, show a variety of amplitudes of ecological tolerance. The analysis of certain successional tendencies shows a definite correlation and continuity in the occurrence and importance of all tree and understory elements encountered within the Central St. Lawrence Lowlands.

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APPENDIX 1

STATION LIST

Stand No.	Nat.T.M.	County	Nearest Municipality	Tree Dominants	Moisture	Date	Observers
1003	31G/10E	Prescott	Hawkesbury	*Ua-Fn-Ar-Fp-As	W	01/06/62	PFM,RG
1004	31G/11W	Russell	Clarence	*As-Ta-Fg-Pgr-Ov	M	02/06/62	PFM,RG
1005	31F/ 1E	Carleton	Ashton	*Ua-Fp-Ta-Fn-To	W	03/06/62	PFM,RG
1012	31H/12W	Deux Montagnes	St. Eustache	*As-Fg-Ta-Ov-Cc	M	20/06/62	PFM,RG
						24/05/68	JO,AB
1031	31H/12E	Jacques Cartier	Saraguay	*As-Ta-Ua-Fp-Ov	DM	08/10/62	PFM
						25/05/68	JO
1034	31G/ 8E	Soulanges	Coteau du Lac	*Asa-Ua-Ta-Fa-As	WM	09/05/63	PFM,JL,GD
1035	31G/ 1W	Glengarry	Lancaster	*Bpop-Ua-Pt-Pb-Fp	W	11/05/63	PFM,JL,GD
1036	31H/12E	Jacques Cartier	Dollard des Ormeaux	*To-Ab-Pgl-Tc-Bp	DM	25/05/66	PFM,BD
1037	31G/ 2E	Glengarry	Loch Garry	*Pt-Bp-Cc-To-Ua	DM	13/05/63	PFM,JL,GD
1038	31G/ 2W	Glengarry	Apple Hill	*As-Ua-Ta-Fg-An	M	14/05/63	PFM,JL,GD
1039	31G/ 3W	Dundas	Winchester	*Ua-To-Ar-Asa-Fp	WM	15/05/63	PFM,JL,GD
1040	31B/13W	Lanark	Merrickville	*As-Ut-Cc-Ov-Fa	DM	16/05/63	PFM,JL,GD
1041	31B/12W	Leeds	Addison	*Asa-Ua-Fn-Fp-To	W	17/05/63	PFM,JL,GD
1042	31B/12W	Leeds	Butternut Bay	*As-Ar-Ua-Fa-Cc	M	19/05/63	PFM,JL,GD
1077	31H/ 5W	Jacques Cartier	Beaurepaire	*Ua-Fp-Fn-Ar-Fa	W	25/08/63	GD
1079	31H/ 5W	Vaudreuil	Ile Perrot I	*Tc-Ar-Fp-Bl-Ua	DM	01/10/63	PFM
						27/05/68	JO,AB
1080	31H/ 5E	Jacques Cartier	Cote St. Luc	*Asa-Fp-Ua-Ta	WM	21/10/63	PFM,AA
						23/05/68	JO
1084	31I/ 1E	Nicolet	Defoy	*Bpop-Ar-Pt-Pp-Bp	W	10/09/64	GD
1086	31H/12W	Deux Montagnes	Ste. Marthe	*Ua-Bpop-Ar-Pt-Ps	W	20/06/64	GD
						28/05/68	PFM,JO
1089	31H/ 5W	Jacques Cartier	Morgan Arboretum	*Ar-Co-Fp-Ta-Ua	WM	03/10/61	PFM
						22/05/68	JO,AB
1090	31H/12W	Terrebonne	Morris Island I	*Ta-As-An-Ua-Tc	M	29/09/65	PFM,BD
						24/05/68	JO,AB
1091	31H/12E	Jacques Cartier	Blvd. L'Acadie	*Fa-Ua-Ur-Ta-As	WM	23/10/67	PFM,JO
						23/05/68	JO,AB

CONTINUED

1092	31H/ 5W	Vaudreuil	Ile Perrot III	*Bpop-Ar-Pt-Bp-Pse	WM	05/10/67	PFM,JO
						22/05/68	JO
1093	31H/ 4W	Chateauguay	Cairnside	*Pri	D	18/05/66	PFM,BD
1177	31H/ 5W	Vaudreuil	Ile Perrot II	*Pre-Ps-Tc-Qr-Qa	D	20/09/69	JO
						28/05/68	JO,AB
1178	31H/12W	Terrebonne	Lorraine	*Ps-Ar-Fg-Ab-Bpop	DM	26/10/66	PFM
						27/05/68	PFM,JO,AB
1179	31H/ 4W	Chateauguay	Ste. Martine	*Ps-Ar-Ab-Ov-Pgr	DM	10/05/68	PFM,JO,AB
1181	31H/14W	Berthier	Lavaltrie	*Ar-To-Bl-Ll-Tc	WM	27/06/67	PFM,JO
						27/05/68	JO,AB
1182	31H/14W	Berthier	Lanoraie	*Pre-Ps-Bpop	D	28/06/67	PFM,JO
						07/06/68	JO
1183	31H/13E	Montcalm	St. Jacques	*As-Ta-Fa-Ov-Bl	M	28/06/67	PFM,JO
						07/05/68	JO,AB
1184	31H/12E	Terrebonne	Montée Masson	*As-Ta-Cc-Ov-Ua	M	06/07/67	PFM,JO
						27/05/68	PFM,JO,AB
1185	31H/11E	Rouville	Ste. Madeleine I	*Bpop-Ar-Ps-Pt	WM	20/07/67	PFM,JO
						04/06/68	JO,AB
1186	31H/11E	St. Hyacinthe	Ste. Madeleine II	*Tc-Ar-Bp-Ps-Bl	WM	20/07/67	PFM,JO
						04/06/68	JO,AB
1187	31I/ 2W	Yamaska	St. Gérard	Ps-Ar-Ab-Bpop	DM	21/07/67	PFM,JO
1188	31H/14E	Verchères	Lisieux	Pre-Ps-Bp-Qr	D	22/07/67	PFM,JO
1189	31H/ 6W	St. Jean	St. Jean	Asa-Fp-Ar-Ua	W	30/07/67	PFM,JO
1190	31B/14W	Dundas	Iroquois	*As-Tc-Ar-Bl-Ta	M	05/08/67	PFM,JO
						16/05/68	PFM,JO,AB
1191	31B/14E	Stormont	Ingleside	*Ua-Fp-Asa-Ar-Fn	W	06/08/67	PFM,JO
						16/05/68	PFM,JO,AB
1192	31G/ 2W	Stormont	Long Sault Pkwy.	*Cc-Ov-Fa-Ua-Ur	DM	07/08/67	PFM,JO
						16/05/68	PFM,JO,AB
1193	31G/ 1W	Huntingdon	St. Anicet	*As-Fg-Qr-Ta-Ov	DM	14/05/68	PFM,JO,AB
1194		St. Lawrence N.Y. State	Racquette River	*Tc-As-Fg-Ar-Ps	M	15/05/68	PFM,JO,AB
1195	31G/ 2W	St. Lawrence N.Y. State	Cornwall Bridge	*Qr-Qa-As-Ar-Co	D	15/05/68	PFM,JO,AB

CONTINUED

1196	31B/13E	Grenville	Groveton	*As-Ov-Fg-Ta-Fa	M	26/05/69	JO,HG
						17/05/68	PFM,JO,AB
1197	31G/ 4E	Carleton	Carsonby	*Ua-Ta-As-Fn-Fp	WM	13/09/68	JO
						17/05/68	PFM,JO,AB
1198	31G/ 5W	Carleton	South March	*Qm-Ov-Cc-Ut-Fa	D	30/05/68	PFM,JO,AB
						17/05/69	JO,HG
1199	31F/ 7E	Renfrew	Goshen	*As-Ov-Fg-Ps-Ua	DM	18/05/68	PFM,JO,AB
1200	31F/ 8E	Carleton	Antrim	*Ta-Fn-Ua-An	WM	30/05/69	JO,HG
						18/05/68	PFM,JO,AB
1201	31H/ 5W	Vaudreuil	Ile Perrot	*Ar-Fg-Ta-Fa-Co	WM	22/05/68	JO,AB
1203	31H/12W	Terrebonne	Ile de Mai	*Qm-Asa-Ua-An	WM	09/06/69	JO
						28/05/68	PFM,JO,AB
1204	31G/ 8E	Deux Montagnes	Oka Provincial Pk.	*Ps-Qr-Pgr-Qa	D	07/06/69	JO
						28/05/68	PFM,JO,AB
1205	31H/11E	Rouville	Ste. Madeleine	Ar-Ps-Ll-Ab-Pgl	WM	25/08/69	JO
1207	31G/ 1E	Huntingdon	Rockburn	*As-Ta-Cc-Pgr	M	05/07/69	JO
						30/05/68	PFM,JO
1208	31H/ 3W	St. Jean	Montée Henrysburg	*As-Fa-Ov-Cc	DM	25/09/69	JO
						30/05/68	PFM,JO
1209	31H/ 3E	Missisquoi	Phillipsburg	*Ov-As-Ta-Ur	DM	05/07/69	JO
						31/05/68	PFM,JO
1211	31I/ 8W	Nicolet	Rivière Gentilly	Asa-Fp-Fa-Ar	W	28/08/69	JO
1213	31I/ 3E	Berthier	Berthierville	Fn-Ar-To-Ab-Bl	WM	06/09/69	JO,LG
1215	21L/14E	Montmorency	St.Pierre - Ile d'Orléans	*Fg-As-Bl	DM	06/06/68	JO,AB,GL
1224	21L/15E	Montmagny	Berthier	*Fg-As-Ar	DM	08/09/69	JO
						08/07/68	JO
1225	31H/12W	Laval	Laval Ouest	Ua-Asa-Ll-Pgl-Fn	W	23/07/68	JO
1226	31H/ 5W	Beauharnois	Melocheville	As-Fa-Qr-Ar-Co	M	07/07/69	JO
1227	31G/ 8E	Beauharnois	St. Timothée	Ar-Bpop-Tc	WM	03/07/69	JO
1228	31H/12W	Terrebonne	Ste.Anne des Plaines	As-Ar-Ta-Tc-Fg	M	30/07/68	JO,MW
1229	31H/12E	L'Assomption	Terrebonne	*Asa-Ar-Fn	W	12/08/69	JO
						06/06/68	JO,MW

CONTINUED

1260	31H/13E	L'Assomption	Mascouche	Qr-Ar-Ps-As-Fg	D	12/08/68	JO,MW
1261	31H/13W	Terrebonne	Ste. Sophie	Pt-Bpop-Ll-Ab-Ps	WM	13/08/68	JO,MW
1262	31I/ 3W	Joliette	Joliette	Ar-As-Ps	M	13/08/68	JO,MW
1263	31I/ 3W	Berthier	St. Norbert	Pt-Bpop-Ar-Bp	WM	15/08/68	JO,MW
1264	31H/12W	Terrebonne	Morris Isle II	Cc-Ta-Ua-Asa-Qb	WM	27/08/68	PFM,JO,MW
1265	31H/12W	Terrebonne	Morris Isle III	Asa-Ua	W	27/08/68	PFM,JO,MW
1266	31H/ 3W	Napierville	Napierville	As-Fg-Ar-Tc-Fa	M	29/08/68	PFM,JO,MW
1267	31H/ 3W	St. Jean	Noyan	*Asa-Fp-Ua-Ar-Fa	W	29/08/68	PFM,JO,MW
						30/06/68	PFM,JO
1268	31H/ 3W	Mississquoi	Ash Island I	*Qb-Ua-Qm-Fp-Asa	W	30/08/68	PFM,JO,MW
	"					30/06/68	PFM,JO
1269	31H/ 3W	Mississquoi	Ash Island II	*Asa-Ua-Fp-S-Qb	W	30/08/68	PFM,JO,MW
						30/06/68	PFM,JO
1270	31G/ 9E	Deux Montagnes	St. Canut	Ar-As-Ab-Ps	M	02/09/68	JO
1271	31G/ 1W	Huntingdon	Fraser's Point	*Asa-Fp-Ua-Fn-Ar	W	04/09/68	JO
						14/05/68	PFM,JO,AB
1272	NYstate	St. Lawrence	Reynold's Aluminum	Ar-Tc-Ta-Fp-As	WM	05/09/68	JO
1273	31G/ 2W	Stormont	Cornwall I	Ar-Tc-Ps-Asa-Bl	WM	06/09/68	JO
1274	31B/14W	Grenville	Pittston	*Pt-Pb-Bp-Ll-Bpop	WM	08/09/68	JO
						14/05/68	PFM,JO
1275	31G/ 5E	Carleton	Jock River	Ar-Bp-Qr-Ta-Qm	DM	10/09/68	JO
1276	31B/14W	Grenville	Johnstown	*Sn-Asa-Fp-Ua-S	W	10/09/68	JO
						02/06/68	PFM,JO,AB
1277	31G/ 1E	Beauharnois	Beauharnois Canal	Sn-S	W	13/10/68	PFM,JO,AB
1278	31H/12W	Terrebonne	St. Janvier	Ps-Pre-Ar-Bpop-Ab	D	10/10/68	PFM,JO,AB,MW
1279	31G/ 8E	Vaudreuil	Hudson Heights	Fg-As-Qr-Tc-Ar	DM	17/10/68	PFM,JO,AB,MW
1280	31H/ 5E	Jacques Cartier	Ile St. Paul	Ua-Fp-Asa-Ta	WM	24/10/68	PFM,JO,AB,MW
1281	31H/16W	Drummond	Ste. Brigitte	Ar-As	DM	26/09/69	JO,LG
1283	31H/12E	Jacques Cartier	La Réparation	*Ar-Ua-Fa-Qr-Fp	WM	12/05/69	PFM,JO,AB,HG
1284	31G/ 8E	Vaudreuil	Ville Ile Cadieux	*Pse-Qr-Ar-Fg-Bp	M	14/05/69	JO,HG
1285	31H/ 5W	Jacques Cartier	Terrasse Vaudreuil	*As-Ta-Fa-Ar-Ua	M	15/05/69	JO,HG

CONTINUED

1286	31G/ 8E	Vaudreuil	St. Lazare Station	*Tc-Ar-Bl-Pru	WM	15/05/69	JO,HG
1287	31G/ 8E	Soulanges	Les Cèdres	*Ar-Ua-Qr	WM	16/05/69	JO,HG
1288	31G/ 8E	Soulanges	Coteau sur le Lac	*As-Pse-Ta-Fa-Ur	M	17/05/69	JO,HG
1289	31G/ 8W	Soulanges	Dalhousie Stn.	*As-Ta-Ov	M	17/05/69	JO,HG
1290	31G/ 2E	Glengarry	Glen Gordon	*To-Pgl	M	18/05/69	JO,HG
1291	31G/ 2E	Glengarry	Williamstown	*Ps-Bpop	DM	18/05/69	JO,HG
1292	31H/ 5E	Jacques Cartier	Petit Bois Franc	*Ar-Ua-Asa-Fa	W	20/05/69	JO,HG
1293	31G/ 2W	Stormont	Cornwall Centre II	*Tc-Ar-Fg-Ps	WM	21/05/69	JO,HG
1294	31G/ 2W	Stormont	Northfield	*To-Ll-Pgl-Ua	W	22/05/69	JO,HG
1295	31G/ 7W	Stormont	Maxville	Pt-Ar-Ua-Pb	W	22/05/69	JO,HG
1296	31G/ 3E	Dundas	Chesterville	*Bpop-Ar-Pp	WM	24/05/69	JO,HG
1297	31G/ 4E	Carleton	Osgoode	*Ar-Fa-Ua-As	WM	25/05/69	JO,HG
1298	31G/ 4E	Grenville	Kemptville	*Ar-Fa-Bl-As-Ta	WM	25/05/69	JO,HG
1299	31B/13W	Lanarck	Nolan's Corner	*Ut-As-Fa-Ta-Qm	DM	28/05/69	JO,HG
1371	31G/ 4W	Carleton	Stapledon	*Ar-Bp-Pt-To-Ab	DM	29/05/69	JO,HG
1372	31G/ 9E	Deux-Montagnes	La Trappe	*Ar-Fa-Pp-Ta-Ov	DM	08/06/69	JO
1373	31H/12W	Deux-Montagnes	Fresnière	*Ar-Tc-Bpop-Ab	WM	10/06/69	JO
1374	31G/ 9W	Deux-Montagnes	Pointe aux Anglais	*Ar-As-Fg-Bl-Ta	M	11/06/69	JO
1375	31G/ 9E	Deux-Montagnes	St. Placide	*Ar-Pgr-Bl-Tc-Bp	DM	12/06/69	JO
1376	31G/ 9W	Argenteuil	St. André Est	*As-Qr-Ta-Ov-Cc	M	12/06/69	JO
1377	31G/ 9E	Argenteuil	Brown's Gore	*Ab-Ar-To-Tc-Bl	WM	16/06/69	JO
1378	31G/ 9W	Argenteuil	Chatboro	*Ar-Bpop-Ps-Pse	WM	17/06/69	JO
1379	31G/ 9E	Deux-Montagnes	Ste. Scholastique	*Pt-Pp-Ar	WM	18/06/69	JO
1380	31H/13E	L'Assomption	Cabane Ronde	*Ar-Fg-Tc-Qr-Pse	DM	19/06/69	JO
1381	31I/ 6E	Maskinonge	Ste. Ursule	Bpop-Ar-Pt-S	W	01/07/69	JO
1382	31H/ 5E	Napierville	Cote Ste. Thérèse	As-Fg-Ta-Fa-Pgr	M	04/07/69	JO
1383	31H/ 4W	Huntingdon	St. Antoine Abbé	Ar-As-Tc	DM	05/07/69	JO
1384	31H/ 3W	St. Jean	Roxham	Pt-Fp-Ua-Bl-Ar	WM	06/07/69	JO
1385	31H/ 2W	Missisquoi	Farnham Centre	Bpop-Pt-Ar	WM	11/08/69	JO
1386	31G/ 8W	Vaudreuil	Rigaud Mtn I	As-Ua-Ur-Jc-Pse	M	02/08/69	JO
1387	31G/ 8W	Vaudreuil	Ste. Justine	*To-Pgl	M	03/08/69	JO
						14/05/68	PFM,JO,AB
1388	31H/ 6W	Chambly	Chambly	Ps-Ar-Ua-Fa	DM	10/08/69	JO

CONTINUED

1389	31H/ 6E	Iberville	Ste. Brigitte	As-Ar-Ov	M	11/08/69	JO
1390	31H/ 7W	Shefford	Granby	Tc-Ar-Bpop-Pru-Fa	WM	12/08/69	JO
1391	31I/ 8W	Nicolet	Gentilly	Fg-As-Ar-Ta-Bl	M	15/08/69	PFM,JO,MW
1392	21L/14E	Montmorency II	St. Laurent d'Orléans	Qr-As-Ov-Bp	D	17/08/69	PFM,JO,MW
1393	21L/12E	Portneuf	St. Augustin	Ua-Fp-Fn-Cr	W	18/08/69	PFM,JO,MW
1394	31I/ 7W	St. Maurice	Yamachiche	Ab-Ar-Bl-To	W	09/09/69	JO
1395	31I/ 7E	St. Maurice	Les Vieilles Forges	Ar-Bpop-Pm-Ll	W	10/09/69	JO
1396	21L/11W	Lévis	St. Nicolas	Ar-Fg-As-Bp-Qr	DM	28/09/69	JO
1397	21L/ 5W	Lotbinière	Villeroy	Ar-Bl-Tc-Pgl	WM	27/09/69	JO
1398	21M/ 1W	L'Islet	St. Eugène	As-Fg-Tc-Qr-Pse	DM	30/09/69	JO
1399	21M/ 1W	Montmagny	Cap St. Ignace	As-Ov-Fa-To	DM	02/10/69	JO
1400	21L/11W	Lévis	St. Etienne de Lauzon	Ar-Bp-Bpop-Ab	WM	04/10/69	JO
1401	21L/11W	Lévis	Chaudière Bassin	Ps-Qr-Pre-Pr	D	04/10/69	JO
1402	31I/ 8W	Champlain	Champlain	Ps-Ar-Pgr-Ab	D	05/10/69	JO
1403	31H/15E	Yamaska	St. Joachim	Qr-Ar-Pse-Fa-Pp	WM	27/08/69	JO
1404	21L/12W	Lotbinière	Lotbinière	Qr-Fg-Ar-As	DM	31/08/69	JO
1405	31I/ 3E	Berthier	St. Ignace	Tc-Ar-Bl-Qr	WM	08/09/69	JO
1406	31G/ 8W	Vaudreuil	Rigaud Mtn. II	Ps-Tc-Pre	D	11/10/69	JO,LG
1407	31G/10W	Prescott	Alfred	Pt-Ar-Pgr-Bp-Pse	WM	12/10/69	JO,LG
1408	31G/11E	Prescott	Plantagenet	Bpop-Pt	WM	12/10/69	JO,LG
1409	31G/11W	Russell	Cumberland	As-Ov-Tc	DM	13/10/69	JO,LG

KEY TO ABBREVIATIONS

Nat. T.M. - National Topographic Maps (1/50,000 scale)

Tree Abbreviations

Ab - Abies balsamea
An - Acer nigrum
Ar - Acer rubrum
As - Acer saccharum
Asa - Acer saccharinum
Bl - Betula lutea
Bp - Betula papyrifera
Bpop - Betula populifolia
Cc - Carya cordiformis
Co - Carya ovata
Fa - Fraxinus americana
Fg - Fagus grandifolia
Fn - Fraxinus nigra
Fp - Fraxinus pennsylvanica
Jc - Juglans cinerea
Ll - Larix laricina

Ov - Ostrya virginiana
Pb - Populus balsamifera
Pgl - Picea glauca
Pgr - Populus grandidentata
Pm - Picea mariana
Pp - Prunus pensylvanica
Pre - Pinus resinosa
Pri - Pinus rigida
Pru - Picea rubens
Ps - Pinus strobus
Pse - Prunus serotina
Pt - Populus tremuloides
Qa - Quercus alba
Qb - Quercus bicolor
Qm - Quercus macrocarpa
Qr - Quercus rubra

S - Salix spp.
Sn - Salix nigra
Ta - Tilia americana
Tc - Tsuga canadensis
To - Thuja occidentalis
Ua - Ulmus americana
Ur - Ulmus rubra
Ut - Ulmus thomasi

Cr - Crataegus spp.

Moisture Segment Abbreviations

D - dry   DM - dry-mesic   M - mesic   WM - wet-mesic   W - wet

* Stands surveyed in spring season for vernal species

Abbreviations for Observers

AB - André Bouchard
AA - Allan Auclair
GD - Gavin Daly
BD - Brian Davies

HG - Howard Gilbey
LG - Louise Gohier
RG - Robert Goodland
JL - John Lambert

GL - Gisèle Lamoureux
PFM - Paul F. Maycock
JO - Jacques Op de Beeck
MW - Michael Warder

APPENDIX:

Samples of all data sheets used.

Data Form No. 1 | Plant Ecology Research | University of Toronto

STAND RECORD | FORESTS | Stand No.

Name: Locality:
County: T: C: L:
Date: Observers:
Size of Stand: Size of Area Sampled:
Forest Type: Soil Type:
Topography: Slope: Directions

Condition of Stand:

Open Grown Trees: % Canopy:
Stumps:

1.	4.	7.	10.
2.	5.	8.	11.
3.	6.	9.	12.

Soil Data:

	pH	N	P	K	Ca	Mg	Org. Mat.	Colloids	W.H.C.		
A_o											
A_1											
A_2											
B											

	DEPTH	CHARACTERISTICS (Color, Texture, Structure, etc.)
A_o		
A_1		
A_2		
B		

Parent Material:

Map:

Plant Ecology Research

Data Form No. 12 PRESENCE

NORTHERN CONIFER-HARDWOOD FOREST

McGill University STAND NO.

TREES

Abies balsamea
Acer negundo
Acer nigrum
Acer pensylvanicum
Acer rubrum
Acer saccharinum
Acer saccharum
Amelanchier spp.
Betula lutea
Betula papyrifera
Carpinus caroliniana
Carya cordiformis
Carya ovata
Crataegus spp.
Fagus grandifolia
Fraxinus americana
Fraxinus nigra
Fraxinus pennsylvanica
Juniperus virginiana
Juglans cinerea
Larix laricina
Ostrya virginiana
Picea glauca
Picea mariana
Picea rubens
Pinus strobus
Pinus resinosa
Populus balsamifera
Populus grandidentata
Populus tremuloides
Prunus pensylvanica
Prunus serotina
Quercus alba
Quercus macrocarpa
Quercus rubra
Quercus velutina
Salix nigra
Thuja occidentalis
Tilia americana
Tsuga canadensis
Ulmus americana
Ulmus rubra
Ulmus thomasi

SHRUBS AND HERBS

Acer spicatum
Achillea millefolium
Actaea pachypoda
Actaea rubra
Adiantum pedatum
Agrimonia gryposepala
Allium tricoccum
Alnus rugosa
Amphicarpa bracteata
Anemone quinquefolia
Anemone virginiana
Antennaria spp.
Apocynum androsaemifolium
Aquilegia canadensis
Aralia nudicaulis
Aralia racemosa
Arctostaphylos uva-ursi
Arenaria lateriflora
Arisaema atrorubens
Asarum canadense
Aster acuminatus
Aster cordifolius
Aster lateriflorus
Aster macrophyllus
Aster puniceus
Aster umbellatus
Athyrium filix-femina
Athyrium thelypterioides
Bidens frondosa
Boehmeria cylindrica
Botrychium virginianum
Brachyelytrum erectum
Calamagrostis canadensis
Caltha palustris
Carex arctata
Carex brunnescens
Carex crinita
Carex communis
Carex deweyana
Carex eburnea
Carex gracillima
Carex intumescens
Carex laxiflora
Carex pedunculata
Carex pensylvanica
Carex plantaginea
Carex rosea
Carex stipata
Caulophyllum thalictroides
Ceanothus americanus
Celastrus scandens
Chamaedaphne calyculata
Chelone glabra
Chimaphila umbellata
Chrysosplenium americanum
Cicuta maculata
Circaea alpina
Circaea quadrisulcata
Clematis verticillaris
Clintonia borealis
Comandra richardsiana
Comptonia peregrina
Coptis groenlandicum
Corallorhiza maculata
Cornus alternifolia
Cornus canadensis
Cornus racemosa
Cornus rugosa
Cornus stolonifera
Corylus cornuta
Cypripedium acaule
Cypripedium calceolus
Cryptotaenia canadensis
Cystopteris bulbifera
Cystopteris fragilis
Dennstaedtia punctilobula
Dentaria diphylla
Dentaria laciniata
Desmodium acuminatum
Dicentra canadensis
Dicentra cucullaria
Diervilla lonicera
Dirca palustris
Dryopteris disjuncta
Dryopteris cristata
Dryopteris goldiana
Dryopteris intermedia
Dryopteris palustris
Dryopteris marginalis
Dryopteris noveboracensis
Dryopteris spinulosa
Epifagus virginiana
Epilobium glandulosum
Epipactis helleborine
Equisetum arvense
Equisetum hiemale
Equisetum scirpoides
Equisetum sylvaticum
Epigaea repens
Erigeron philadelphicus
Erigeron strigosus
Erythronium americanum
Eupatorium maculatum
Eupatorium perfoliatum
Eupatorium rugosum
Fragaria vesca
Fragaria virginiana
Galium aparine
Galium boreale
Galium lanceolatum
Galium obtusum
Galium triflorum
Gaultheria procumbens

Data Form No. 12a

Stand No.

Geranium maculatum
Geranium robertianum
Geum aleppicum
Geum canadense
Geum rivale
Glyceria striata
Habenaria hyperborea
Habenaria orbiculata
Habenaria psycodes
Hepatica acutiloba
Hepatica americana
Hieracium aurantiacum
Hieracium scabrum
Hydrophyllum virginianum
Hypericum perforatum
Hystrix patula
Ilex verticillata
Impatiens capensis
Impatiens pallida
Iris versicolor
Juniperus communis
Kalmia angustifolia
Kalmia polifolia
Laportea canadensis
Ledum groenlandicum
Lilium canadense
Lilum philadelphicum
Lindera benzoin
Linnaea borealis
Lonicera canadensis
Lonicera dioica
Lonicera hirsuta
Luzula acuminata
Lycopodium annotinum
Lycopodium clavatum
Lycopodium complanatum
Lycopodium lucidulum
Lycopodium obscurum
Lycopus americanus
Lycopus uniflorus
Lysimachia ciliata
Lysimachia quadrifolia
Lysimachia thyrsiflora
Maianthemum canadense
Medeola virginiana
Melampyrum lineare
Menispermum canadense
Mitchella repens
Mitella diphylla
Mitella nuda
Monotropa uniflora
Myosotis scorpioides
Onoclea sensibilis
Oryzopsis asperifolia
Oryzopsis racemosa

Osmorhiza claytoni
Osmorhiza longistylis
Osmunda cinnamomea
Osmunda claytoniana
Osmunda regalis
Oxalis montana
Panax quinquefolius
Panax trifolius
Parthenocissus quinquefolia
Pedicularis canadensis
Penthorum sedioides
Phryma leptostachya
Pilea pumila
Poa compressa
Poa pratensis
Podophyllum peltatum
Polygala paucifolia
Polygonatum pubescens
Polypodium virginianum
Polystichum acrostichoides
Potentilla simplex
Prenanthes alba
Prenanthes altissima
Prunella vulgaris
Prunus virginiana
Pteretis pensylvanica
Pteridium aquilinum
Pyrola asarifolia
Pyrola elliptica
Pyrola secunda
Ranunculus abortivus
Ranunculus recurvatus
Ranunculus septentrionalis
Rhamnus cathartica
Rhus radicans
Rhus typhina
Ribes americanum
Ribes cynosbati
Ribes glandulosum
Ribes triste
Rosa spp.
Rubus (blackberry)
Rubus idaeus
Rubus odoratus
Rubus pubescens
Rumex obtusifolius
Sambucus canadensis
Sambucus pubens
Sanguinaria canadensis
Sanicula gregaria
Sanicula marilandica
Satureja vulgaris
Saxifraga virginiensis
Scutellaria epilobiifolia
Scutellaria lateriflora
Shepherdia canadensis

Sium suave
Smilacina racemosa
Smilacina stellata
Smilax herbacea
Smilax hispida
Solanum dulcamara
Solidago caesia
Solidago canadensis
Solidago hispida
Solidago flexicaulis
Solidago juncea
Solidago rugosa
Spiraea alba
Stellaria media
Streptopus amplexicaulis
Streptopus roseus
Symphoricarpos alba
Taraxacum officinale
Taxus canadensis
Thalictrum dioicum
Thalictrum polygamum
Tiarella cordifolia
Tovara virginiana
Trientalis borealis
Trillium erectum
Trillium grandiflorum
Trillium undulatum
Triosteum aurantiacum
Urtica dioica
Uvularia grandiflora
Uvularia sessilifolia
Vaccinium angustifolium
Vaccinium myrtilloides
Veronica officinalis
Viburnum acerifolium
Viburnum alnifolium
Viburnum cassinoides
Viburnum lentago
Viburnum rafinesquianum
Viburnum trilobum
Viola canadensis
Viola conspersa
Viola cucullata
Viola incognita
Viola pensylvanica
Viola pubescens
Viola renifolia
Viola sororia
Viola selkirkii
Vitis riparia
Waldsteinia fragarioides
Woodsia ilvensis
Xanthoxylum americanum

Data Form No. 11 Plant Ecology Research **University of Toronto**

POINT RECORD TREES NORTHERN CONIFER-HARDWOODS STAND NO.

STATION NO.	1	2	3	4	5	6	7	8	9	10
Abies balsam										
Acer rubrum										
Acer pensylvanicum										
A. sacchar.										
Acer saccharinum										
Betula lut.										
B. papyrif										
Fagus gran										
Fraxinus americana										
Fraxinus nigra										
Ostrya virg										
Picea glau										
Pinus Bank										
P. resinosa										
P. Strobus										
Populus bals										
P. grand										
P. trem										
Prunus serotina										
Q. rubra										
Tilia amer										
Tsuga can										
Thuja occ										
Ulmus amer										
Distance										

Data Form No. 13

Plant Ecology Research

University of Toronto

TREE DATA SUMMARY SHEET

of Northern Conifer-Hardwood Forests

Stand Number:

TREE	# PTS	# TRS	DOM. CLASSES			TOT. DOM.	# SAP	D. % SAP	F. % SDL.	F. % TRS.	% SUM F.TR.	D. % TRS.	DOM% TRS.	DFD INDEX	
			-80	-320	321										
Abies balsamea															
Acer rubrum															
Acer saccharin.															
Acer saccharum															
Betula lutea															
Betula papyrif.															
Fagus grandif.															
Fraxinus amer.															
Fraxinus nigra															
Ostrya virgin.															
Picea glauca															
Picea rubens															
Pinus banksiana															
Pinus strobus															
Pinus resinosa															
Populus grand.															
Populus tremul.															
Prunus pensylv.															
Quercus rubra															
Salix nigra															
Thuja occident.															
Tilia americana															
Tsuga canadens.															
Ulmus americana															

-AVE. DIST. BTW'N TREES: AVE B. A.: # TREES/ACRE: DOM./ACRE: