VEGETATION, FLORA AND VEGETATIONAL ECOLOGY OF THE HUDSON BAY LOWLAND: A LITERATURE REVIEW AND ANNOTATED BIBLIOGRAPHY

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ABSTRACT

The report is divided into two major units: (i) a written literature review dealing with topics under four headings: study area, floristics and phytogeography, vegetational ecology, and natural impacts upon vegetation; and (ii) an annotated bibliography organized by author's surname and indexed by keywords (subjects) and locations. The review sections (1-5) are subdivided into specific topics and include sections on gaps in the scientific knowledge and research needs. The bibliography (section 6) contains some 265 titles, chiefly on the Hudson Bay Lowland, but including additional publications from Canada and the United States that give a current perspective on the state of knowledge for the area. Two additional sections are presented to aid the reader in locating information by *keywords* (section 7) and by Hudson Bay Lowland *locations* (section 8).

RÉSUMÉ

Le rapport est divisé en quatre unités principales: (i) une rétrospective de la littérature traitant de sujets d'importance sous quatre titres: région étudiée, floristique et phytogéographie, écologie de la végétation, et impacts naturels sur la végétation; et (ii) une bibliographie annotée par noms d'auteurs, indexée au moyen de mots-clés (par sujets) et lieux. Les sections récapitulatives (1 à 5) sont subdivisées en sujets spécifiques et contiennent des sections qui traitent des lacunes dans les connaissances scientifiques et des besoins de recherche. La bibliographie (section 6) contient quelque 265 titres, portant surtout sur les basses terres de la Baie d'Hudson, mais incluant d'autres publications canadiennes et américaines qui donnent une perspective de l'état actuel des connaissances pour la région. Deux sections additionnelles aideront le lecteur à trouver l'information voulue avec *mots-clés* (section 7) et par *endroits* dans les basses terres de la Baie d'Hudson (section 8).

ACKNOWLEDGMENT

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1. INTRODUCTION

In undertaking environmental baseline studies for a region, one must first review the existing literature and assess the gaps in knowledge and the needs for research. This report represents such a review and assessment for the flora and vegetation of the Hudson Bay Lowland[3].

The report consists of a literature review and an annotated bibliography. The literature review is organized into four main sections, dealing with the study area, floristics and phytogeography, vegetational ecology, and natural impacts upon vegetation. Each of these sections in turn is subdivided into specific topics and each includes a final section on gaps and research needs.

The bibliography is organized alphabetically by author's surname, and each citation includes an annotation and a list of keywords.

Two additional sections are presented to aid the reader in locating information--one, an alphabetical list of *keywords* (subjects) with the pertinent references listed for each; the other, a list of *locations* of HBL settlements, rivers and other named places in the HBL.

This literature review deals mostly with work done in the HBL, including Quebec and Manitoba as well as Ontario sections. We have not attempted to make a complete bibliography of work on flora and vegetation in the HBL, because a nearly complete list has been included in the first number of the present series[4]. We have included selected publications concerning work done in areas close to, but not in, the HBL when we considered them relevant. Also, we have cited other literature of more general importance to give a current perspective on the state of our knowledge of the HBL.

For references to any particular subject the keyword index (Section 7) can be used. References cited in the text can be found in the annotated section (Section 6) with the exception of those footnoted.

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[3]Hereafter, the Hudson Bay Lowland may be referred to in shortened form as HBL or the Lowland.

[4]Haworth, S.E., Cowell, D.W. and Sims, R.A. 1978. Bibliography of published and unpublished literature on the Hudson Bay Lowland. Can. For. Serv., Sault Ste. Marie, Ont. Report O-X-273. 270 p.

2. STUDY AREA

The Hudson Bay Lowland is recognized as one of Canada's major physiographic regions. It is an extensive flat plain located on the west and south sides of James Bay and Hudson Bay (Fig. 1), and spans some nine degrees of latitude and seventeen degrees of longitude.

It has an area of 324,000 square kilometres, approximately the size of Finland, and extends across three provinces. The greater portion, some 260,000 square kilometres, lies in northern Ontario, representing one-quarter of the area of the province. The remaining area is mostly in Manitoba, but a small portion of the southeast corner lies in Quebec.

There are few areas in the world comparable to the HBL. It is a flat, watery plain with only a very slight general incline to the east and north toward its coastlines. The average slope toward the James Bay coast in the Moose River basin is on the order of 65 cm per km[5], and from Big Trout Lake to the shore of Hudson Bay, it is 75 to 100 cm per km (Hustich 1957b). With such subtle slopes as these, it is understandable that the environmental factor of greatest importance in the landscape is the poor drainage which has given rise to the waterlogged terrain with an abundance of water bodies. Much of its area, on the order of 85 to 90%, is covered by a watery 'sea of peat' that may reach depths of up to several metres. The area has been described by some as the largest 'continuous' peatland expanse in the world. However, the area is dissected by a number of large rivers which are bedded in mineral soil or bedrock and have mineral soil banks and forested levees. Nonetheless, there are certainly very large continuous peatland areas within the HBL.

In addition to its flatness, the HBL is characterized by a sedimentary limestone bedrock of Paleozoic age, which in turn is covered by varying amounts of glacial drift which can be up to 200 m in depth[6]. This is in turn overlain by clay sediments deposited in the Tyrrell Sea which covered the area after the last glacial retreat. The HBL has in fact been defined as the furthest extension southwards, eastwards and westwards of either the Paleozoic limestone bedrocks or the clays (Hustich 1957b). The use of both these features to define the

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[5]Kindle, E.M. 1923. Geology of a portion of the northern part of the Moose River Basin, Ontario. Geol. Surv. Can., Summ. Rep. 192, P. & C. 24 p.

[6]Sandford, B.V., Norris, A.W., and Bostock, H.H. 1968. Geology of the Hudson Bay Lowlands. Geol. Surv. Can., Paper 67-60. 118 p.

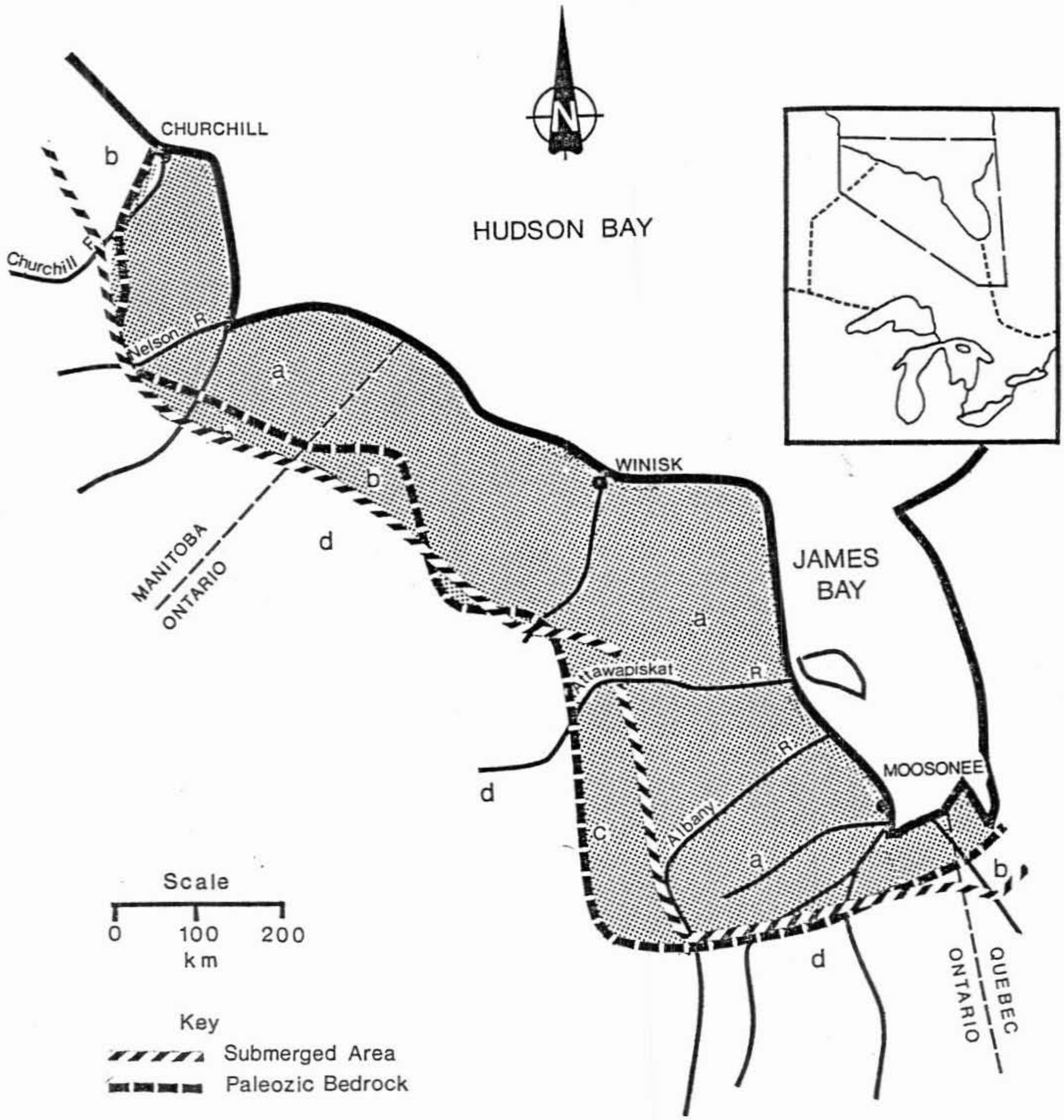

Fig. 1. The Hudson Bay Lowland has been defined by Hustich (1957*b*) as the area to the south and west of Hudson and James bays which is underlain by Paleozoic bedrock, and/or overlain by sediments from the post-glacial period of marine submergence.
a = areas where the Paleozoic bedrock is overlain by glacial till and sediments from the submergence period ($\pm$ peat),
b = areas where the Precambrian bedrock is overlain by glacial till and marine sediments ($\pm$ peat),
c = areas with Paleozoic bedrock covered by glacial till ($\pm$ peat),
d = areas with Precambrian bedrock covered with glacial till ($\pm$ peat), i.e., areas outside of the HBL proper (after Hustich 1957*b*).

area of the HBL is complementary from an ecological point of view, since they are both suggestive of generally flat terrain and also of areas with bedrock and soil parent materials which are less acid and usually more calcium-rich than the surrounding parts of the Precambrian Shield (Fig. 1).

The boreal climate, low rates of decomposition of organic matter, and its accumulation as peat deposits are major factors influencing the flora and vegetation of the area.

Climatically, the area extends from temperate boreal conditions in the southwest to arctic conditions along the Hudson Bay and northern James Bay coastlines. In more specific terms, the climate becomes cooler from south to north, with isotherms generally paralleling the Hudson Bay coastline[7]. However, it becomes drier from the southeast to the northwest. These trends are portrayed with isolines in Figure 2. According to the Thornthwaite climatic classification, the moisture regions in the HBL extend from B_3 humid in the southeast to B_1 humid in the Manitoba portion, and the thermal climates are C_2' microthermal in the southern (approximate) half, and C_1' microthermal in the northern half[8].

A broad transition between at least two major floristic and vegetational provinces is found in a transect from south to north, as boreal taxa reach their northern limits, and arctic species become increasingly prominent (cf. Macoun 1888). It is thought that the persistence of ice and cold water in the bays well into the summer months reduces summer temperatures and creates locally cooler and moister maritime conditions during the growing season along the coastlines. Although climatic data are sparse for the HBL, the experience of field workers, the vegetational and floristic zonations, and the occurrence of a narrow strip of continuous permafrost along the Hudson Bay coastline, tend to confirm the above hypothesis (e.g., Hare 1950, Sjörs 1963b, Ahti 1964, Brown 1967, 1973, H. Lumsden, personal communication). The fact that the discontinuous permafrost zone reaches its most southerly location on the continent in the HBL (Brown 1967, 1968, 1973) is probably explained by its preservation in certain well vegetated, poorly drained peatlands (Cowell et al. 1978).

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[7]Chapman, L.J. and Thomas, J.K. 1968. The climate of northern Ontario. Climatol. Stud. No. 6. Can. Dep. Transp., Meteorol. Br. 58 p.

[8]Sanderson, M.K. 1948. The climates of Canada according to the new Thornthwaite classification. Sci. Agric. 28:501-517.

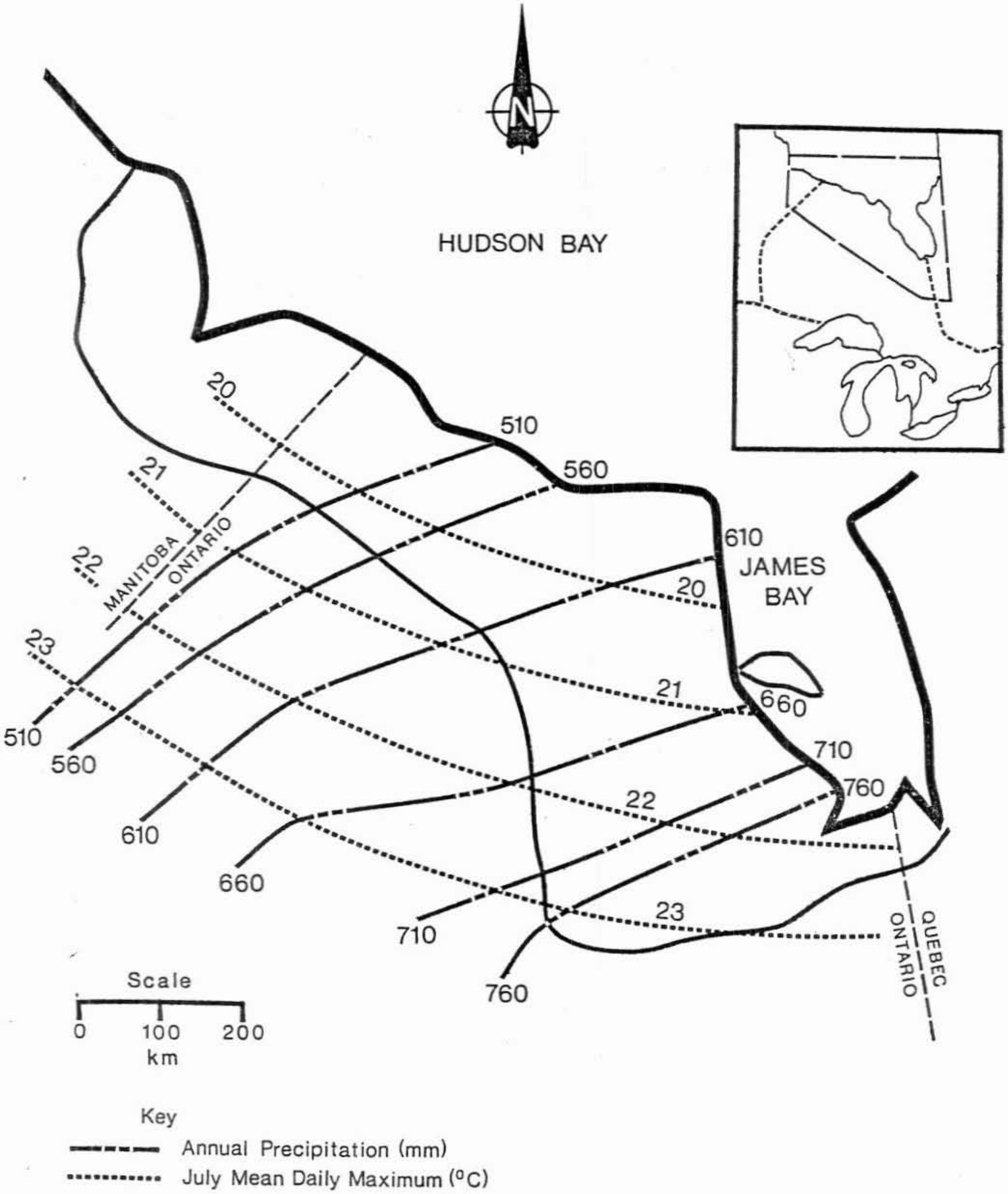

Fig. 2. Precipitation and temperature isolines for the most part transect one another in the Hudson Bay Lowland. Generally the HBL becomes cooler south to north, drier southeast to northwest (data from Chapman, L.J. and Thomas, M.K. 1968).

In spite of its superficial categorization as a large, swampy wasteland, the HBL has a diverse flora with extremely complex and dynamic vegetation systems. The greater part of its surface is covered with peatlands and wetlands--marshes, fens, swamps, and bogs--interlaced with ponds, lakes, streams, and rivers. The poorly developed drainage network results in varying processes of vegetation encroachment and infilling, peat decomposition, paludification, pattern formation, and drainage constriction and redirection. Subtle changes in surface drainage, soil-water chemistry, and geomorphology can give rise to significant changes in the wetland patterns.

Mineral soil uplands are scarce, and are found primarily in the form of beach ridges, particularly near the coast, river banks and levees, and less commonly as other gravel and sand formations such as moraines, dunes, and eskers. However, there are a few larger areas of continuous mineral soil uplands, such as the Precambrian outcrop called Sutton Ridge (containing Sutton and Hawley Lakes), an upland area south of Cape Henrietta Maria, and several extensive limestone outcrops along the lower reaches of the Attawapiskat River.

As one progresses north, permafrost, first discontinuous and then continuous (Brown 1967, 1968, 1973), interacts with and has an increasingly pervading influence on the ecology and development of both peatland and upland ecosystems.

Since the melting of the last continental glacier, the Lowland has been slowly rebounding. This uplift began even before the Tyrrell Sea incursion of 7800 years ago. Rates of rebound were about 1.5 m per century from 3000 to 1000 years ago[9], and are at present an estimated 1.2 m per century[10].

The rebound phenomenon is strikingly apparent in the vegetation and landform patterns paralleling the 1900 km coastline. The new shore that emerges is first occupied by halophytic species of salt marshes. The raised beach ridges support a variety of communities ranging from sparse pioneering populations of lichens, mosses and low vascular plants, particularly along the Hudson Bay shore, to thickets, conifer swamps and woodlands and forests on the highest ridges.

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[9]Craig, B.G. 1969. Late glacial and post-glacial history of the Hudson Bay region. Geol. Surv. Can. Pap. 68-53:63-77.

[10]Webber, P.J., Richardson, J.W. and Andrews, J.T. 1970. Post-glacial uplift and substrate age at Cape Henrietta-Maria, south-eastern Hudson Bay, Canada. Can. J. Earth Sci. 7:317-325.

Only a short distance inland from high tide, the influence of saltwater diminishes and beach ridge complexes with river breakthroughs create a variety of wetland and upland habitats. Here one finds highly productive freshwater marshes, sedge meadows and swamps, with upland forests on the higher beach ridges and levees. With increasing peat accumulation further inland, the meadows and marshes yield to fens, and one finds the early stages of raised bog developing in situations where the flow of mineral soil water has been reduced.

This pattern of shoreline emergence, and the complex interrelations of beach ridges, intervening low swales, stream breakthroughs and other shoreline processes, with vegetational succession, peat accumulation and gradual drainage blockage, can be used as a working model to explain the evolution of an even greater complexity of pattern and process that is found in interior locations.

The rivers and streams are oriented more or less parallel with one another, and at right angles to the coastline. The downcutting and redeposition of sediment on the banks and levees has tended to separate the stream and river systems from the broad wetland interfluves. The interfluves have broad sheet surface water flow, usually toward the coast. As one progresses from the coast to the interior, the wetland ecosystems tend to have greater accumulations of peat and to become less well drained and poorer in nutrient supply. The numerous small ponds and lakes in some areas may reflect the trend, over the centuries, for the areas to become progressively less well drained.

The relatively few major rivers in the HBL are slow and shallow but often cut deeply through layers of marine clay sediments and glacial till into the underlying Paleozoic sedimentary bedrock. Along rivers, one finds dynamic events and change as banks and riverbeds erode, become redeposited downstream, and form new soils and habitats for vegetation colonization. Along rivers and streams, drainage is generally better than in the interfluvial peatlands, often sufficient to support good growth stands of timber on the raised upland banks or levees, as well as in forested swamps just behind the levees. It was these good growth forests which gave some early explorers, travelling by canoe on larger streams and rivers, the mistaken impression of vast timber resources in the Lowland.

The HBL is a relatively pristine and underdeveloped area in comparison with the rest of Ontario. The main impacts of man consist of small villages or towns at the mouths of main rivers, winter haul roads between the towns, railways from the south to Moosonee and Churchill, and scattered bases and camps used by hunters, trappers, scientists, recreationists, and industrial developers. Lack of development is explained by the uninviting physical aspects of the region, the absence of highly valued resources, and the costs of extracting and transporting such resources as there are to southern markets.

Surface conditions present formidable problems for ground travel, construction, and habitation. In the summer only the main rivers and streams provide ready access by boats and canoes. Cross country travel by canoe or foot is extremely difficult, and the mosquitoes and black flies add to the general discomfort of the traveller. In the winter, cross-terrain travel is better, owing to the frozen surfaces and snow cover, and winter haul roads are utilized for transporting materials and goods between the communities.

Even when using fixed-wing aircraft it is not possible to gain access to much of the interior, owing to the lack of suitably deep and long stretches of water. Most ponds and lakes are too shallow for safe landings. Only in the last few years, with the greater availability of helicopters and greater interest in resources, has there been much scientific exploration on the ground in the HBL interior.

In spite of the inhospitable environment, it is certain that more development will occur in the Lowland. The lives of its hardy inhabitants will change. The large populations of waterfowl and other wildlife will be influenced by development, as will the land base itself. For these reasons, it is essential that we begin to accumulate information and knowledge about the Lowland so that it can be more intelligently and rationally developed and managed in the future.

3. FLORISTICS AND PHYTOGEOGRAPHY

3.1 History of Botanical Collecting

Our knowledge of the HBL flora and plant distribution has developed almost entirely within the last century. Often this has proceeded in association with field studies encompassing other sciences, particularly geology and zoology, or as a byproduct of more casual visits to the area.

A few notes exist for very early botanical work (e.g., Barnston 1841, Holmes 1884, Geldhare 1887) and this constitutes the first published botanical knowledge. However, the bulk of the early explorations occurred mainly through the offices of the Geological Survey of Canada (G.S.C.). John Macoun (1881, 1884, 1904, 1905, 1906), James Macoun (1885, 1888, 1889), Bell (1886) and Low (1887) reported on their own and others' botanical observations along the major rivers and coastline. James Macoun and William Spreadborough collected extensively, providing, in particular, records from the coastline and some islands along it, and more remote, interior areas along the Moose and Kapiskau Rivers. Bell also collected in the area but confined his published remarks to observations on what he thought to be the extent and economic value of tree species.

From the time of the early G.S.C. work until the mid-1940s, a number of notes were prepared which contained lists of mainly vascular plants (Potter 1932, 1934, Stormer 1933, Gussow 1933, Gardner 1937, 1946, Kirk 1940, Fagerstrom 1948). However, their main contribution was to enlarge substantially the knowledge of the coastal, and to some extent reparian, vegetation.

In the two decades preceding 1960 a great deal of basic vascular botanical investigation was undertaken in the HBL. Most notable were the published explorations and species catalogues of Dutilly and Lepage (1948, 1952, 1963), Dutilly, Lepage and Duman (1954, 1958, 1959) and Lepage (1954, 1959, 1963). The most valuable of these catalogues are the 1954 list (Lepage and Duman 1954) from the west coast of James Bay and the 1963 list (Dutilly, Lepage and Duman 1963) for the southern James Bay area, in the James Bay drainage basin. Included, therefore, are some species found only on the Precambrian Shield outside of the HBL. In these latter two lists they combined previous collection data with their own collections, and thus produced some basic floras for much of the HBL. Taken as a whole, the works of Messrs. Dutilly, Lepage and Duman represent the major distributional data with which more recent floristic work can be compared. In this same time period, Baldwin (see Table 1) also collected extensively in accessible portions of the HBL. Concurrently with the work of these individuals, the western portions of the HBL, beyond the Ontario border, were being investigated by Scoggan (1950, 1957, 1959), Schofield (1958) and Ritchie (1956a, 1957, 1960b, 1960c, 1962), with much of this work being incorporated into the distributional data of Scoggan's (1957) Flora of Manitoba. In the preparation of this flora, Scoggan referred to collections available in other herbaria, and thus provided an accumulative synopsis of the vascular plant flora of Manitoba's portion of the HBL.

Hustich (1950, 1955, 1957a, 1957b, *see also* Fagerstrom 1948) studied the phytogeography of the Lowland, and added (Hustich 1957b) 104 vascular species to the Dutilly et al. (1954) check list. Earlier papers by Hustich (1949a, 1949b) also dealt peripherally with the Lowland. By excluding species occurring outside the Lowland, and including other recent additions by Scoggan (1950), Ritchie (1956a) and himself, Hustich estimated a native vascular flora of at least 735 species (1957b). This amounts to a rich flora, even in comparison with those of adjacent southern areas. For example, Baldwin (1958) has identified 856 species for the Clay Belt, south of the HBL. Furthermore, the whole Canadian Arctic has a vascular flora of about 900 species and the large Arctic part of the continental Northwest Territories and Ungava, about 650 species (Porsild 1964). The last intensive floristic work to be done in the period was that by Moir (1958); in his floristic survey of the Severn River drainage basin he catalogues more than 600 species and provides notes on habitat and representative plant communities.

Vegetation studies in the HBL have included plant check lists as necessary appendices to environmental, associational or process characterization. Although as yet uncompiled, additions to the knowledge of the vascular flora have been made through the work of Moir (1958), Sjörs (1961b, 1963b), Ritchie (1962), Ahti (1964), Ahti and Hepburn (1967), Riley and Moore (1972), Kershaw and Rouse (1973), McKay and Arthur (1974), Kershaw (1976), Larson (1975), Fabiszewski (1976), and Arthur and Marshall (1976, 1977) (refer also to Section 3.2).

It is only in relatively recent years that significant advances in our knowledge of the non-vascular flora have been made. The most notable works have been those concentrating on bryophytes and lichens (Lepage 1945, Crum and Schofield 1959, Persson and Sjörs 1960, Ahti 1964, Ahti and Hepburn 1967, Ireland and Cain 1975, Fabiszewski 1976). Recent work by Kershaw and others on lichen-dominated coastal associations of southwestern Hudson Bay has helped establish floristic data for that area (Rouse and Kershaw 1971, Kershaw and Rouse 1973, Kershaw and Larson 1974, Neal and Kershaw 1973a, 1973b, Larson and Kershaw 1974, 1975a, 1975b, 1975c, 1975d, 1976, Kershaw 1974, 1975, 1976).

As early as 1908, Setchell and Collins provided the first list of algal species collected from Hudson Bay. Early work did include minor collecting of algae (Gardner 1937, 1946). Recently some additional collecting has been done for the blue-green bacteria (algae) and the fungi, mainly in the context of microbial counts and physiological studies (Blasco and Jordan 1976, Jordan et al. 1972), but these nonvascular plants are undoubtedly the least known groups of plants.

3.2 Collections, Checklists, Floras

Table 1 presents a selected set of references to herbarium collections and published checklists of Lowland material, providing information on date, collector location, collection/list size, and place of maintenance. Known major collections are included. Other collections may exist in numerous herbaria, but it is felt that most significant work is represented.

Identification of elements of the Lowland flora is, at a general level, hampered by the lack of comprehensive checklists, manuals and keys developed expressly for the area. Scoggan (1957) treats the taxa of Manitoba, providing keys for plants of the western Lowland region. The narrow coastal strip from Cape Henrietta-Maria northwest is often considered part of the Arctic proper, and as such, is further covered in part by Porsild's (1964) Eastern Archipelago manual. However, there are many low-Arctic or sub-Arctic species that do not reach the Arctic islands and are not included in Porsild's work

Table 1. A selected listing of floristic checklists and botanical collections from the Hudson Bay Lowland and vicinity. Entries are listed alphabetically by authors with information included on date and location of collections, numbers of species (*denotes cryptogamic collections, in whole or in part), and the herbaria maintaining the material.[a] Unpublished collections are indicated by a † beside the authors' names. Collectors, if other than authors, are given in parentheses.

Author(s)	Date	Location	No. of species	Herbaria
† Abbe	1939	Manitounuck S., Cairn Is., etc.		CAN
Ahti	1964	n.Ontario	150+*	
† Arthur & Marshall	1975	North Pt., sw.James Bay	150	OMNR, Moosonee
† Arthur & Marshall	1976	Buoy's Bluff, s.James Bay	196	OMNR, Moosonee
† Baldwin	1947-49	Moose R. northward, e.Hudson Bay (Long Is., Great Whale R., etc.)	300+	CAN
† Baldwin	1951	n.Manitoba (Baralzon L., Nueltin L., Cochrane R., etc.)		CAN
Baldwin	1953	s.James Bay, Gasket Shoal;	35	CAN
		s.James Bay, Solomons Temple Is. (fieldwork 1949)	67	CAN
† Baldwin	1950s	General HBL Collections		CAN, TRT
† Barlow	1950	Churchill		TRT
† Bassett	1959	Moosonee area		DAO
Beckett	1959	Churchill	76	DAO
† Brown	1950	Churchill		CAN
† Cairnes	1915	Churchill River		CAN
† Coates	1947	Bear Is., James Bay		CAN
† Conner	1893	Depot Is.(?), Manitoba		CAN
† Courtin, Bissett	1969	Cape H.-H.		CAN
† Cowell	1968-69	Polar Bear Provincial Park	170	CAN
			31*	CAN
† Cringan	1950	Nikip Lake, Hagiss Lake		CAN, TRT
Crum & Schofield	1959	Gillam		CAN
† Desgoffe	1954	Belcher Is.		CAN
† Dickinson, Haber	1968	Moosonee area, Shipsands Is.		TRT, CAN
† Doutt	1935	Twin Is.		Carnegie Museum
† Dunbar	1958	Belcher Is.		TRT
Dutilly, Lepage & Duman	1948	s.end James Bay & interior on Albany, Moose, Harricana, Nottawa Rs.	976	QFA, RIM, etc.
Dutilly & Lepage	1952	Harricana River	262*	QFA, RIM, etc.
Dutilly, Lepage & Duman	1954	w.James Bay; coast, Albany, Attawapiskat Rs.	900+	QFA, RIM, etc.
Dutilly, Lepage & Duman	1958	e.James Bay & islands	956	QFA, RIM, etc.
Dutilly, Lepage & Duman (Liebow)	1959	Winisk'	68	QFA(?)
Dutilly & Lepage	1963	s.end James Bay (+ Macoun specimens)		QFA, RIM, etc.
† Elliot	1976	North Pt., Longridge Pt. (James Bay)		TRT, C.W.S.
Fabiszewski	1976	Moosonee	*	CAN(?)
Fagerstrom (Hustich)	1949	Moose River basin	265	H (elsinki)
† Freeman	1960	Belcher Is.		CAN, TRT
Gardner	1937	(Labrador, Hudson Bay) Churchill	99*	Paris (?)
Gardner	1946	Moosonee, Shipsands Is., Willow & Moose Is.	60+*	Paris (?)
Gardner	1973	Arctic, subarctic Quebec (Moosonee area & Churchill)		Paris (?)
Geldart	1887	Fort Churchill	38	?
† Gillett	1948,1959	Churchill, Hudson Bay Railway		DAO
† Greenwood	1968	Moosonee		CAN
Gussow	1933	Churchill & N.W.T., north of Hudson Bay Lowlands (fieldwork 1932)	50+	CAN, DAO
† Hahn	1911	Charlton Is.		TRT
† Howe	1950	Warkworth Ck. (Churchill area)		CAN
Hustich	1955	Moose River, Renison (fieldwork 1947, with Tuomikoski)	301	H, CAN
† Hustich	1957	Fort Severn, Big Trout Lake (fieldwork 1956)	346	CAN
Hustich	1957	Hudson Bay Lowlands	104	H(?), CAN

(continued)

Table 1. A selected listing of floristic checklists and botanical collections from the Hudson Bay Lowland and vicinity. Entries are listed alphabetically by authors with information included on date and location of collections, numbers of species (*denotes cryptogamic collections, in whole or in part), and the herbaria maintaining the material. Unpublished collections are indicated by a † beside the authors' names. Collectors, if other than authors, are given in parentheses.[a] (continued)

Authors(s)	Date	Location	No. of species	Herbaria
Ireland & Cain	1975	Ontario	79*	CAN, TRT
† Irvine	1951	Churchill		CAN
† Jeglum, Boissoneau, etc.	1976	Lake Kinoje (James Bay Lowlands)	*	CAN, SSMF
† Johansen	1920	Moose Factory, South Twin Is., Cape Jones, w.James Bay		CAN
† Johnson	1949	Churchill	219	?
Kershaw & Rouse	1973	East Pen Is.	*	CAN
Kershaw	1974, 1976	East Pen Is.	*	?
† Kirk	1940	Moose River, Abitibi River	321	TRT
† Lamoureux & Repentigny	1972	Rupert Bay		CWS (?)
† Lamoureux & Zarnovican	1974	Baie Oies	80	CWS (?)
Larson	1975	East Pen Is.	*	?
† Lawson	1853	Big Trout Lake, York Factory		CAN
† Legault	1963	e.Hudson Bay		SFS
Lepage	1945	James Bay, Lake Mistassini	*	RIM(?)
Lepage	1947-49	Quebec	*	RIM(?)
Lepage	1959	James Bay,	932	various
		Northern Clay Belt	866	various
Lepage	1966	Winisk, Shamattawa R., Ekwan R.	356	RIM(?)
† Lewis	1940	Attawapiskat, Akimiski Is.		CAN
Low	1887	Lake Winnipeg to Hudson Bay	15	CAN
† Low	1889	Fort George, Little Whale River		CAN
† Lumsden	1957, 1958	Cape Henrietta-Maria	52	OMNR, Moosonee
		Sutton River, Little Cape	37	OMNR, Moosonee
† Lumsden	1969-1970	Cape Henrietta-Maria area	100	OMNR, Moosonee
J. Macoun (Bell)	1884	York Factory	52	CAN
J. Macoun (Spreadborough)	1904	James Bay, Hudson Bay		CAN
J. Macoun (Dowling)	1904	Ekwan River & Albany River at James Bay	41	CAN
J.M. Macoun	1889	James Bay coast & islands (fieldwork 1887),	207	CAN
		Moose River area	346	CAN
J.M. Macoun (Wilson)	1902	James Bay & Kapiskau River	109	CAN
† J.M. Macoun	1910	Churchill		CAN
† Manning	1973	North Twin Is.		DAO
† Marsh	1936	w.Hudson Bay		TRT
Haycock (†Baldwin, Doutt, Gardner)	1968	Manitounuk Is., e.Hudson Bay (fieldwork 1960, 1967)	159	MTMG(?), CAN
† Maycock	1970s	Sutton-Hawley Ls., Opinagau L., Winisk, Cape H.-M., Moosonee area, Shipsands Is., Kesagami L., etc.		Herb Maycock
McClure	1943	Churchill	80+	?
† McKay & Arthur	1975	Shipsands Is., Puskwuche Pt., s.w. James Bay	150+	TRT, OMNR Moosonee
† McTavish	1853	Big Trout Lake, Severn River		CAN
† Moir († Macoun, Scott Cringan, Hustich)	1958	Severn River drainage basin (fieldwork 1951-53, 1957)	600+	MINN, CAN, TRT
† Morton, Adams	1968	Moosonee area, Shipsands Is.	203	WAT
Neal & Kershaw	1973	Cape Henrietta-Maria		?
Persson & Sjörs	1960	HBL interior, HB coast	*	S (tockholm) (?)
Polunin (Potter)	1939	n.Hudson Bay		DAO(?)
† Porsild	1929	South Twin Is., Charlton Is., Akimiski Is., Fort George, Moose Factory, Albany R.		CAN

(continued)

Table 1. A selected listing of floristic checklists and botanical collections from the Hudson Bay Lowland and vicinity. Entries are listed alphabetically by authors with information included on date and location of collections, numbers of species (*denotes cryptogamic collections, in whole or in part), and the herbaria maintaining the material. Unpublished collections are indicated by a † beside the authors' names. Collectors, if other than authors, are given in parentheses.[a] (concluded)

Author(s)	Date	Location	No. of species	Herbaria
† Porsild	1930	Churchill		CAN
† Porsild, Baldwin, Sjörs	1957	Attawapiskat R. (ref. Sjörs 1963), Cape Henrietta-Maria, Sutton-Hawley Narrows		CAN
† Porsild	1959	Great Whale River, etc.		CAN
Potter	1934	s.James Bay (fieldwork 1929)	200+	?
† Reznicek, Carlton	1974	Lower Missinaibi River		TRTE
† Riley	1972	Shipsands Is., s.James Bay	150+	TRT, OMNR
		Onakawana, Abitibi River	150+	Moosonee
† Riley	1976	Moosonee, Kinoje L., North Pt., Longridge Pt., Attawapiskat, Winisk, Wachi Ck., Gooseberry Brook		TRT
† Riley	1977	Attawapiskat River, Shagamu River mouth area	*	TRT
† Riley	1978	148 locations scattered in HBL from Manitoba border to the Albany River and Akimiski Island (N.W.T.)	*	TRT
† Ringius	1977	Kapiskau River at James Bay		DAO(?)
Ritchie	1956	Churchill	290	WIN(?), CAN
Ritchie	1962	n.Manitoba	580	WIN(?), CAN
J. Rousseau	1966	George R. (fieldwork pre-1950)		QUC(?), DAO (in part)
J. Rousseau	1968	Quebec, Arctic,	320	QUC(?), DAO (in part)
		Hemiarctic (fieldwork pre-1950)	555	QUC(?), DAO (in part)
† Schofield	1950	Gillam		DAO
Schofield	1958	Churchill (fieldwork 1956, partly with Crum)		CAN
Scoggan	1951	Hayes R. at Fox R. area,	82	CAN
		Hay Is.,	60	CAN
		Marsh Pt.,	43	CAN
		H.B. Co. post.	220	CAN
Scoggan	1959	Manitoba (including work 1948-50, at York Factory, Norway House, Nelson River, etc., partly with Baldwin)	1417	various
† Scott	1940	Fort Severn, Churchill		CAN, TRT
† Shay	1976	Lower Missinaibi River		LKHD(?)
† Sims	1977	s.James Bay Lowlands, coastal and interior; Lake Kinoje (James Bay Lowlands); Winisk	*	SSMF, TRT (in part), CAN
† Sims	1978	s.Hudson Bay coast and interior from Shagamu R. to Kapiskau R.; Cape Henrietta-Maria; Winisk	*	SSMF, TRT (in part), CAN
Smith	1943, 1944	w.coast James Bay		CAN (in part)
† Spreadborough	1896	Richmond Gulf		CAN
† Sparling	1966	Sutton-Hawley Lakes		TRT
† Stirrett	1952-55	s.James Bay	100+	C.F.S., DAO
Stormer (Johansen)	1933	Churchill	105	O(slo)
† Tessier	1976	North Pt., James Bay		TRT, CWS
J.W. Thompson	1953	n.Manitoba, Churchill	248*	?
S.L. Thompson	1959	Great Whale R., Port Harrison		TRT
† Watson	1948	Cape Henrietta-Maria		TRT, CAN
† Williams (& Sjörs)	1968	Sutton Ridge	61*	?
† Winterhalder	1969	Cape Henrietta-Maria		CAN
† Wood	1955	Churchill		TRT
Wynne & Steere	1943	e.Hudson Bay, Hayes Is., & South Twin Is.	170*	CAN

[a] _____. 1974. Index Herbarium. Part 1. The herbaria of the world. Completed by P. Holmgren and W. Keuken. 6th ed. Regnum vegetabile Vol. 92. 397 p.

(Savile 1968). For the James Bay region, no manual exists, although the checklists of Messrs. Dutilly, Lepage and Duman (1954, 1958, 1963) can be used in conjunction with manuals such as those of Fernald (1950)[11] or Rousseau (1968) for the temperate regions of eastern Canada. Baldwin's (1958) catalogue for the Clay Belt provides a valuable checklist for an area immediately adjacent to the southeastern portion of the HBL. Rare and endangered vascular species known to Ontario's Lowland are catalogued in Argus and White (1977). The moss flora is tabulated in Ireland and Cain (1975) while the known lichen flora is contained on an updated computer file for Ontario, maintained by National Museums of Canada in Ottawa.

3.3 Plant Distribution and Migration

Distributional data on maps are provided for tree species by Hustich (1953, 1957b), and for other elements of the flora by Polunin (1959), Porsild (1964), Hulten (1968), and Phillips and Stuckey (1976)[12]. In general, most of these distributional data relate more to southern limits of arctic species than to northern limits of temperate and boreal species.

Endemic taxa are not anticipated in heavily glaciated regions; no endemic species occur in the HBL (Dutilly et al. 1954). However, infraspecific taxa may be endemic (e.g., *Linum lewisii* spp. *lepagei*) and several poorly understood taxa have been described from material collected from the Lowland (e.g., *Antennaria nitida, Arnica lowii, A. wilsonii*). Staff of the rare and endangered species project in Ontario (Argus and White 1977) are engaged in looking at collections of poorly understood rare taxa, and may help clarify the taxonomic status of some of these species.

There are distributional anomalies for many coastal and interior species. Discussion has focussed, without consensus, on James Bay/St. Lawrence River disjunctions of predominantly halophytic species, so-called "shoreline outliers" (Potter 1932, Polunin 1938, 1948, Marie-Victorin 1938, Boivin 1952, Cody 1954, Schofield 1958, Rousseau 1974). Theories proposed to explain such disjunctions have involved the extent of intervening proglacial lakes, marine limits and outflow channels, the degree of postglacial uplift, and the effect of the warmer hypsithermal climatic period on range extensions. Marie-Victorin's "rainbow theory" (1938) was put forward

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[11]Fernald, M.L. 1950. Gray's manual of botany. 8th ed. (reprinted 1975). Am. Book Co., New York. 1632 p.

[12]Phillips, W.L. and Stuckey, R.L. 1976. Index to plant distribution maps in North American periodicals through 1972. G.K. Hall & Co., Boston, Mass. 686 p.

to explain the occurrence of species in eastern and western Canada, without central Canadian stations. The theory proposed by Potter (1932) to explain disjunct halophyte distributions by means of a post-glacial marine connection between the St. Lawrence River and Hudson Bay has been discredited by Boivin (1952), Hustich (1957b) and others. Schofield (1958), however, supported the theory, reconstructing the post-glacial history of the Hudson Bay and Churchill area as follows: "The arctic species moved southward from their refuge north of the glacial boundary, or northward from their refuge south of the glacial boundary. Their present arctic concentration, as well as their absence elsewhere, may be attributed to their fitness to the environment."

Paleobotanical work in the HBL has been scarce (Johnson 1949, Potzger and Courtemanche 1956, Ritchie 1957, 1967, Terasmae and Hughes 1960, Norris et al. 1976), and has not been utilized fully to clarify distributional problems.

3.4 Gaps in Knowledge and Research Needs

The great majority of vascular plant species occurring in the HBL have probably been encountered. However, more collecting needs to be done in remote interior locations, in the context of other ecologically oriented studies. Bryophytes and lichens are probably only marginally less well known than the vascular plants, although more collecting should be done in the far northern arctic transition. The groups for which the fewest collections have been made are the microorganisms (algae, bacteria and fungi) and basic taxonomic and ecological work is required for these groups.

Work in the Lowland is hampered in part by a lack of up-to-date checklists, manuals and keys specific to the area for the vascular, bryophyte and lichen species. Many existing checklists are difficult to obtain, and contain nomenclatural snarls that require attention. A definite checklist, at least, is required for the Lowland.

Baldwin (1958) noted the frequency of vague statements in the manuals concerning the northern limits of ranges (e.g., Labrador to Alaska); these reflect the inadequacy of our floristic knowledge of the central subarctic.

Hustich (1957b) described a "vacuum in the floristic exploration of central Canada" that has persisted, while "more interesting" areas such as the Rockies or the Gaspé Peninsula and Newfoundland have been favored by botanists. As a result, theories supporting migrational patterns for Lowland species have been based on inadequate field data. Boivin (1952) has described the situation: "It has long been known that a number of entities presenting a disjunct range occur along the southern edge of Hudson and James bays. The 'intervening' area of northern Ontario and adjacent Quebec and Manitoba was very little known botanically, but it was expected that, when better known, it would show that many of those disjunct species really have a continuous range. As new collections continue to be made in this area, relatively few intervening localities for these disjunct species are turning up..."

Recent scientific work in the Lowland may help to complete our knowledge of distributional patterns. However, considerable synthesis is required of the collected materials already available, in terms of the preparation of complete checklists, good distributional data, the recognition of floristic provinces (e.g., the boreal versus the arctic, as well as others), and the analysis of geographic affinities of the floras for various major regions or biogeoclimatic zonations (cf. Baldwin 1958).

4. VEGETATIONAL ECOLOGY

4.1. Broad Scale Vegetational Ecology

A large land area which is relatively poorly known should be subdivided at an early stage into broad zones and regions, for the geographical orientation of persons interested in the area and for ease in handling information concerning the area. It is important that this subdivision be done during initial investigations, even if it is a first approximation, mainly for purposes of communication and orientation. It is also important that the subdivisions be based on a good ecological foundation, one that categorizes the environment such that similarities and dissimilarities are easily perceived in the field (Packee 1974)[13].

The map scale of such broad land units is on the order of 1:500,000 to 1:1,000,000.

4.1.1 The Role of Vegetation

Since the environment is a function of climate, geology, bedrock overburden, soils, topography, biota, and time, knowledge of each is essential in order to understand the whole. Yet one must,

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[13]Packee, E.C. 1974. The biogeoclimatic subzones of Vancouver Island and the adjacent mainland and islands. MacMillan Bloedel Res. Note No. I, 24 p.

Hence, arctic or subarctic vegetational zones probably parallel the Hudson Bay coastline, and veer south along the James Bay coastline (e.g., Sjörs 1963a, Bates and Simkin 1969). These zonations roughly parallel temperature isotherms for the growing season which trend mainly in a NW-SE direction[7]. Indeed, the influence of the ocean on these coastal climates results in one of the world's most southerly expressions of arctic and subarctic landforms, paralleling in some respects the maritime subarctic zones of the Labrador coast and the Aleutians.

Away from the coast, the major climatic gradients influence major vegetational zonations and regions. It has already been noted that it becomes cooler from south to north, and drier from southeast to northwest (Fig. 2).

Another major feature which could be used to segment the HBL broadly is the watersheds of major rivers. These include the Harricanaw, Moose, Albany, Attawapiskat-Ekwan, Winisk and Severn Rivers. An additional province in the northeast, around the Polar Bear Park and including Cape Henrietta, could be recognized.

4.1.3 Broad Scale Zonations in Northern Ontario

There are a number of contributions to zonal divisions and subdivisions of northern Ontario. A number of these stress climate (Hare 1950, 1954, Ahti 1964 (Fig. 3a), Chapman and Thomas[7], Hare and Ritchie 1972). Some use a combination of vegetation and physiographic considerations (Hills 1958, 1961 (Fig. 3b), Rowe 1972 (Fig. 3c), Zoltai et al. 1974). A map prepared by Brown (1967, reprinted in 1969) shows permafrost regions in Canada, and includes broad physiographic regions, isotherms and explanatory notes. Permafrost regions, composed of discontinuous permafrost (southern fringe, widespread subzones) and continuous permafrost, have isolines which are oriented mainly on an east-west basis. These regions should have pertinence to the establishment of large-scale biogeoclimatic or biophysical zones.

A number of European workers have commented on broad zonations in the HBL (Hustich 1957b, 1959, Kalela 1962, Ahti 1964, Ahti and Hepburn 1967, Sjörs 1963b). The works by Hustich (1957b), Ahti (1964) and Sjörs (1963b) are the most in-depth treatments available, in terms of relating their zonations for northern Ontario to previous literature and to zonations recognized in northern Europe. McEwan (1964) related European peatland literature to vegetational cover mapping of the upper Albany River.

One of the earliest broad classifications was developed to indicate habitat preferences of Canada geese (Hanson and Smith 1950), and names five categories: 1) well timbered muskeg, 2) open muskeg, 3) lake-land muskeg, 4) pothole muskeg and 5) "smallpox" muskeg.

for practical reasons, choose the most obvious features of the landscape on which to base ecological classification units.

A common practice among ecologists has been to use vegetational similarities and differences for recognition of broad zones, for example, the biogeoclimatic zonations and subzonations utilized in British Columbia (Krajina 1965[14]; Packee 1974[13]) or the land region/land district concepts applied in biophysical, or ecological, land classification (Lacate 1969[15], Jurdant et al. 1975, 1977[16]). These vegetational zonations are understood to reflect general climatic trends as well, and generally climatic characteristics are used as descriptive adjuncts of the vegetational zones and sub-zones. However, because measurements of climatic variables are often scanty, the main delineation focuses on vegetational zonations. The emphasis on vegetation is logical where it is the most apparent feature of the environment, and it is assumed to be the most consistent integrator of all other environmental variables.

4.1.2 Major Factors Influencing Broad Scale Units

In the HBL the vegetational zonations tend to parallel the Hudson and James Bay coastlines (Bates and Simkin 1969). This reflects at least three major environmental features that parallel the coast--topographic contours, time since emergence (isostatic rebound) from the sea and hence time for peat accumulation and peatland evolution, and moderation of local coastal climate by proximity of the bays.

This latter effect has often been reported, especially in terms of temperature[7]. It has been noted (Sjörs 1963b) that there are marked differences in temperatures in the summer, cooler at the coast and warmer to the interior, and this is because of the influence of the ice which persists in James Bay and Hudson Bay well into the summer.

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[14]Krajina, V.J. 1965. The biogeoclimatic zones and classification of British Columbia. Ecology of Western North America 1:1-17.

[15]Lacate, D.S. 1969. Guidelines for bio-physical classification of forest lands and associated wildlands. Can. For. Serv., Ottawa, Ont. Publ. No. 1264, 61 p.

[16]Jurdant, M., Bélair, J.L., Gerardin, V. and Ducruc, J.P. 1977. L'inventaire du Capital-Nature. Méthode de classification et de cartographie écologique du territoire. (3 ème approximation). Pêches Environ. Can., Dir. Rég. Terres, Serv. Études Écol. Rég., Québec, P.Q. 202 p.

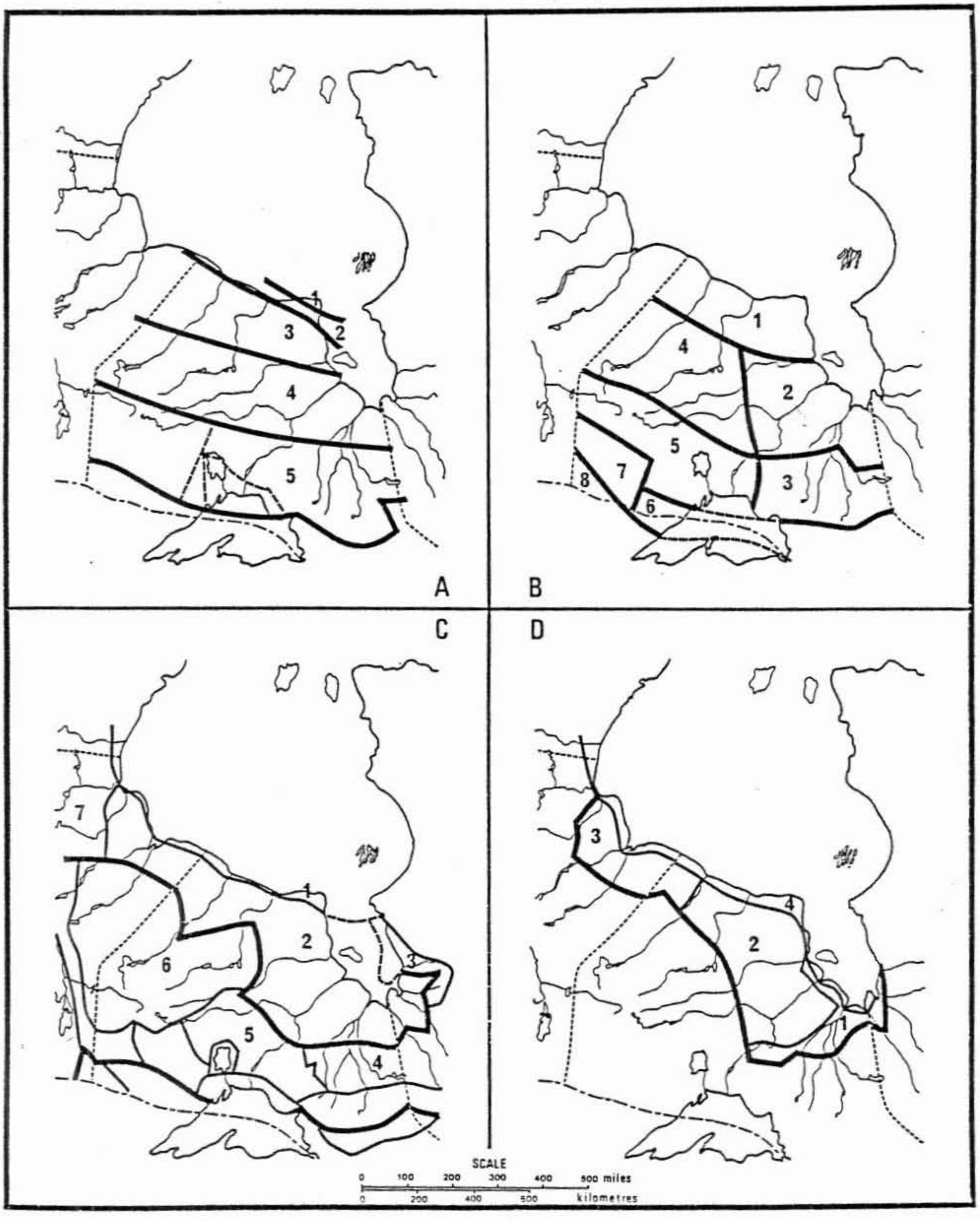

Fig. 3. Some zonations applying to the HBL.

A. Ahti's (1964) climatic zonation based on potential evapotranspiration isolines: 1. (Maritime) southern arctic tundra, 2. hemiarctic forest tundra, 3. northern boreal, 4. middle boreal, 5. southern boreal (with four subzones recognised).

B. Hills' (1961) Site Regions for northern Ontario, derived from humidity and thermal isolines and from potential "climax" vegetation in zonal locations: 1. Hudson Bay (1E), 2. James Bay (2E), 3. Lake Abitibi (3E), 4. Big Trout Lake (2W), 5. Lake Nipigon (3W), 6. Pigeon River (4W), 7. Wabigoon Lake (4S), 8. Lake of the Woods (5S).

C. Rowe's (1972) Forest Regions, defined by major tree species' cover types and by physiographic characteristics: 1. Forest-Tundra (B.32), 2. Hudson Bay Lowlands (B.5), 3. East James Bay (B.6), 4. Northern Clay (B.4), 5. Central Plateau (B.8), 6. Northern Coniferous (B.22*a*), 7. Northwestern Transition (B.27).

D. Coombs' (1954) physiographic subdivisions of the Hudson Bay Lowland: 1. Dry Zone, 2. Muskeg and Small Lake Zone, 3. Marine Clay Zone, 4. Coastal Zone.

Since they reflected apparent differences of climate, drainage and geological history, these types were subsequently incorporated in a regionalization of the HBL by Coombs (1952, 1954) which mapped four physiographic subdivisions: Coastal Zone, Marine Clay Zone, Muskeg and Small Lake Zone, and Dry Zone (Fig. 3d).

Brokx (1965, 1967) carried out work on habitat types of the caribou using poor quality 1954 aerial photographs (DWD scale 1:54,000) to obtain regional perspectives of peatland macro-patterns. In this project it was necessary to redefine a number of cover types which could be readily appreciated from the photos. Brokx proposed 26 subdivisions of the lowlands north of the 52nd parallel. Modifying these categories and applying the interpretations to the Ontario portion of the HBL north of 52°N, Bates and Simkin (1969) produced a more detailed mapping (one inch to ten miles) and glossary of 96 vegetation types, derived mainly from their experience in interpreting air photos and from the literature. Colors and coding given to vegetation types on the map reflect zonations which are parallel, approximately, with the James and Hudson Bay coasts. This relates primarily to time since emergence from the sea, and hence stage of development of peatlands.

4.1.4 Broad Scale Zonations in the Lowland Outside of Ontario

Ritchie (1960b, 1962) established eight zonal divisions of Northern Manitoba (four within the HBL) based on interpretation of aerial photos and floristic surveys. In 1974, a systematic biophysical classification of northern Manitoba was initiated, incorporating aspects of soil, climate and vegetation into a more accurate ecological breakdown of land units (Mills et al. 1976a). Portions of the Lowland have since been ground-truthed in detail using this approach (Mills et al. 1976b). Tarnocai (1974a) includes a portion of the northernmost lobe of the Lowland in his exploratory terrain study of northern Manitoba and southern Keewatin, N.W.T.

In Quebec, zonations were proposed by Hustich (1949a,b, 1950, 1953), Hare (1950, 1954), Hare and Taylor (1956) and I. Rousseau (1952). More recently, considerable biophysical work sparked by the James Bay Hydro-Electric Development has been carried out in an extensive area along the east coast of James Bay, including the Quebec portion of the Lowland (Majken 1973a, Ducruc et al. 1975, Jurdant et al. 1975).

4.2 Fine Scale Vegetational Ecology

4.2.1 Coastal ecosystems. Coombs (1952) describes a "coastal zone" based primarily on its unique vegetation associations and the physiographic patterning that more or less parallels the shoreline: The Coastal Zone in southern James Bay, from Hannah Bay at the mouth of the Moose River north to the Ekwan varies in width from a few hundred yards to several miles. North of the Ekwan, as it rounds Cape Henrietta-Maria the zone broadens, extending inland up to ten miles (16 km). In general from Cape Henrietta-Maria to Churchill, it averages about five miles in width, closely following the treeline".

This narrow strip of shore, exceeding 1900 km in distance, is well characterized by beach ridges which are mostly untreed and parallel the still-rising coastlines. In the north, along Hudson Bay, one finds such features as sparsely vegetated littoral and estuarine salt marshes, coastal fens, tundra heath, lichen woodland, patterned fens, palsa bogs and peat plateaus in fen, polygon muskeg and "slot lakes" between the beach ridges (Bates and Simkin 1968). Along James Bay are better developed salt and freshwater marshes, *Salix* thickets, and coastal fens, and often much broader zones of tidal flats, sometimes up to 10 km wide at low tide. Here treed fen, swamp and ridge associations usually occur immediately beyond the tide and storm influence of the coast.

The coastal belt provides new habitat continuously, for as old raised beaches are colonized by various stages of vegetational development, new ground rises out of the sea through isostatic rebound. Moir (1954) has isolated seven of the "factors" influencing the HBL coastal habitats: 1) an average bottom slope of about 3 ft per mile (60 cm per km), 2) bottom materials consisting of fine silt, clay and sand, 3) long stretches of relatively straight shoreline, 4) high frequency of onshore winds during the period when the coastal waters are free of ice, 5) slow uplift of land surfaces caused by crustal recoil, 6) occasional exceptionally high spring and fall tides, sometimes accompanied by storms, and 7) onshore ice piling during the spring and early summer. In addition, this narrow zone is characterized by considerable microtopographical variation associated with beach ridges and swale complexes, river levees and offshore material movements; local climate moderation by the onshore winds, which in spring and summer are cool owing to the slow melting of the ice in the seas; and changes from saline to freshwater conditions. Vegetational patterns reflect this diversity of habitats and rapid changes over short distances as one progresses from the coast to the interior. Manning[17], for example, in ornithological notes on the Ontario HBL coastline, remarked on "bewildering ecological changes

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[17]Manning, T.H. 1952. Birds of the West James Bay and Southern Hudson Bay coasts. Natl. Mus. Can. Bull. No. 125. 114 p.

which occur [along most of the coast] during a three-mile walk inland", changes in physiognomy which are more striking than those differences between similar sites at Moose Factory and York Factory, separated by five degrees of latitude!

This narrow strip of the HBL requires particular consideration in assessing potential impacts of any future development, because the coastline habitats are vital staging areas and "refuelling" stops for large numbers of migrating geese and other waterfowl and are important nesting grounds for many species of shorebirds.

Vegetation comprising the immediate coastal region may be further considered within four main categories: 4.2.1.1 Offshore bottom vegetation, 4.2.1.2 Salt marsh, 4.2.1.3 Beach ridges, and 4.2.1.4 Coastal freshwater marshes, meadows and thickets.

4.2.1.1 Offshore bottom vegetation. Marine bottom flora along the HBL coast consists mainly of macro-algae and eelgrass (*Zostera marina*), with some other freshwater aquatics in estuarine situations. Floristic studies are few (Setchell and Collins 1908, Gardner 1937, 1946, Bursa 1969) yet the tidal pools, mud-covered flats and protected shallows and bays are ideal habitats for algae, providing solid substrate for attachment, sunlight for photosynthesis and nutrients for growth. At present the most thorough inventory of algal species that can be applied deals with the Labrador Peninsula/northwest Newfoundland area (Wilce 1959).

Eelgrass distribution indicates that this species prefers protected areas along the HBL coastline sheltered from the scouring action of water currents and drift-ice. Such areas exist south of Akimiski Island (Porsild 1932, Hulten 1968), near North Point and Halfway Point in southwest James Bay (Herrick 1977) and in numerous other sheltered locations. Along the southeast coast of James Bay north of Vieux Comptoir, eelgrass locations have been mapped (Anon. 1976). The species is not found in the estuaries of the major rivers. From centres of distribution, floating eelgrass collects sporadically along the Hudson and James Bay coast (Smith 1954). Eelgrass experienced catastrophic declines in populations throughout the world, presumably including James and Hudson bays, in the 1930s (Cottam and Munro 1954), although it has since revived. Because it forms a staple diet for American Brant and Scaups, and is an important food for Canada Geese migrating through the area (Curtis 1973), maintenance of offshore eelgrass beds is of particular significance.

4.2.1.2 Salt marsh. The shores of Hudson and James bays (particularly James) are characterized by extensive salt marsh development (Fig. 4 and 5). Owing to the extremely gentle relief, some of the tidal flats may be as wide as 10 km during low tide. Generally the salinity of near-shore waters of James and Hudson bays is low because of river and ice influence. However, soil salinity fluctuations in these coastal marshes reach seasonal extremes that must be tolerated by the plants (Glooschenko 1978b). The inland sides of recently exposed beach ridges are occasionally "traps" for salt water inundations of high tides or of high waves during storms. Salt and brackish marsh vegetation can also be well developed in the estuaries of rivers where silt deposition serves to build up flats that are protected from ice drifts, storms waves and offshore currents, and where an evaporative buildup of salts can occur. Sand spits and islands along the coast are usually associated with large shallow standing pools on their inshore flanks, encouraging particularily extensive salt marsh development (McKay and Arthur 1975, Kershaw 1976). The coastal marshes are extremely important as wildlife habitat, yet few comprehensive process studies upon them have been made.

Most work in salt marshes has emphasized floristic information. However, some vegetational descriptions or ecological interpretations are often included. Publications emphasizing floristics include Potter (1932), Porsild (1932), Smith (1943, 1944), Dutilly, Lepage and Duman (1954, 1958), Dutilly and Lepage (1963), Beckel et al. (1954), Cody (1954) and Lumsden and Stirrett (1972). Several floristic studies have emphasized brackish rivermouth systems such as Shipsands Island in the Mosse River (Gardner 1946, Baldwin et al. 1962, McKay and Riley 1975). Lamoureux and de Repentigny (1972) describe salt marsh flora occurring in shallow, protected pools in Rupert Bay (Quebec). Salt marshes of the Churchill area are considered by Ritchie (1957, 1960c, 1962), Schofield (1958) and Scoggan (1959), and these descriptions are probably representative of shore marshes along Hudson Bay in both Manitoba and extreme northern Ontario. Doutt (1941) comments on the influence of salt spray on vegetation near the coastline.

Studies of an ecological nature are more recent. Several soil and water chemical parameters were related to coastal vegetation sequences at Shipsands Island (Riley and Moore 1973). In saline situations, distinct associations of halophytes distribute themselves across micro-topographical gradients. These were considered in more detail by McKay and Arthur (1975) who showed as well that each shore of this island has a unique assemblage of plants adapted to the conditions of that particular area. At North Point, tidal flats have a grassy turf-like appearance in the seaward zone, with a fairly uniform cover of mostly *Puccinellia phryganodes* and *P. lucida* except for very shallow, pond-like depressions which may be a result of

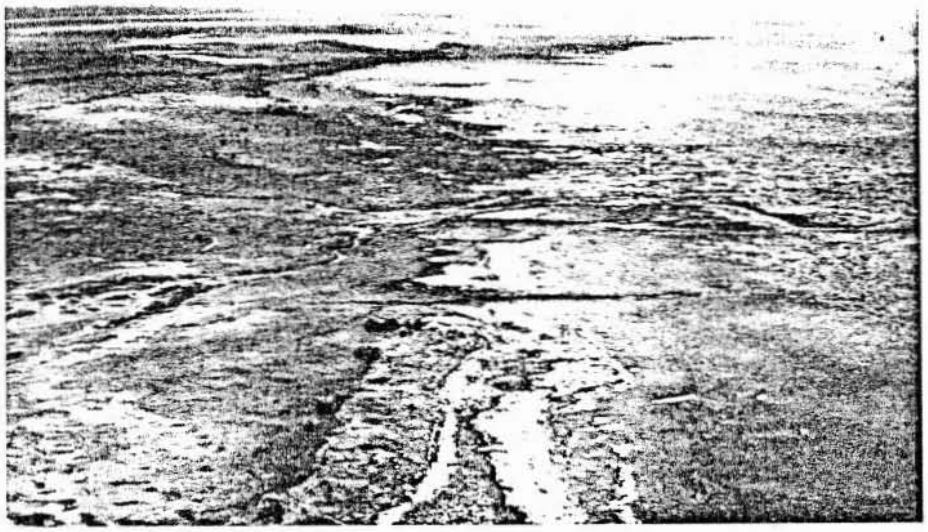

Fig. 4. Coastal flats along James Bay north of Fort Albany with broad tidal beaches and salt marshes. Beach ridges are in the centre of the photo.

Fig. 5. Hudson Bay tidal flats and marshes west of Winisk, Ontario. Beach ridges are in the centre of the photo.

scouring by drifting ice or ice-rafting of sediments following spring breakup. In the mid and upper flats the vegetation becomes diverse and very productive (Glooschenko 1978a). In a coastal area approximately 8 km north of North Point, the vegetational structure is described by Arthur and Marshall (1976) in terms of two phases. Lower tide zones are relatively devoid of vegetation except for occasional *Fucus* sp. Upper zones are characterized by mounds possibly formed by ice action, which support varying stages of developing vegetation, from sparse clumps to closed carpets of vascular plants. Vegetational and habitat variations along transects in salt marshes have also been described at Puskwache Point (Marshall and Arthur 1976), a gravel promontory with developing salt water pools along its protected arm, and at Bouy's Bluff (Arthur and Marshall 1977), near northwest Hannah Bay. The salt marshes of East Pen Island are described quantitatively by Kershaw (1976). The sequence of species encountered from the coast toward the interior is affected by saltwater inundation and runoff of permafrost meltwater. A recent study by Pielou and Routledge (1976) attempts a theoretical mathematical treatment of vegetational zonation for salt marshes at eastern Canadian and HBL sites, the latter including estuarine sites at Moosonee, Attawapiskat and Churchill. However, the paper discusses only relatively compacted zones of salt marsh, which may not reveal as much as sites at which broader zonations occur. Glooschenko (1978a) provides initial information on standing crop and biomass estimates for a south-west James Bay salt marsh, yielding values comparable to results for similar Baltic Sea salt marshes[18]. Glooschenko and Sampson (1977) recorded detectable DDT and PCB traces from the sediments of a James Bay salt marsh.

Chapman (1960) makes no reference to the salt marshes of the Hudson Bay area in his extensive treatise on the subject, although certainly his principles can be extended to this area. The preponderance of data cited by Chapman from other parts of the world reinforces the conclusion that HBL halophytic vegetation and vegetation processes are as yet poorly documented.

4.2.1.3 Beach ridges. Conspicuous features of the coastal region are the beach ridges paralleling the shoreline and irregularly extending inland, sometimes for 75 to 150 km (Moir 1954). These show varying patterns from short discontinuous ridges, to crowded beaches, sometimes anastomosing, to long, uniform, parallel strips (e.g., Fig. 6 and 7). These beach ridge systems are

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[18]Wallentinus, H.G. 1973. Above-ground primary production of a *Juncetum gerardi* on a Baltic sea-shore meadow. Oikos 24:200-219.

Fig. 6. Light-colored lichen-covered beach ridges, inter-ridge marshes and fens, and shallow "slot" lakes near Fort Severn, coastal Hudson Bay.

Fig. 7. Compressed, coarse-gravel beach ridges with little vegetation cover, in the vicinity of Hook Point, 25 km south of Cape Henrietta-Maria.

caused by the action of waves and offshore currents on sediments in shallow waters which are eventually exposed by the ongoing crustal uplift. They normally range in vertical height between .5 and 1.5 m above the intervening swales. Often composed of coarser sorted materials, such as gravels or large-grained sands, the ridges host distinctive flora.

Moir (1954) was the first to describe vegetational sequences on beach ridges from the first and youngest storm beach inland. The coastward beaches, because of edaphically newer 'soils' and more exposed growing conditions, support only the most vigorous coastal colonizers. As one progresses inland, one finds open to dense stands of *Picea mariana, Picea glauca, Larix laricina* or *Populus balsamifera* along their crest (Hustich 1957, Moir 1957, Rouse and Kershaw 1973) (e.g., Fig. 8). Because their soil parent materials are coarse-grained, many of the species, especially near the coast, are xerophytic and resistant to desiccation. Furthermore, the northern HBL forests that develop on the higher, well drained ridges are often of the 'lichen woodland' type (Hustich 1957b, Ahti 1964, Ahti and Hepburn 1967, Kershaw and Rouse 1971, Kershaw 1977) (Fig. 9).

Floristic descriptions of the coastal beach ridges have been made by a number of individuals. Along the James Bay coastline floristic information is provided by Hustich (1957b), Brokx (1965, 1967), McKay and Arthur (1975) and Arthur and Marshall (1976). The latter two publications consider plant distribution on the ridges, with some quantitative measures, in relation to some measured environmental parameters. Floristic data provided by Dutilly and Lepage (1948, 1952, 1963) and Dutilly et al. (1954, 1958) include plants frequenting the ridge systems in the James Bay area.

The raised beaches of the Hudson Bay coast have vegetation and flora with arctic affinities, and are predominantly lichen-dominated systems (Fig. 6). Initial work was begun by Neal and Kershaw (1973a, 1973b) and Kershaw and Rouse (1973) at Cape Henrietta-Maria and East Pen Island. The former work provides phytosociological analyses, and concludes that several plant associations can be roughly segregated on the basis of water availability, pH and the presence of a peaty substrata. Both localities demonstrated the existence of an edaphic "general lichen heath" dominated by *Cetraria nivalis, C. cucullata, Cladina stellaris, C. rangiferina, Alectoria ochroleuca* and *Rhododendron lapponium* in varying abundances.

A considerable amount of further research has been carried out recently in the vicinity of East Pen Island. Relationships between vegetation structure and the more apparent environmental variables, both on an inter- and intra-ridge basis, have been

Fig. 8. Inland ridges are typically black spruce dominated and support either bog, swamp or occasionally upland vegetation (15 km inland from James Bay near the Ekwan River).

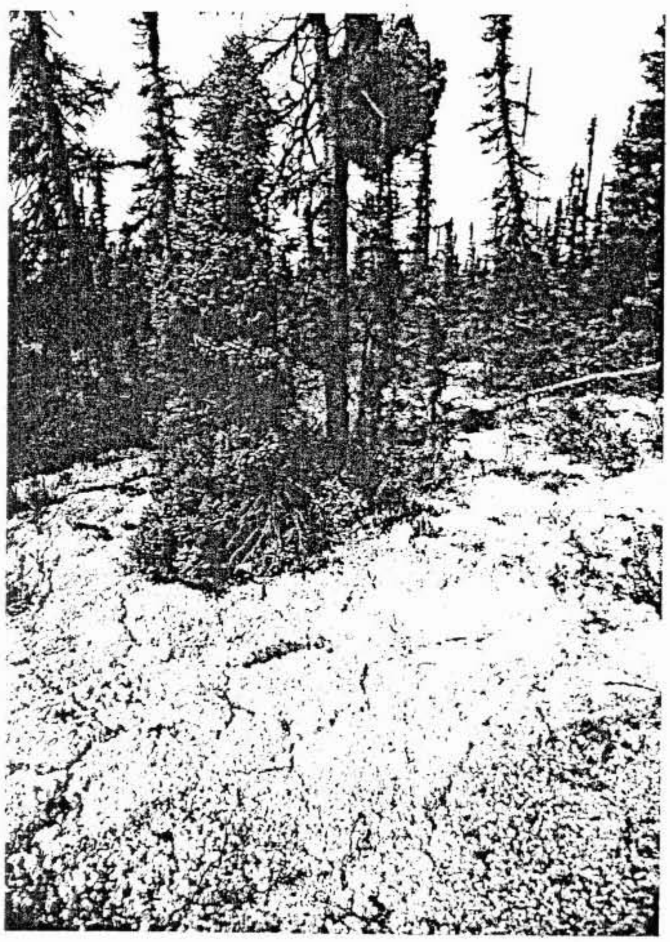

Fig. 9. In the northern HBL, spruce-lichen woodlands are widespread features of inland ridges and peat landforms. This *Picea mariana-Cladina stellaris* woodland by the Shagamu River exhibits a common polygonal pattern in the dry lichen mat.

examined by Larson and Kershaw (1974, 1975a), Larson (1975) and Pierce and Kershaw (1976). Microsite development on ridge crests, inslopes and outslopes is attributed to differences in surface soil moisture, pH, organic content, exposure, and winter snow cover (Rouse and Kershaw 1973, Larson and Kershaw 1974, 1975a, Pierce and Kershaw 1976). Such differences are reflected across individual ridges, independent of any age sequence, as well as along gradients of successively older ridges.

Microclimate differences related to ridge microtopography are considered to play a major role in vegetation structure and long-term adaptations by the species (Rouse 1973, Rouse and Kershaw 1973, Larson 1975). Field et al. (1974) have described an electronic system for monitoring microclimate in such studies, and Rouse and Kershaw (1971) and Kershaw et al. (1975) have expanded on the methodology.

Recognition of such ridge microsites has led to the publication of a number of reports concerning morphological adaptations by the lichens, particularly *Cetraria nivalis* and *Alectoria ochroleuca* (Larson 1975, Larson and Kershaw 1975b, 1975c, 1975d, 1976) and *Peltigera canina* (Maikawa and Kershaw 1975).

4.2.1.4 Coastal freshwater marshes, meadows and thickets. Immediately above the tidal flats and salt marshes there are often broad expanses of sedge, sedge-shrub or thicket development which indicate the beginnings of interior peatland formation. These marshes, meadows or thickets may exhibit some residual influence of salt water, but they seem to lose this influence very quickly as they are isolated from high tides and high wave action. These are mostly brackish transitional types between salt and freshwater influences. In some areas these coastal marshlands occur interspersed among successive ridges, while in others, in the absence of much relief, they form part of a continuum from areas of coastal salt marsh development to open fen further inland (Fig. 10). The young, recently emerged sediments and the diversity of habitat provide a richer and more productive flora compared with that appearing inland (Hustich 1957a). The raised beaches and ridges restrict drainage (Fig. 11) and thereby create conditions favorable to the development of a distinct peat horizon relatively close to the shoreline, often within a few kilometres of high tide levels (Hustich 1957b).

McKay and Arthur (1975) describe a successional trend from a grass-sedge-rush meadow to a willow-orchard thicket at Shipsands Island, an estuarine situation influenced only slightly by salt water. Ritchie (1960c) has outlined a simple vegetation sequence, strongly dependent upon the influence of peat deposition with time, for a broad, flat low river levee near the mouth of the Hayes River.

Fig. 10. A scientist collects plant cover data from a brackish meadow marsh at Gull Bay, southeast James Bay. Such broad vegetated flats are vital food sources for large flocks of waterfowl and shorebirds migrating in autumn. (Photo: G. Wickware)

Fig. 11. Coastal beach ridges are effective in blocking and redirecting near-coast drainage; this contributes to the rapid development of wet marshes and peatlands, and shallow "slot lakes" in the inter-ridges (near Winisk, Ontario).

The seral development passes through phases of salt marsh, meadows, marsh and thicket to *Populus balsamifera* forests and mature treed bog. A more subtle succession has been delineated for a series of inter-ridge sedge meadows near East Pen Island, and a time sequence comparable with a corresponding raised beach sequence is established (Kershaw 1974). Bates and Simkin (1969) concluded that the sedge meadows and near-coastal fens lacked a distinctive internal pattern and they were subsequently mapped as one large unit.

Floristic descriptions of these habitats are provided by Ritchie (1957, 1960c), Beckel (1957), Scoggan (1959), McKay and Arthur (1975) and Arthur and Marshall (1976).

In regions within and approaching the HBL area north of the 'tree-line' (Hustich 1953) and along the Hudson Bay coast, continuous permafrost (Brown 1967, 1968, 1973) influences formation of frost polygons, palsa fields, raised bogs and tundra heaths (Brokx 1967). Coastal meadow development, such as occurs along the James Bay coast, is markedly reduced by the introduction of these features to the near-coast environment.

4.2.2 Interior upland ecosystems. Approximately 8% of the HBL's surface area is considered 'dry land' (Coombs 1952) as opposed to wetland. In spite of their infrequent occurrence, upland interior areas have been more accessible than peatlands, owing to their frequent occurrence along the better drained embankments, slopes and flats of the large riverways (Hustich 1955, Moir 1958, Dean 1959, Ritchie 1960, Sjörs 1961a, 1963b, Kalela 1962) (Fig. 12). A number of HBL upland forest types are recognized by Hustich (1957a, 1957b) and Sjörs (1961b, 1963b). These are listed in Tables 2 and 3, along with wetland and peatland types. As a result, upland habitats are better described floristically and vegetationally than are the wetlands, especially along river systems (Dutilly et al. 1954, 1963, Hustich 1957a, 1957b).

North of 52° latitude, upland forests along rivers may occur only as narrow borders, and permafrost features are common. In mapping the northern limits of the major tree species, Hustich (1953, 1957b) noted how the river bank habitats are capable of extending northern limits because of their better drained soils with somewhat warmer microclimates.

Hustich (1955) described a seral stage of succession up a riverbank, developing from fragmentary vegetation in a zone of erosion/deposition near the water, progressing up the bank through intermediate stages to a well developed *Populus balsamifera* grove with occasional

Fig. 12. Larger rivers are bedded in mineral soil or bedrock. Better drained river levees, such as those along the Harricanaw River in the Quebec portion of the HBL, can support good growth forests.

Picea glauca. Ritchie (1960) described a similar event along the lower Hayes River, where a *Populus balsamifera* stand gave way to a *Picea glauca* forest. The forests of the river levees are predominantly coniferous, although most pure hardwood stands may be found on frequently burned-over banks along the Kapuskau, Lawasaki and Albany Rivers in the south (Dean 1959, Brokx 1965, 1972). In situations where the larger rivers have eroded through the till into the Paleozoic strata, cliff habitats, silt/limestone barrens and other atypical sites occur. The lower Attawapiskat River exhibits a 60 km stretch of reefal limestone cliffs and eroding islands, which support a number of unusual non-wetland habitats (Riley and Cowell, unpubl. data) (Fig. 13).

One of Coombs' (1952, 1954) four physiographic zones for the HBL was the southerly 'Dry Zone' (Fig. 3d), characterized as having approximately 40% dry land. The 'dry' was used only in a relative context compared to the other zones. Although much peatland exists here, particularly large patterned fens and conifer swamps (Johnson and Sharpe 1927, Hustich 1957b), a portion of the area is well wooded upland vegetation. The drier condition is attributed to the development of a more mature drainage system than in the other zones, although a somewhat milder climate and a longer frost-free period each year also contribute to the dissipation of soil moisture in this zone (Coombs 1954). The conifer swamps in this area are dominated by broad expanses of *Larix laricina* and *Picea mariana*, singly or in mixtures. *Thuja occidentalis* occurs in richer drainageways. Mixed forests of *Picea glauca*, *Betula papyrifera*, *Populus tremuloides* and *P. balsamifera* are

Table 2. Vegetation and habitat types recognized by Hustich (1957a, 1957b) in the Hudson Bay Lowland.

I. Around Fort Severn (1957a and 1957b)

1. raised beach community
2. open *Carex*-dominated fen
3. open tundra heath on old peat
4. balsam poplar grove
5. white spruce and tamarack swamp
6. white spruce swamp
7. white spruce feather moss forest (*Hylocomium* is dominant moss)
8. transition type between feather moss forest and lichen woodland
9. black spruce forest (*Pleurozium* is dominant moss)
10. lichen woodland, on mineral and peat
11. black spruce muskeg
12. open tamarack "bog" [actually fen, with numerous indicators of minerotrophy]
13. tamarack and black spruce "bog" [actually fen, adjacent to above type]
14. fen and bog complexes
15. palsa bogs
16. low willow field
17. tall willow thicket
18. marsh and marshland

II. Forest types in Hustich (1957b) after Hustich (1949)

Dry series: 1. Conifer lichen forest*, 2. conifer dwarf, shrub forest*, 3. conifer blueberry forest.

Moist series: 4. conifer feather moss forest, 5. conifer bunchberry forest, 6. rich conifer forest, 7. mixed groves.

Wet series: 8. black spruce muskeg, 9. rich swamp forest, 10. open bog forest.

*Types 1 and 2 combined are equivalent to lichen woodland

III. Other types in Hustich (1957b) not given above

1. open swampy tamarack forest
2. treeless string "bog", sometimes with tamarack invading ridges [better called string fen or patterned fen]
3. fen
4. raised bog
5. tundra "bog" [having calcicolous mosses and vascular plants, probably better called tundra heath]
6. cedar swamp forest

Table 3. Vegetation and habitat types recognized by Sjörs (1961b, 1963b) in the Hudson Bay Lowland.

Forests on upland mineral soil

1. black spruce forest
2. open lichen - black spruce woodland on gravel ridges
3. burned black spruce
4. jack pine
5. balsam poplar
6. white spruce
7. trembling aspen

Wetlands and peatlands

- small lakes with calcareous bottoms
- patterned fen with flarks ("rimpis")
- bog with small palsas
- palsa bog
- bog with large bog pools
- lake shores
- plants in water
- black spruce muskeg or swamp forest
- seasonally wet black spruce forest
- fens - open, wooded, extremely rich, rich, moderately rich, poor, laggs, pools, seepages
- raised bogs considered transitional between raised and blanket bogs
- black spruce islands in fens
- laggs - fen belts separating bog from mineral soil
- bog - open, wooded, hummocks, hollows, pools
- black spruce muskeg
- tamarack swamps
- spruce forest [swamp] being paludified by beaver flooding of a stream

Fig. 13. Reefal limestone cliffs and eroding islands line a 60 km stretch of the lower Attawapiskat River, about 90 km west of James Bay. (Photo: D. Cowell)

found along the rivers (Kalela 1962). South and west of James Bay there are also some stands of hardwood swamp dominated by *Fraxinus nigra* and *Ulmus americana* occurring in moist to wet situations along streams (Rowe 1972).

Upland vegetation also exists on the beach ridges in the Lowland (Moir 1954, Hustich 1957b, Kershaw and Rouse 1973, Neal and Kershaw 1973, Larson and Kershaw 1975) (Fig. 8 and 14). Interior beach ridges which have experienced fires in the past often support stands of *Pinus banksiana*, particularly in areas south of the Attawapiskat River (Brokx 1965). More northerly beach ridges, physiographically younger and subject to a harsher climate, develop open stands of mature spruce (Moir 1954) or, near the tree line, open lichen woodland (Hustich 1957b, Brokx 1965, 1967, Kershaw 1977) (Fig. 9). Moir (1954) described three sequences of emergent landforms developing on beach ridges from the coast inland.

The diabase outcrop of Sutton Ridge, extending from 80 to 120 km south of Winisk, is the largest of a few such outcrops within this portion of the Lowland where silicicolous vegetation flourishes (Sjörs 1961b) (Fig. 15). Although some species associations are unique to these Precambrian exposures, the main vegetation type is black spruce-lichen woodland on dry or wet, drained or undrained soils (Sjörs 1961b, Zoltai 1973).

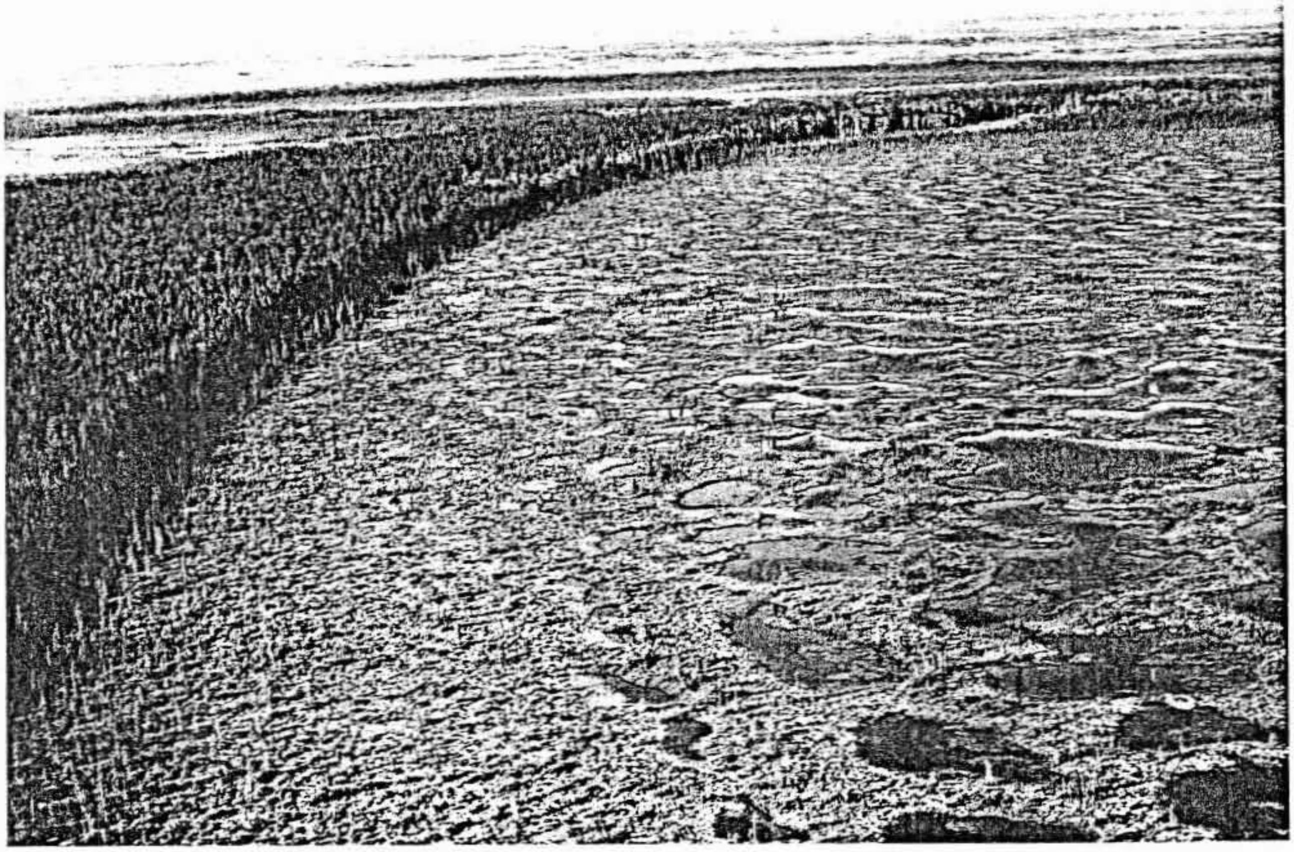

Fig. 14. This major inland beach ridge, 70 km northwest of Moosonee, Ontario, supports mature black spruce (*Picea mariana*)-jack pine (*Pinus banksiana*) forests similar to those of the boreal region south of the Lowland. The beach complex backs abruptly on patterned open fen.

4.2.3 Interior wetland ecosystems. Wetlands, predominantly peatlands, occupy 85% or more of the HBL (Coombs 1954, Radforth 1973). In fact, well over half of the organic soil deposits in Ontario are located in the HBL (Ketcheson and Jeglum 1972).

The formation of peat begins very near the coast, only a few kilometres from high tide shores (Coombs 1952, 1954, Moir 1954, Ritchie 1957). The narrow coastal strip along James and Hudson bays, approximating Coombs' (1954) Coastal Zone, contains peat-forming plants. With isostatic rebound, there is a slow coastward development of peat over recently exposed mineral ground. Hustich (1957) reported organic layers nearly 1 m deep only 6 to 10 km south of the mouth of the Severn River. From the rate of isostatic uplift and the distance of peat deposits from the seashore, an annual accumulation of organic material of 1.3 mm was calculated for that area.

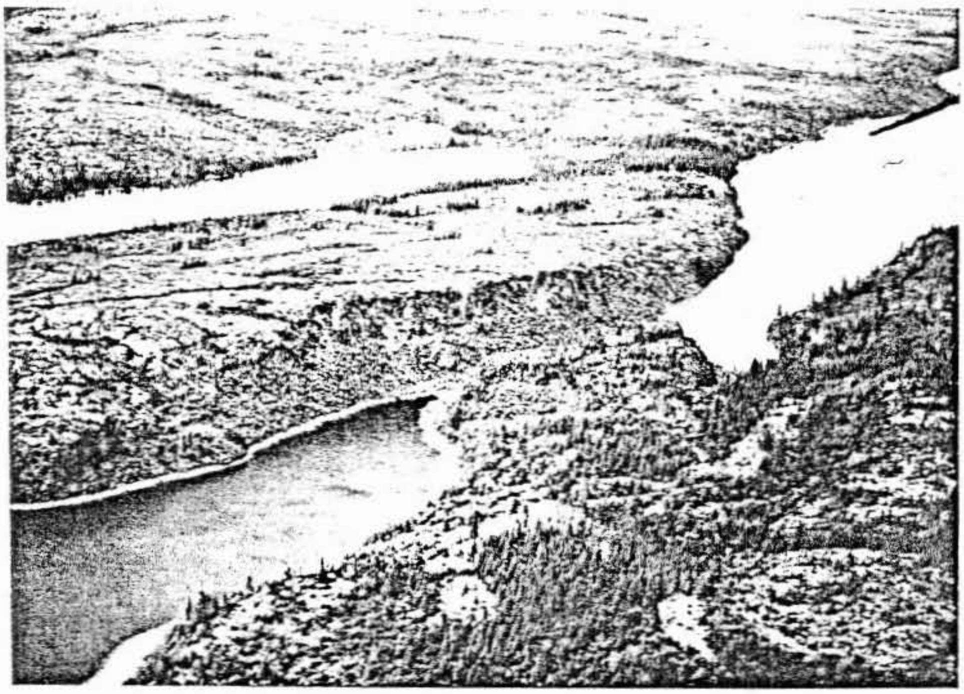

Fig. 15. The Sutton Ridges, one of the Precambrian inliers in the HBL. Sutton Lake is lower left, Hawley Lake upper right. The escarpment crest is approximately 100 m above the lake level.

A few detailed accounts of wetland vegetation and its ecology have appeared. In his phytogeographical accounts of northeastern Canada, Hustich (1949, 1950, 1955, 1957a, 1957b) describes the interior wetlands, utilizing European, mainly Finnish, peatland concepts. The final paper by Hustich (1957b) is a landmark for two reasons. First it synthesizes past information on the flora, habitat types, dynamics of pattern formation, and phytogeographical information then available. Voids in the knowledge of the HBL were identified. Second, it is the first work in the HBL to utilize the airplane as the main mode of travel and for obtaining detailed aerial observations.

Although Hustich was not able to do a large amount of on-the-ground field work, he recognized and described a number of forest or vegetation types (1957a and b), which are cited in Table 2.

Another important worker in the HBL is the Swedish mire scientist Hugo Sjörs, who produced several influential publications (Sjörs 1959, 1961a, 1961b, 1963b). In these works he introduces the Swedish concepts of ombrotrophic bog and minerotrophic fen, and delves into many aspects of peatland ecology and processes. His monograph (1961b) on forests and peatlands near Hawley Lake includes lists of representative species for a number of forest and wetland communities, and detailed descriptions of palsa bogs.

Sjörs' work on the Attawapiskat River (1963b) is a more thorough treatment of peatland types, with data on water chemistry and expanded lists of indicator species. He includes considerable description and discussion of frozen ground in bogs and the genesis of black spruce islands (Fig. 16), and presents the results of detailed transects across bogs and river banks, including stratigraphic information.

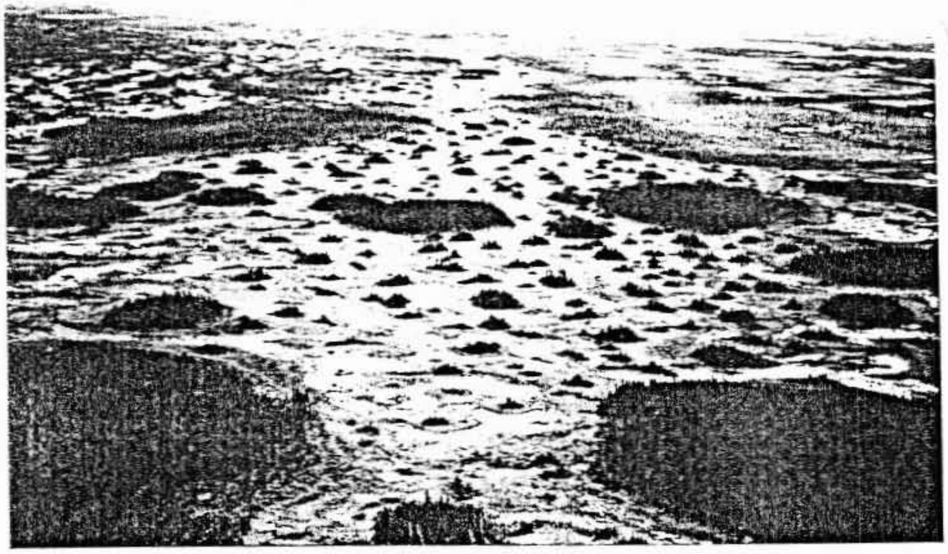

Fig. 16. Interior peatlands of the HBL are seemingly endless complexes of treed and open bog, fen and swamp. Here black spruce islands of varying sizes dot an expanse of minerotrophic open fen (near the Albany River, 50 km inland from James Bay).

He finally discusses in some detail successional trends, the origin of lakes, and potential resources of the area.

The vegetation and habitat types described by Sjörs (1961b, 1963b) are summarized in Table 3.

The great variety of patterns and complexes of peatland and upland types have intrigued most workers, and when first encountered from the air these are quite confusing. They have been described only partially, and their relative scales, relationships to other adjacent systems, and processes of formation require much more investigation.

Some of the patterns and complexes which have been described include 'lake-land muskeg', 'pothole muskeg' and 'smallpox muskeg' (Hanson and Smith 1950); beach line-wetland complexes (e.g., Hustich 1975b); string, ripple mark or patterned fen (Sjörs 1959, 1961a, 1963b, 'string bog' of Hustich 1957b); 'patterned scum marshes' (Hustich 1957b); black spruce islands, often tear-drop shaped (Hustich 1957b; Sjörs 1959, 1963b) (Fig. 17); bog lakes sometimes apparently in process of becoming larger by coalescence (Sjörs 1963b); palsas and palsa fields in bogs and fens (Sjörs 1959, 1961b, 1963b; Bates and Simkin 1969); bog islands in fen expanses (Bates and Simkin 1969); ice-formed polygons (Bates and Simkin 1969); and ice collapse features in palsas, black spruce islands, and peat plateaus (Sjörs 1961b, 1963b; Zoltai 1971, 1972).

Fig. 17. Tear-drop shaped black spruce islands have "minerotrophic tails" in the direction of water-flow, but lie in a patterned string-fen with low ridges oriented at right-angles to water-flow.

The string fens (Fig. 17) are the most frequently mentioned patterns. They exhibit a linear patterning of ridges alternating with low mats of sedge fen and/or pools (Swedish 'flarks' and Finnish 'rimpis'). These linear ridges and lows are oriented at right angles to the movement of water (Hanson and Smith 1950; Coombs 1954; Hustich 1957b; Sjörs 1959, 1961b, 1963b; Knollenberg 1964; Pollard 1970). These features may be caused by surface slippage of the organic mat, which results in surface 'wrinkling', linear deposition of surface debris related to sheet surface flow, seasonal frost action, wet surface oxidation by algae, and/or other factors not well understood (e.g., Sjörs 1963b, Hofstetter 1969, Zoltai 1973).

Seasonal frost and permafrost reltationships to peatlands and peat landforms have received considerable attention. Sjörs (1961b, 1963b) emphasized palsa formation, but also stressed black spruce islands or bog island/frozen ground relationships. He noted that, after a fire, the ice core of an island will melt and the 'island' will collapse before the spruce has a chance to regenerate. Recent work by Zoltai and Tarnocai has provided more detailed descriptions of permafrost-palsa and permafrost-peat plateau relationships. Recent work by Cowell et al.(1978) suggests that some black spruce islands near the southern limit of discontinuous permafrost are primarily the result of raised mineral islands in the peatland matrix, and that vegetative cover is very important in maintaining frozen ground late into the summer.

Because discontinuous permafrost is found throughout much of the HBL peatland, it can be considered a natural feature of the physical environment. It manifests itself in two raised peatland features: palsas and peat plateaus. Bog vegetation on raised palsas and peat plateaus is isolated above the water table and normally reflects ombrotrophic conditions for growth.

Palsas are peatland mounds with perennially frozen cores and are most common in southern portions of discontinuous permafrost (Brown 1967) (Fig. 18 and 19). They are generally much less than 100 m in diameter and usually vary in height between 1 and 3 m (Sjörs 1961a), although they may reach 7 m (Zoltai and Tarnocai 1971). Palsas may support ombrotrophic vegetation varying from an open ericaceous shrub-lichen "krummholtz" in the north to a heavily wooded stand of *Picea mariana* in southern regions. The most southern distribution of palsas recorded in the literature for Canada is within the HBL at 53.0° N along the Attawapiskat River (Brown 1968). The dynamics of palsa growth and collapse are complex, involving winter snow cover, albedo associated with vegetation types and a critical annual negative thermal conductivity (Sjörs 1961a, Lundqvist[19], Brown 1964, Forsgren[20], Zoltai 1971, 1972, Railton and Sparling 1973).

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[19]Lundqvist, G. 1961. Patterned ground and related frost phenomenon in Sweden. Sveriges Geol. Unders. Arsb. Ser. C. Adv. Uppsater 583:1-101.

[20]Forsgren, B. 1968. Studies of palsas in Finland, Norway and Sweden, 1964-66. Biul. Peryglac. 17:117-123.

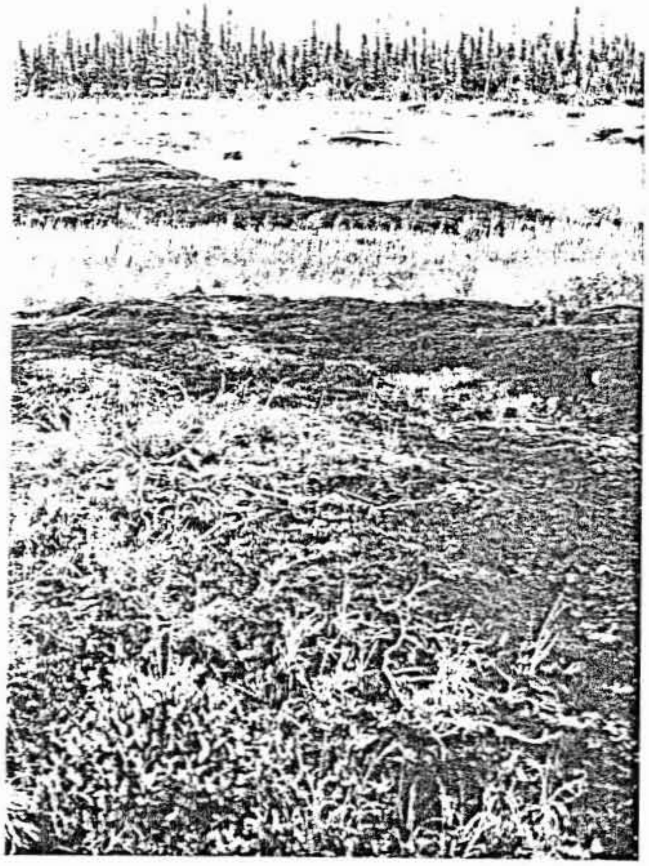

Fig. 18

Peat palsas are features of the discontinuous permafrost zone. Raised and with perennially frozen cores, these palsas are often covered with dark brown fen mosses, commonly *Scorpidium scorpioides*.

Fig. 19. Inland from Hudson Bay, sinuous lichen-covered palsas surrounded by water-saturated fen and fen pools (within the widespread permafrost zone, near Winisk, Ontario).

Palsas appear to be consistently associated with mineral soil, the permafrost extending below the palsa into the inorganic horizons. The growth of palsas results from an accumulation of segregated ice in the inorganic fine-grained soil (Zoltai and Tarnocai 1971).

Peat plateaus are characterized by relatively dry peats, elevated up to 120 cm above the water-saturated fen peat (Brown 1968), in the HBL typically covered by dense stands of black spruce (Fig. 20). Peat plateaus may extend over several square kilometres. They are flat with only minor irregularities, and permafrost, generally found within 75 cm of the surface, does not extend into the substratum (Zoltai 1973). Widespread in central and northern HBL, they occur along creeks and rivers, on the margins of fens or as large ombrotrophic bog islands in fens (Zoltai 1971, 1972).

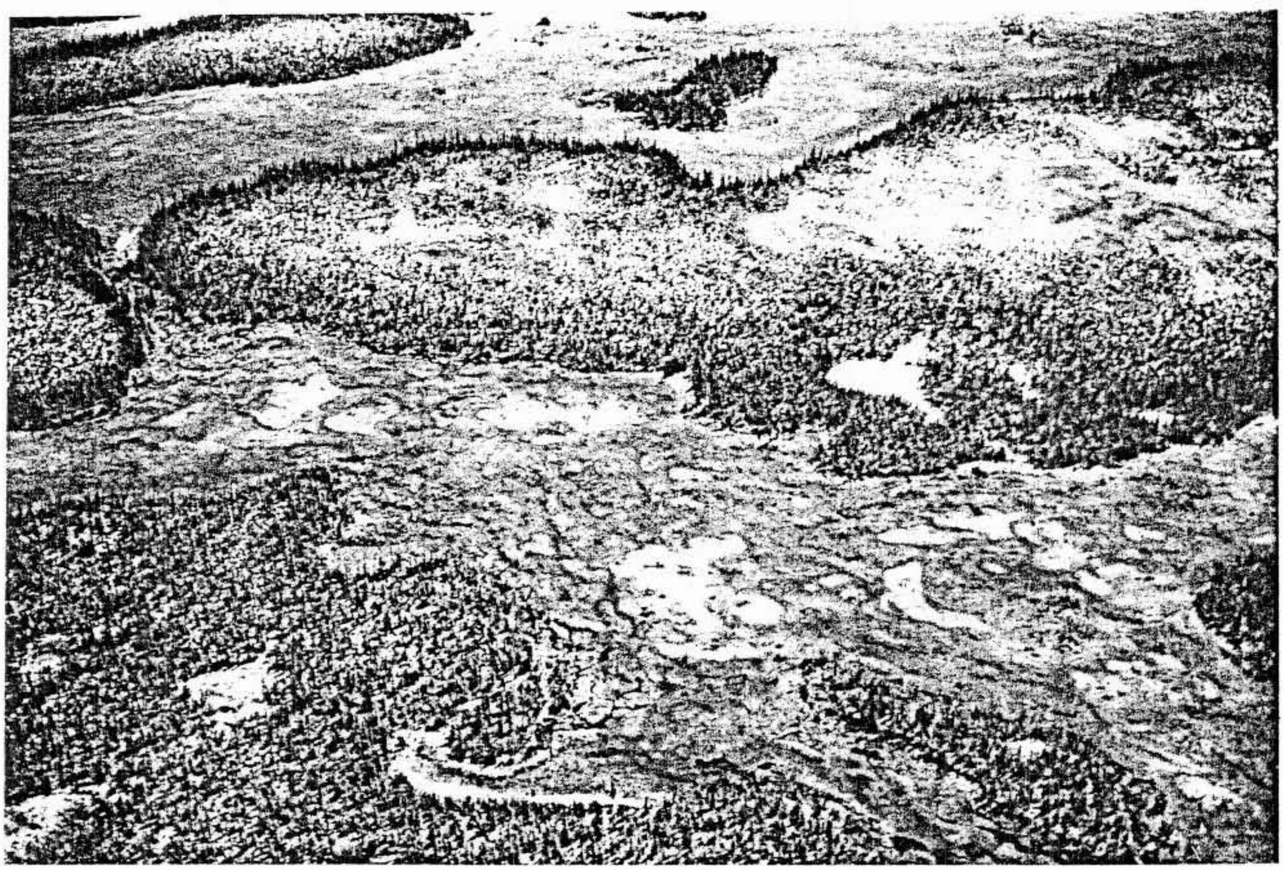

Fig. 20. Round, perennially frozen peat plateaus surrounded by open fen are also found in the HBL's discontinuous permafrost zone. The brown areas on the peat plateaus are collapse scars. (Churchill area, Manitoba) (Photo: C. Tarnocai)

Advanced remote sensing techniques have not been utilized fully in defining landforms and the environment of the Lowland. Tarnocai (1972a) has described the effectiveness of various types of remote sensing information for analyzing environmental features, including permafrost. Satellite imagery was found in one exercise to be of limited application and only useful in recognizing readily identifiable features such as raised beaches, lichen woodlands, coniferous forests, lakes and streams in the Fawn-Winisk area of the Lowland (Suffling 1973). Thie (1976) has considered the accuracy and cost-effectiveness of LANDSAT imagery in comparison within other remote sensing techniques for a local unit near Churchill.

Fabiszewsky (1976) has published on studies of the vegetation, flora and ecology of raised bogs in eastern Canada, including one bog site near Moosonee. He compares Canadian plant associations with European ones using the Braun-Blanquet classification approach, and reports on detailed studies on lichen flora, lichen ecology, and the inhibitory effects of lichens on seed germination and growth of other bog species.

4.3 Wetland Classification for the HBL

The classification system of wetlands has fallen under scrutiny recently in Canada (Lacate[21], Jeglum et al. 1974, Zoltai et al. 1975, Zoltai and Tarnocai 1976, Jeglum and Boissonneau 1977) and units are gradually becoming standardized. This may help to reorient future classification attempts in the Lowland and eliminate confusion over concepts and terms. Table 4 summarizes some of the main wetland classifications applied or applicable to the HBL wetlands.

The classification for Ontario (Jeglum et al. 1974) recognizes four main "formations" (bog, fen, swamp, and marsh), and four subdivisions (subformations, physiognomic groups, dominance types, and site types). Vegetational physiognomy and dominance were emphasized for ease of air photo interpretation (Jeglum and Boissonneau 1977). Landform (including permafrost-induced) is not a criterion of the scheme although modifications such as those proposed by Tarnocai (1970, 1974a) fit easily into the hierarchy.

Hustich (1955, 1957a, 1957b) has detailed the characteristics of the physiognomic forest-types (Table 2), discussing wetland non-forested types in terms of bog and fen.

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[21]Lacate, D.S., Compiler. 1969. Guidelines for bio-physical land classification, for classification of forest lands and associated wildlands. Dep. Fish. For. Can. For. Serv., Ottawa, Ont. Publ. No. 1264, 61 p.

Table 4. Summary of selected wetland classification schemes applied in the Hudson Bay Lowland.

Author(s)	Basis of wetland classification	Major classification units
Hanson, H.C. and Smith, R.H.	-aerial interpretation of peatland pattern in the HBL	MUSKEG TYPES - Well-timbered, Open, Lakeland, Pothold, "Smallpox"
Radforth, N.W. (1955*b*, 1958)	-aerial interpretation of vegetation-landform-hydrological pattern in northern Canadian peatlands. Hierarchical, based on scale of photo imagery	AIR FORM - (high altitude) dermatoid marbloid, reticuloid, stipploid, terrazoid; (lower altitude) apiculoid, cmuloid, intrusoid, planoid, polygoid, vermiculoid
Hustich, I. (1957*b*)	-aerial interpretation of peatland pattern in the HBL, vegetational physiognomy and dominance, and landform	FOREST TYPES - Black Spruce Muskeg, Lichen Woodland (on peatland), Open Tamarack Forests BOG TYPES - Fens, Swamp, Bog (Raised, String, Tundra, Heath, Forested)
Ritchie, J.C. (1960)	-general vegetational dominance; aerial interpretation of pattern and texture; broad peat depth categories. Hierarchical	VEGETATION TYPES - 1) Primarily peat-Bog (with trees, without trees), Fen; 2) primarily mineral-Marsh
Sjörs, H. (1961, 1963*b*)	-plant indicators of degree of minerotrophy; general vegetational dominance	MAIN VEGETATION UNITS - Bog, Fen (Poor, Intermediate, Rich, Very Rich). (Other qualifiers based on topography and habitat: fen seepages, ridges, flarks, fen and bog pools, open bog, woodland bog, etc.)
Ahti, T. and Hepburn, R.L. (1967)	-vegetational dominance, general physiognomy, but also peat depth classes and minerotrophic plant indicators. Hierarchical	FORMATIONS - Fen, Bog, Muskeg, Swamp, Swamp Forest
Tarnocai, C. (1970, 1974*b*)	-peat landforms, general topography, vegetational community structure, organic soil classification. Hierarchical	CLASS, SUBCLASS - Bog (Domed, Plateau, Flat, Bowl, Blanket); Fen (Horizontal Patterned, Sloping, Floating, Collapse, Spring, Domed); Swamp (Lowland)
Jeglum, J.K. Boissonneau, A.N. and Haavisto, V.F.(1974)	-vegetational physiognomy, dominance of vegetation, major complex gradients, including ranges of minerotrophy/ombrotrophy, water-table depths and peat depths. Hierarchical	FORMATIONS and SUBFORMATIONS - Marsh, Fen (Open and Treed), Swamp, Bog (Open and Treed)

As major classification units for HBL wetlands at Hawley Lake and near the Attawapiskat River, Sjörs (1959, 1961a, 1961b, 1963b) suggested the bog and the poor, intermediate, rich and extremely rich fen catgories of DuRietz[22].

Bog vegetation is strictly ombrotrophic, characteristically supporting such plants as *Sphagnum* spp., *Ledum groenlandicum, Chamaedaphne calyculata, Rubus chamaemorus, Carex limosa, Scirpus cespitosus,* and where wooded, *Picea mariana* and occasional *Larix laricina*. The poor fen is distinguished from the bog by a limited number of minerotrophic indicators including *Menyanthes trifoliata, Equisetum fluviatile,* and, in shallow pools, *Utricularia* spp. (Fig. 21). The rich fen and extremely rich fen support minerotrophic cyperaceous species usually associated with dense underscrub, and a comparatively diverse flora.

Fig. 21. Minerotrophic open fen and fen pool (foreground) and ombrotrophic open and treed bog (background) near Kinoje Lake.

The bog patterns delineated by Sjörs (1961a, 1963b) are the hummock-hollow-bog formation, black spruce islands and palsas. Minerotrophic peatlands, the most extensive type in the HBL, are

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[22]DuRietz, G.E. 1949. Huvudenheter och huvudgränser i svensk myrvegetation. Svensk. Bot. Tidskr. 43(2/3):274-304.

represented by patterns of ridges, flarks, fen pools, wooded fen and riparian fen (Sjörs 1963b).

In the northern Manitoba portion of the Lowland, five community types commonly occur in seral successions on alluvial and marine clay substrata, and six on organic soils. These groupings, described for the lower Hayes River region, are based on subjective decisions of "homogenous vegetation features" from field work and aerial photomapping (Ritchie 1960). A seral invasion of five community types encroaches on the estuarial flats of the Churchill River (Ritchie 1957). Further terrain units have been recognized in the Churchill area (Beckel et al. 1954; Scoggan 1957, 1959).

Radforth (1955b, 1958) proposed a peatland classification based on form alone, using aerial photography at various altitudes. With photos taken primarily from the Churchill area, he categorizes airform pattern in five main units: marbloid, terrazoid, reticuloid, dermatoid and stipploid. While the system does not directly reflect inherent ecological processes or detailed floristic or ecological data, it "objectively classifies wetlands, avoiding the use of abstract notions of minerotrophy" (Radforth 1973). Some information on the vegetation cover can be derived from the application of "Radforth Muskeg Cover Classification System" (McFarlane 1958) to the air photos. The concept is perhaps best adapted to hydrological and engineering requirements of terrain analysis. A revised system, which makes use of hydrology, has been developed recently (Radforth and Bellamy 1973, Radforth 1973).

Classification systems often vary, depending on the purpose for which they were designed. Ahti and Hepburn (1967) proposed five peatland formations (fen, bog, muskeg, swamp and swamp forest) and numerous subdivisions within each formation in interpreting woodland caribou ranges in northern Ontario. The classificatory concepts are synthesized from Sjörs (1959, 1961a, 1961b), Hustich (1955, 1957a, 1957b) and Kalela (1962). Units are interpreted in terms of their importance to caribou.

A preliminary attempt, based on field observations, has been made to classify vegetation groupings for southeast James Bay wetlands (Majken 1973). Two steps are outlined: 1) identify recognizable units and their distinguishing species on aerial photographs and 2) describe principal plant groups and habitats. Major divisions are made: structured minerotrophic peatlands, depressions, pools, ponds; unstructured minerotrophic peatlands; transitional, structured ombrotrophic peatlands; and unstructured ombrotrophic peatlands. The outstanding indicator species of each habitat type are provided.

Responding to the need for a peat landform classification, Tarnocai (1970, 1974a) proposed a system for Manitoba based on features of morphology, peat material, hydrology and water movement patterns, vegetation and ecology. Major classes of bog, fen and swamp are further divided into subclass and land type (Tarnocai 1974a). The method is applied with photo-interpretation and ground truthing of peat landforms in northern Manitoba and southeastern Northwest Territories terrain (Tarnocai 1974b). More intensive landform classification has been carried out in the Manitoba HBL involving a systematic regional biophysical study (Mills et al. 1976a, b).

4.4 Gaps in Knowledge and Research Needs

An ecologically based subdivision into broad zones and regions of the HBL would provide a framework for the handling of information on the area. While several such subdivisions have been proposed in the past to serve a number of purposes, to date none have been universally adaptable. A research need, then, is either to develop more complete descriptions of zones defined by a past worker, or to create an improved and revised subdivision of the HBL based on a number of ecological criteria (cf. Lacate[21], Jurdant et al.[17]).

Coastal ecosystems are of particular importance when one is clarifying primary research needs for the Lowland. These ecosystem complexes are critical nesting and staging areas for many species of migrating shorebirds and waterfowl, including species whose existence is threatened or endangered. While a number of floristic studies have been carried out in coastal habitats, further ecological information is now required on productivity of vegetation communities, the distribution, areal extent and fine-scaled classification of coastal habitats, long-term successional and process studies, and detailed analyses of wildlife-vegetation relationships. With such baseline data on the coastal ecosystems in hand, informed and rational management decisions with respect to these biologically highly productive areas could be made in the future, particularly since most foreseeable developments (e.g., hydro-electric dams and river diversions, utility corridors, seaport development) will likely have their greatest environmental impact on the coast.

The great variety of patterns and complexes of peatland and upland types have been only partly described, and their relative scales, relationships to adjacent systems, and processes of formation require continued investigation.

More emphasis should be given to understanding the dynamic processes of systems in the interior uplands and wetlands. We know, from similar areas such as parts of the MacKenzie Valley, that wetland and peatland systems in particular can be extremely susceptible to damage when permafrost is present (Anon.[23], Zoltai and Tarnocai 1976). Work on drainage blockage caused by road damming of a peatland drainageway (Jeglum 1975) indicates that peatlands can revert to open, wetter conditions very rapidly. By documenting various kinds of man-caused disturbances on peatlands and wetlands, and by conducting inventories of the interior upland and wetland types and systems with major processes controlling them, it will be possible to assess more knowledgeably the possible impacts that proposed developments may have on the HBL.

Future classification attempts in the Lowland, particularly of the wetlands, should follow a structured system employing well defined, generally accepted terminology. A standardization of approach is required. A simple inventory of features is certainly essential as a first step to resource management in the HBL, and will provide the tools for understanding the processes that pattern the land.

5. NATURAL IMPACTS UPON THE VEGETATION

5.1 Fire

It is being recognized now that fire has played an important role in the boreal forest. Unfortunately, forest fire research allows only a few generalizations because of the wide differences in soil, geology, climate and vegetation type in the boreal region across Canada (Scotter 1972, Row and Scotter 1973) and no investigative project has been carried out specifically in HBL boreal areas. This situation can be attributed in part to the inaccessibility of the area, in part to the meager timber resources; only in the extreme southern portion has commercial resources harvesting been conducted (Hustich 1957b).

Large fires, in excess of 200 ha, are infrequent in the HBL as compared with other portions of Ontario (Anon. 1973) because of the prevailing humid atmosphere and wet surface conditions. Nevertheless, numerous small fires are believed to have had considerable influence on forest type development (McInnes 1912, Hustich 1955, 1957b, Ritchie 1959, 1960b, Brokx 1965, 1967).

Even though much of the area is peatland, there can be dry periods of sufficient duration to dry out surface organic layers and allow them to burn. Lichen woodlands have been recognized as the forest type most susceptible to fire in the HBL (Hustich 1957a, b, Lumsden 1974, Kershaw 1977). Ahti and Hepburn (1967) observed increases in ground lichen stands following fire in northern Ontario. For a black spruce-lichen woodland near Abitau L., Northwest Territories, a post-fire developmental sequence described by Maikawa and Kershaw (1976) demonstrated the major role of ground lichens in the recovery. The

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[23]Anon. 1974. MacKenzie Valley and Northern Yukon pipelines. Socio-economic and environmental aspects. Environ. Soc. Comm., North. Pipelines, Task Force on Northern Oil Development. Rep. No. 74-17. 197 p.

suggestion has therefore been made that controlled burnings be used as a caribou range management strategy (Scotter 1964, 1970, Ahti and Hepburn 1967). However, it is not known if the above sequence occurs after fire in the HBL. Ritchie (1960) describes a black spruce-lichen tract destroyed by fire and replaced by *Salix* spp. communities near the mouth of the Albany River. Net radiation and soil heat flow have been compared for a 16-year-old burnt surface and a mature *Cladina stellaris*-black spruce woodland near Hawley Lake, to provide preliminary evidence on the course of post-fire recovery in the Lowland (Rouse and Kershaw 1971). Kershaw (1977) concedes that the early recovery sequence after fire in lichen woodland is a complex process. Moreover, lichen woodland overlying ice lenses (palsas, peat plateaus) upon burning undergoes interactions with the landform that complicate the cyclic recovery pattern.

Inland beach ridge and riverbank forests are also subject to fire. Ground mats of feather moss (*Pleurozium schreberi*) and leaf litter can become extremely dry and will serve to carry fire in drier peatland and upland forests on burned-over beach ridges, especially south of the Attawapiskat River. Stands of *Pinus banksiana* were observed to regenerate (Brokx 1965), while hardwood stands (primarily *Populus balsamifera* and *Betula papyrifera*) are characteristic of post-fire recoveries on the banks of the Kapiskau, Lawasaki and Albany Rivers in the south (Brokx 1965, 1967). Aspen may rejuvenate after fire on some medium- and fine-grained soils. A seral succession was governed by increasing organic layer thickness for a continuum near Churchill (Ritchie 1957), and establishment of *Picea glauca* following a fire on raised alluvium was thought quite probable.

Occasional unchecked fires may have a significant effect on water level increases in a locality. Initially a burned-over area experiences greatly diminished evapotranspiration rates. Probably because of its hygroscopic nature, *Sphagnum* is more resistant to burning than other ground layer species and is provided with an opportunity to expand its area in the more favorable conditions of higher water. This could lead to paludification of the post-burn area (Hustich 1957).

5.2 Insect Damage

Major natural barriers of topography or climate are not present in the HBL to deter insect infestations. Within the HBL, mass attacks of larch sawfly (*Pristiphora erichsonii*) over large areas have been documented (McInnes 1908, Munroe 1956, Hustich 1957). The other destructive tree pests, the spruce budworm (*Choristoneura fumiferana*) and the forest tent caterpillar (*Malacosoma disstria*), are also found here. The extent of influence of the numerous vegetation grazers, such as the northern grasshopper (*Melanoplus borealis*), numerous caterpillars, and root maggots (*Hylemia* sp.) is not known. The Canadian Forestry Service's Forest Insect and Disease Survey does not carry out its surveys north of merchantable forest areas that are being harvested, and thus excludes the HBL. In the interpretation of vegetation patterns of certain HBL areas, the role of insect attacks may be more significant than the present paucity of data would suggest.

5.3 Flooding

Flooding has a great effect on the dynamics of the landscape. One contributing factor in the paludification of the boreal forest zone is the beaver (Hanson and Smith 1950, Sjörs 1959, 1961b, 1963b) (Fig. 22). Following a long period of low numbers attributable to exploitation there have been recent population increases (Sjörs 1963b) which may be intensifying this animal's impact. Spring and early summer flooding along main rivers infrequently results from huge ice jams, producing temporarily high water levels (Sjörs 1959). This also contributes to river bank erosion, a process which creates new habitats for plant species (Hustich 1955, Sjörs 1959). Several ecological conditions, such as corrosive oxidation and ice uplift, may contribute to retardation of peat development in pools and wet hollows (Sjörs 1963). When these conditions are induced locally, even temporarily, by flooding they may significantly alter the paths of succession/retrogression. Jeglum (1975) documented vegetation changes following flooding of a peatland drainageway after road building in northern Ontario, describing a process that could well occur as a natural event in the HBL.

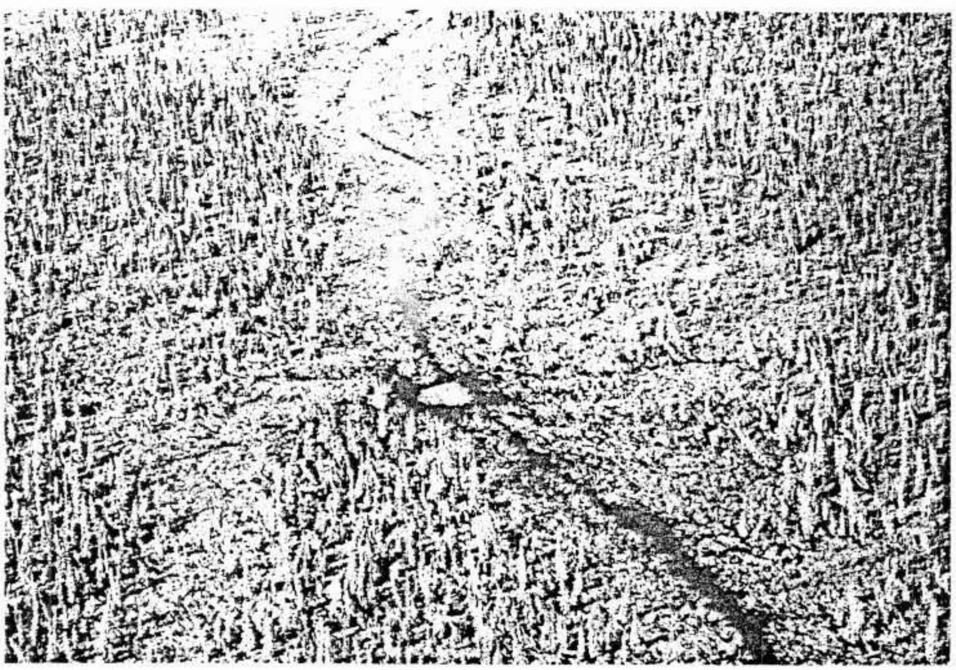

Fig. 22. Beaver damming can affect drainage and cause accelerated paludification in local areas in the Lowland (southeast of Fort Severn, Ontario).

5.4 Winds

As a natural process, prevailing wind influences snow cover in particular; snow cover, in turn, can play a key role in determining vegetation community structure on beach ridges, sedge meadows and forested areas (Larson and Kershaw 1974b), in permafrost formation under palsas and peat plateaus (Tyrtikov 1959, Sjörs 1961, R.J.E. Brown 1964, 1968b, 1972, Railton and Sparling 1973), in the formation of abnormal growth forms, and in the stunting of vegetation, by taking advantage of protective winter snow levels (Sjörs 1963) (see Fig. 23). There is no documentation of wind-related impact, although a winter low pressure system centres in Hudson Bay (Longley[24]), and certainly the land area, because of its flat topography, is subject to periodic high winds in all seasons. The shallow lakes, for example, frequently demonstrate wave-eroded margins influenced over time by weather conditions (Sjörs 1963b). It has been observed that the east sides of lakes often have shallow and flat zones, probably in response to movement of sediments by the prevailing westerly winds (Lumsden, personal communication).

5.5 Gaps in Knowledge and Research Needs

Natural impacts in the Lowland have received little consideration in past literature, being dealt with only in terms of simple observation. This is due to a lack of baseline data to evaluate the magnitude of natural impacts. The study of these impacts will have no firm orientation until portions of the region are described vegetationally and major ecological processes are identified and well characterized.

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[24]Longley, R. 1972. The climate of the prairie provinces. Dep. Environ., Atmosph. Environ. Serv., Ottawa, Ont. Climatol. Stud. No. 13. vii + 79 p.

6. ANNOTATED BIBLIOGRAPHY

Some 265 titles, indexed by principal author, are included in this section. Each entry consists of:

(i) *An Identification.* Each publication is identified by the author's name, year of publication, title, source and number of pages.

(ii) *An Annotation.* The annotations are brief summaries of the publications. Most annotations have been written by the compilers. Where author abstracts or passages from the texts have been used, these are set off by quotation marks.

(iii) *An 'HBL-prefix'.* The presence of 'HBL' as a prefix to a keyword list denotes an entry containing material geographically pertaining to the HBL. Lack of the prefix indicates a reference included only to provide current perspective on knowledge for the area.

(iv) *A Keyword List.* The list of keywords will help to identify more specific subject areas, and may be used in conjunction with the *keyword index* of Section 7.

Abbe, E.C. 1948. *Braya* in boreal eastern America. Rhodora 50:1-15.

Discusses the notably disjunct population of the Criciferae *Braya humilis* (C.A. Mey) Robins along James Bay. A key to *Braya* in boreal eastern America is provided. The population can no longer be considered disjunct in the light of subsequent field work.

HBL - *Keywords:* taxonomic treatment; phytogeography; plant migration

Ahti, T. 1964. Macrolichens and their zonal distribution in boreal and arctic Ontario, Canada. Ann. Bot. Fenn. 1:1-35.

Major European climatic zonations are applied to boreal and subarctic Ontario, and the divisions into subzones by different authors are considered as well. Three boreal zones (two in the HBL) and two arctic zones are proposed, with potential evaporation values being used as guides. The paper reports on extensive collections (80-100 sites), "listing records in northern Ontario according to vegetation zones, with a general statement on habitats, distribution and abundance in northern Ontario". Also, general zonal distribution in the arctic, boreal and temperate vegetation zones and subzones in the northern hemisphere, with notes on range, taxonomy, etc., are given. The circumpolar nature of 85% of the taxa involved is discussed.

HBL - *Keywords:* climate; lichen, ecology; lichen, species lists; lichen woodland; wildlife habitat relationships--caribou; zonations, regions and districts

Ahti, T. and Hepburn, R.L. 1967. Preliminary study on woodland caribou range, especially in lichen stands, in Ontario. Ont. Min. Nat. Resour., Res. Br., (Wildlife), Res. Rep. 74. 134 p.

A survey of northern Ontario, including the HBL, for the purpose of describing and classifying the vegetation, and particularly the lichen resources of the area, as habitat for woodland caribou (*Rangifer tarandus caribou*).

"Distribution and ecology of 38 of the most abundant macrolichens are discussed. The ecology and composition of typical lichen stands throughout the study are outlined in relation to substrata, to their use as food for caribou, and to the distribution of vascular plants.

On the basis of broad land types and availability of lichens, seven major divisions of the caribou range are proposed, and estimates are given for carrying capacity in each. It appears that present food supplies could support about six times as many caribou as now occupy the range, particularly north of 53° lat.

Controlled burning is suggested as the best method of range management.

Keys to 138 macrolichens of northern Ontario are included in this report".

HBL - *Keywords:* climate; fire; lichen, ecology; lichen, species lists; phytogeography; lichen woodland; wildlife habitat relationships--caribou; zonations, regions and districts

Allington, K.R. 1961. The bogs of central Labrador--Ungava; an examination of their physical characteristics. Geogr. annales. 43(3-4):401-417.

The peatlands of the Labrador-Ungava peninsula are discussed in terms of their dynamics. A main objective was to classify the organic terrain according to physiognomic and morphologic characteristics. These were established from different textures appearing in aerial photographs and the following were recognized: string bog, closed strings, sedge meadow, and bog forest. Some of the wetland processes involved in the formation of these five types are postulated but the popular concept of "climax" is discredited and visualized only in altitudinal or gradient limits; equilibrium is never established in the climax sense. String bog formation is attributed to 1) frost action at the surface, causing ridges to heave, and 2) the depth of spring thaw regulating frost movement and causing melt water inundations in the flarks. Ultimately, a self-perpetuating system is visualized for the ridge-flark system. The short growing season is modified by the ridge-flark land forms creating differential frost-free periods across the microtopographical gradients.

- *Keywords:* remote sensing; climate; hydrology; patterned terrain; peatland, classification; peatland, ecology; string bogs and patterned fens

Andrews, J.T. and Webber, P.J. 1969. Lichenometry used to evaluate past glacial trends. Arct. Alp. Res., 1(3):181-194.

Based on field studies on Baffin Isl. and the author's note that similar work on the ridges of the HBL may not be worthwhile because of relative lack of satisfactory substrate.

HBL - *Keywords:* climate; agriculture; peatland, distribution and extent

Anon. 1973. Fire management map series. (series for Northeastern/Northwestern/Northern Ontario, including the southern HBL.--scale = 1:506,800 or 1 in. = 8 mi.). Ont. Min. Nat. Resour.

A series of prepared maps that display the size, limits and ages of recorded fires for these regions of Ontario. Included are all fires since 1963 that were larger than 500 acres (200 ha). A low incidence of large fires within the HBL boundary is observable.

HBL - *Keywords:* fire

Anon. 1976. Distribution of eelgrass; east coast, James Bay. Map scale 1:125,000. Dep. Environ., Can. Wildl. Serv., Ottawa, Ont.

Mapped are major eelgrass beds along the east coast of James Bay from Point Louis XIV south to Baie du Vieux-Comptoir (just north of the HBL in Quebéc). Data were gathered by 1974 and 1975 helicopter surveys conducted at low tides.

HBL - *Keywords:* paleobotany, pollen spectra

Anon. 1977. Polar Bear Provincial Park--background information. Ont. Min. Nat. Resour., Parks Branch. 54 p.

This publication presents general information on the park environment, including notes on climate, geology, wildlife, and natural vegetation regions and life areas. In addition, the historical relationship of man with the parkland is retraced and the recreation and research opportunities provided by this recently established wilderness park are outlined. Numerous photos and maps and a brief bibliography are included.

HBL - *Keywords:* beach ridges, interior; lichen, ecology; paleobotany, dating

Argus, G.W. and White, D.J. 1977. The rare vascular plants of Ontario. Natl. Mus. Nat. Sci., Natl. Mus. Can., Syllogeus Ser. No. 14. 64 p.

An Ontario list, compiled in collaboration with botanical and naturalist communities in the province, of suspected rare and endangered vascular plant species. Included are over 65 species whose noted range is solely or primarily restricted to HBL habitats.

HBL - *Keywords:* vascular species lists; taxonomic treatment

Arthur, M.D. and Marshall, I.F. 1976. Vegetation survey, nine kilometers northwest of North Point, southwestern James Bay, summer of 1975. Ont. Min. Nat. Resour., Office Sci. Advisor. 39 p. + appendices. (MS)

The study site, a coastal strip area of James Bay about 20 km north of the Moose River mouth (51°33'N, 80°31'W), was investigated in July, 1975. With a transect layout, subdivided into sample units, plant species were characterized by relative frequency, relative density, relative dominance and "importance value". Through the use of data collected at points successively further inland, major vegetation zones were identified as 1) intertidal zone, 2) supralittoral zone, 3) raised beach zone, 4) marsh zone, and 5) other zones (not described intensively, including *Salix* thicket, *Picea-Larix* woods, and raised gravel-covered beaches). The vegetational patterns surveyed were considered representative of much of the southwestern James Bay coastline. Water and soil analyses presented reflect interrelationships of species differences, drainage ability, occasional flooding by tidal waters, isostasy and ice movement.

In general, the source provides a comprehensive detailing of vegetation and environment of the coastal area, successfully grouping associations on the basis of edaphic factors. Five appendices include an annotated checklist of 150 plants, "importance value" calculations, descriptions of the vegetation communities, water sample analyses, soil sample analyses, and a list of the fauna observed.

HBL - *Keywords:* beach ridges, coastal; flooding; hydrology; isostasy; vascular species lists; nutrient dynamics; salt marsh; wildlife habitat relationships-waterfowl; tidal flats; sedge meadows

Arthur, M.D. and Marshall, I.F. 1977. Vegetation survey, Buoy's Bluff, southern James Bay, summer of 1976. Ont. Min. Nat. Resour., District Office. (MS).

A vegetation survey in the vicinity of Buoy's Bluff Creek, approximately 32 km east of Moosonee. Five transects, approximately 500 m apart, were established perpendicular to the coastline, and five major and six minor vegetation zones were delineated and described.

The five major vegetation zones were more intensively surveyed. The lowest-lying of these was an intertidal zone, a configuration of slightly raised mounds of silt-loam, scoured, exposed flats, and shallow trapped tidal pools. Immediately inland from the intertidal zone is an area occasionally flooded by storm tides during the summer and fall, and supporting at least five vegetation communities - *Carex paleacea* marsh, *Festuca rubra* - *Potentilla egedii* meadow, *Scirpus maritimus* pools, *Puccinellia* sp. marsh and *Carex mackenziei* marsh. A discontinuous raised beach zone occurred next (i.e., inland) and differed from a gravel ridge zone of exposed gravel and low vegetation cover by exhibiting considerable soil organic accumulation and a dense vegetation mat of primarily *Salix* spp. and low herbs. The gravel ridge zone, occurring inconsistently in the study area, ended abruptly, with little or no transition into a marsh zone. The marsh zone (10-30 cm standing water) was dominated by a diversity of vegetation sub-complexes which appeared strongly related to microtopographical influences. At the inland side of the marsh zone, the land was slightly higher and the beginning of an open graminoid/tamarack/willow fen and a damp willow woods was observed.

The six minor vegetation zones included a stream verge zone, an old gravel ridge zone, a damp willow wood zone, an open graminoid/tamarack/willow fen zone, an open graminoid fen zone, and a spruce wood zone.

On the basis of environmental measures (soil and water chemistry), the area appears to be somewhat more influenced by fresh waters, probably from the Moose River estuary, than other surveyed strips (Riley and Moore 1972, McKay and Arthur 1975, Arthur and Marshall 1976). Unlike the previous studies, no relationship could be established between K/Na ratio and water-soluble chlorine, and few true halophytes were encountered. One hundred and ninety-six species are listed, a diversity that could be attributed to the low salt stress on the systems.

Six appendices contain tabled field data, water and soil analyses and an annotated checklist of the species encountered.

HBL - *Keywords:* beach ridges, coastal; vascular species lists; nutrients; salt marsh; tidal flats; sedge meadows

Auer, V. 1927. Botany of the interglacial peat beds of Moose River Basin. Geol. Surv. Can., Summ. Rep., 1926, pt. C. No. 114. p. 45-47.

Nine sections, collected by McLearn in 1926, were determined for geobotanic content. The deposits are thought to be largely the result of fluviatile processes, because of the presence of interbedded silt. Although only a few species are described, this is felt to conform with the low diversity expected in northern situations. The compression of the peat by ice-sheet movement is easily observed in the material.

HBL - *Keywords:* paleobotany, pollen spectra

Baldwin, W.K.W. 1948. Botanical investigations on the east coast of Hudson and James Bays. Natl. Mus. Can., Bull. 113:31-32.

A brief account of a 1947 expedition from Moose Factory to Port Harrison, acknowledging collections of 500 plant species, and 265 bryophyte species, deposited in CAN.

HBL - *Keywords:* floristic notes; vascular species lists

Baldwin, W.K.W. 1953. Plants from two small island habitats in James Bay. Natl. Mus. Can., Bull. 128:154-167.

A useful record of CAN collections from James Bay up to 1950. Thirty-five species from Gasket Shoal, 67 from Solomon's Temple Island, for a total of 94 different species.

HBL - *Keywords:* vascular species lists

Baldwin, W.K.W. 1958. Plants of the Clay Belt of northern Ontario. Natl. Mus. Can., Bull. 156. 324 p.

The Clay Belt, a distinct physiographic region lying on the margin of the Precambrian Shield, covers some 180,000 square kilometres adjacent to the southern HBL. Some 993 taxa are catalogued for the area, with representation from 99 families, 343 genera, 856 species and 137 hybrids, varieties and forms. Eighty-one percent (697) of the species are considered native and the number of introduced species is in almost the same proportion (19%) as in Gray's Manual of Botany (20%) (Fernald, M.L. 1950. Gray's manual of botany. 8th ed. (reprinted 1975) Am. Book Co., New York. 1632 p.) Most valuable in applying the catalogue to HBL flora is a summary checklist (250-293) which notes geographic affinities for all species. Indications of reduction in the number of species passing northward through the Clay Belt are obtained through comparison with neighboring areas (including HBL regions) for which lists are available.

The author has incorporated all past available collections from the Clay Belt into the list. The catalogue includes information on distribution, habitat, collector and collection number, and, where possible, dates of flowering and fruiting.

An introduction supplies information on plant community types, topography, climate and geology, and a list of factors affecting changes in the flora (drainage, fire, climate, windthrow, etc.).

- *Keywords:* floristic notes; phenology; phytogeography

Baldwin, W.K.W. and members of the excursion. 1962. Report on botanical excursion to the boreal forest region in northern Quebec and Ontario. Natl. Mus. Can., Cat. No. R92-2162. 107 p.

Accounts by members of a field trip from the Ninth International Botanical Congress, during 1959, with contributions by ecologists, taxonomists, paleobotanists, and phytogeographers. Although much of the information is more applicable to the Clay Belt region, a short portion of the tour included travel into the southern HBL. Included are discussions by Terasmae (geology), Hills (Clay Belt soil/vegetation relations and plant migration routes), Maclean (forestry, growth and yield in the northern Clay Belt), Kalela (forest regions of Ontario and Finland), Morton (Pteridiophytes, species and habitats), and Lepage, Baldwin and Bassett (floristic notes).

In an introductory narrative, Baldwin cutlines the expedition's route; the southern portion of the Lowlands examined was the Moosonee - Shipsands Island - Moose Factory - Moose River Basin area accessible by train from Cochrane. Interesting plants (in the low tide flats, up the river banks, to the sedge meadows and willow thickets on higher ground) occurring on Shipsands Island in particular are remarked upon, and a brief checklist is given.

Kalela relates Moosonee area peatlands to comparable areas in Finland's aapasuo-region. He notes for the HBL that "the bog complexes further increase in extent; in string bogs, the strings become higher and wider; the swales also widen and are less moss-covered, with a larger number of open pools. Such types of aapasuo dominate the Attawapiskat and Muketei river areas in the Hudson Bay

Lowlands..."A similar change in the aapsuo region has been recognized in Finland as one travels north through the Pohjanmaa region". (See also Ruuhijarvi 1960. Annales. Bot. Soc. Zool. Bot. Fenn. Vanamo 31(1). Helsinki. 360 p.)

C.V. Morton's notes on Pteridiophyta provided no additions to the 44 species then known for the Clay Belt and James Bay area, although there were a few new localities. Locational and habitat data, and brief taxonomic notes are given for 13 ferns.

E. Lepage, W.K.W. Baldwin and I.J. Bassett list additions and revisions to a checklist prepared in a guide book for the field party (see Lepage 1959). Fifty-five distributional and taxonomic notes, with names of herbaria in which specimens are deposited, are given, with several of these from the HBL portion of the route.

HBL - *Keywords:* floristic notes; vascular species lists; paleobotany, pollen spectra; boreal forest; plant migration; soil relation; phytogeography

Barnston, G. 1841. Observations on the progress of the seasons as affecting animals and vegetables at Martin's Falls, Albany River, Hudson's Bay. Edinburgh New Philos. J. 30:252-256.

Some general phenological data on animals and vegetation around Martin's Falls, 51' 30°N, 86° 20'W, describing the normal times for ice breakup, snow cover disappearance, flowering dates for a few species, fall frost, freezeup, etc. Entries on seasonal progress from March through November.

HBL - *Keywords:* phenology

Bates, D.N. and Simkin, D. 1969. Vegetation patterns of the Hudson Bay Lowland. Ont. Min. Nat. Resour., Res. Br., Map 3269.

Intricate mapping of the Ontario portion of the HBL north of the 52nd parallel, classifying vegetational features. Some 96 vegetation types are noted, although no mention of methods of mapping, vegetational dynamics or dominant plant species (except conifers) is made. Included are a glossary of terms, and information on permafrost extent, climate, land elevations, geological history and the stages of emergence of the lowland area. The material is an elaboration of P. Brokx (1965, M.A. thesis) by the authors.

HBL - *Keywords:* remote sensing; peatland, distribution and extent; patterned terrain; peatland classification; permafrost; tree-line; maps of HBL; climate, zonations, regions and districts

Beckel, D.K. Brown. 1957. Studies on seasonal changes in temperature gradient of the active layer of soil at Fort Churchill, Manitoba. Arctic 10(3):151-183.

A wide sample of wetland and dry-terrain sites was monitored for a 2-4 year period (in the upper active layer of the permafrost sites). Four of the sites are illustrated fully in this report, and information is given on soil temperatures at 2-5 week intervals over four years, snow and water depth measurements, temperature gradient changes correlated to solar radiation and ambient air temperature patterns.

Similar patterns (with variable lag periods) were documented between soil temperature curves and ambient air temperature/solar radiation patterns. Areas such as sedge meadows reached their coldest temperatures before the ambient air and were deeply covered by snow early in the winter (and thereby insulated). Where snow cover was less, cold extremes in the soil were more closely related to ambient air minima. In summer, soils consistently reached their highest temperatures before the ambient air (N.B.: soil temperatures were measured during the day only).

The results are summarized in terms of the variable thickness of the active layer between habitat types. Deeper levels of permafrost underlay thin peats, with maximum depth of thaw occurring on 15 September (average) and the most extreme cold occurring on 1 March (average). Snow affected the rate of freeze and thaw according to its density, moisture content, depth and longevity of cover.

HBL - *Keywords:* microclimate; permafrost; soil relations, tundra; sedge meadows; snow cover

Beckel, D.K., Low, C.E. and Irvine, B.R. 1954. Major terrain types of North American tundra and boreal forest areas with examples from the Churchill, Manitoba area. Defense Res. Board. Can., North. Lab., Tech. Note No. 37.

Nine distinct terrain types are recognized in the Churchill, Manitoba area. These types range from "shallow ponds" and "hummocky peat bog" through "open white spruce stands" to "salt marshes and coastal flats" and "sandy foreshore". Scoggan (1959) has characterized the typical vegetation of each of the nine units.

HBL - *Keywords:* patterned terrain; salt marsh; tidal flats; sedge meadows; tundra

Beckett, E. 1945. Plant life of the Churchill District. Can. Geog. J. 31:96-104.

A popular and informative treatment of Churchill's subarctic flora, based on personal collections. Because of the very long days of brilliant sunshine during June and July, there is an extremely rapid plant growth and development, and the colors of many of the wildflowers are more vivid than those of similar species in more southerly regions. The author informally discusses the "great profusion of wildflowers that lend color and charm to the rocky coastline and windswept tundra".

HBL - *Keywords:* floristic notes; tundra; phenology

Beckett, E. 1959. Adventitious plants at Churchill, Manitoba. Can. Field Nat., 73(30):169-173.

Lists 75 adventive plants that have invaded the Churchill townsite and harbor mainly since 1927, when construction for the rail terminal began. Some are spreading while others are unable to survive the short growing season. In sites disturbed 25-30 years ago and left untouched, native species are becoming re-established.

HBL - *Keywords:* human impact; floristic notes

Bell, R. 1886. Report on an exploration of portions of the Attawapiskat and Albany Rivers. Geol. Surv. Can., Annu. Rep. (n.s., 2), 1886:16G, 26G.

A passing mention of black ash and 'grey' elm at Maminska Lake, and black ash, white cedar and white birch at 53° 0' 0" north on the Attawapiskat R. (about 260 km upstream from the mouth).

HBL - *Keywords:* floristic notes

Blasco, J.A. and Jordan, D.C. 1976. Nitrogen fixation in the muskeg ecosystem of the James Bay Lowlands, northern Ontario. Can. J. Microbiol. 22:897-907.

By means of an acetylene-reduction assay, studies were made of biological nitrogen fixation in Ontario muskeg near Moosonee, to establish the relative importance of blue-green bacteria (algae) and other bacteria in the process of nitrogen-fixation. Organisms identified from surface water, pools, and surface mosses, and from *Peltigera* and *Cladonia* spp., included species of the genera *Anabaena, Anabaenopsis, Microchaete, Nostoc,* and *Tolypothrix*. *In situ* and laboratory studies revealed "that nitrogenase activity was predominantly a function of the activities of heterocystic blue-green bacteria associated with surface water, with the phyllosphere of mosses, and with at least one lichen, a species of *Peltigera*". A potential for subsurface nitrogen fixation, particularly under anaerobic conditions, proved to be related to the existence of microorganisms in anaerobic microsites within the organic layers. No microorganisms capable of fixation could be detected under laboratory aerobic incubation.

HBL - *Keywords:* peatland, ecology; soil relations; bacteria and fungi; lichen, physiology

Boelter, D.H. and Verry, E.S. 1977. Peatland and water in the northern Lakes States. USDA For. Serv., North Central For. Exp. Stn., St. Paul, Minn. Gen. Tech. Rep. NC-31, 22 p.

A background paper on the basic characteristics of peatlands, particularly their waters, emphasizing the results of over 15 years of research by the North Central Forest Experiment Station in Minnesota. The paper summarizes some basic principles of peatland ecology, including information on terminology, and how such areas develop and perpetuate. Peatland water is discussed under headings of hydro-geology, peatland water tables, evapotranspiration, stream-flow and water chemistry.

- *Keywords:* hydrology; nutrients; peatland, ecology; soil relations

Boivin, B. 1952. The distribution of *Arnica wilsonii* Rydb. and its significance. Rhodora 54:200-205.

Discusses James Bay disjunctions: "...presumably these species first established themselves around the temporary lakes fronting the glacier after the edge of the ice cap had retreated beyond the Atlantic-Hudson Bay divide". Suggests that Lake Barlow-Ojibway may have been subject to brackish tides and notes that some of the disjuncts are certainly not obligative halophytes. Places disjunct ranges in four categories: 1) prairie outliers, 2) shoreline outliers, 3) cliff outliers, and 4) lowland outliers, providing examples of each from the Hudson Bay region.

HBL - *Keywords:* floristic notes; plant migration; phytogeography

Brokx, P.A.J. 1965. The Hudson Bay Lowlands as caribou habitat. M.Sc. Thesis, Univ. Guelph, Guelph, Ont. 244 p. + appendices.

The author attempts to "stratify the Hudson Bay lowland into winter habitat types, using aerial photographs, and to relate the distribution of caribou to such a habitat classification". The classification is based on three types north of the treeline, while south of the treeline the breakdown is into forested situations (10 types), open treeless situations (three types) and peatlands (seven habitat types). Each habitat type is described in terms of its vegetation, its previous characterization by other authors and its aerial extent.

HBL - *Keywords:* remote sensing; lichen woodland; patterned terrain; peatland, classification; treeline; wildlife habitat relationships--caribou; zonations, regions and districts; peatland, distribution and extent

Brokx, P.A.J. 1967. Aerial photographic types of peatland and vegetation in the subarctic Hudson Bay Lowland of Ontario. Univ. Guelph, Dep. Zool., Guelph, Ont. (MS)

Types of peatland and vegetation of the Lowland of Ontario are classed according to certain aerial photographic characteristics. The classification is often based on pattern of the land and associated vegetation, although ombrotrophy and minerotrophy are mentioned. Twenty-five ecological zones are recognized on the basis of the preponderance of a particular type of habitat. The paper provides an exceptional literature review on Lowlands vegetation work and a good introduction to the vegetation types, in attempting to describe habitats available to the woodland caribou (*Rangifer tarandus caribou*).

HBL - *Keywords:* remote sensing; lichen woodland; beach ridges, coastal; beach ridges, interior; lichen woodland; palsas; patterned terrain; riverbank; fire; treeline; peatland, classification; wildlife habitat relationships, caribou; zonations, regions and districts

Brown, N.J. and Brown, A.W.A. 1970. Biological fate of DDT in a subarctic environment. J. Wildl. Manage. 34(4):929-940.

"Residues of DDT plus metabolites were determined in 660 samples of soil, plants, and animals in a 16-square mile (41 sq. km) area at Fort Churchill treated with 22 airsprays at 0.22 lb/acre (0.24 kg/ha) applied between 1947 and 1964". The material deals mainly with the accumulation of these residues of DDT plus metabolites in the fat of birds, with values ranging between 3 ppm in the willow ptarmigan (*Lagopus lagopus*) and 64 ppm in the arctic tern (*Sterna paradisaea*). The proportion of DDE found in the various bird species is shown to be in part dependent on the DDE production of their plant or invertebrate food. Concentrations of DDT, DDD and DDE are compared for sprayed and unsprayed areas, on the basis of wet weight proportion (ppm) for bearberry (*Arctostaphylos* sp.) fruit and leaves, dwarf willow (*Salix* sp.) leaves, black crowberry (*Empetrum nigrum*) fruit, and arctic avens (*Dryas integrifolia*) leaves.

HBL - *Keywords:* human impact; tundra

Brown, R.J.E. 1966. Influence of vegetation on permafrost. Proc. 1st. Internat. Conf. Permafrost (Nov. 1963) p. 20-25.

"This paper reviews the various ways in which vegetation affects permafrost. Some mechanisms add heat to the ground, others facilitate heat loss from the ground. Some add heat at one time and contribute to heat loss at another time. Influences of vegetation are almost all reversible depending on the conditions under which they occur. The complexity and multifaceted effects of vegetation on permafrost often lead to a situation where under one set of conditions a plant community decreases the soil temperature and increases it under other conditions." An annual heat exchange equation at the earth's surface is considered in terms of vegetation influences on evaporation (including evapotranspiration), conduction-convection and conductivity. The influence exerted on permafrost by vegetation includes aspects of microclimate, drainage and snow cover as well as the role of a heat transfer mechanism between ground and atmosphere.

- *Keywords:* microclimate; palsas and peat plateaus; permafrost; soil relations; snow cover

Brown, R.J.E. 1967. Permafrost in Canada. Geol. Surv. Can. Map 1246A (1st. ed., reprinted 1969), and Div. Build. Res. Publ. No. NRC 9769.

The map shows zones of continuous permafrost and discontinuous permafrost, the latter being subdivided into widespread and southern fringe zones. Also shown on the map are isotherms and broad physiographic regions. Information on latitude-elevation relationships in the southern cordilleras, and air temperature/ground temperature-thickness relationships, to permafrost are presented. Explanatory notes include a definition of permafrost, an account of its distribution and occurrence, a description of physical factors influencing its distribution and occurrence, and a bibliography of sources of information.

HBL - *Keywords:* climate; permafrost; zonations, regions and districts; maps of HBL

Brown, R.J.E. 1968. Permafrost investigations in northern Ontario and northeastern Manitoba. Nat. Res. Counc., Div. Build. Res., Tech. Pap. No. 291. 40 p + appendices + 46 figures.

Climate is the overriding factor influencing the formation and persistence of permafrost. South of the 30°F (-1.1°C) isotherm permafrost was not found, while between 30°F and 25°F (-3.9°C) isotherms, permafrost was patchy and restricted to certain types of terrain, and north of the 25°F isotherm, permafrost was widespread and appeared to be continuous along the Hudson Bay coast. Otherwise, permafrost occurred only in the peatlands and peat bogs of the HBL. Information on climate, geology and relief is provided.

The role of vegetation in the distribution of permafrost is complex. No obvious explanation was found for the occurrence of permafrost peat features in some peatland areas and not in others with apparently similar conditions. Palsa development and collapse is considered. Air photo patterns are interpreted for permafrost features and general notes on vegetation types are given.

HBL - *Keywords:* climate; palsas and peat plateaus; patterned terrain; permafrost; zonations, regions and districts

Brown, R.J.E. 1970. Occurrence of permafrost in Canadian peatlands. Proc. Third Internat. Peat. Congr., 18-23 Aug., 1968. p. 174-181.

"Permafrost underlies about one-half of the total land area of Canada and occurs extensively in peatlands. The discontinuous permafrost zone, which is located mostly in the subarctic, lies in the belt of greatest peatland concentration. The distribution of permafrost and its thermal regime in this zone, particularly in the southern fringe, are governed to a considerable degree by the thermal properties of the peat. Mapping the distribution of permafrost in peatlands is facilitated to some extent by its occurrence in such distinctive micro-relief features as peat plateaus and palsas. The identification of permafrost on aerial photographs is possible by the recognition of these features".

- *Keywords:* microclimate; climate; patterned terrain; permafrost

Brown, R.J.E. 1973. Permafrost-distribution and relation to environmental factors in the Hudson Bay Lowland. p. 35-68 *in* Proc. Symposium on the Physical Environment of the Hudson Bay Lowland. March, 1973, Univ. Guelph, Guelph, Ont.

Provides a review of the distribution of discontinuous and continuous permafrost features within the Hudson Bay Lowlands, an area mostly within the permafrost region of Canada. About half of the permafrost region is in the discontinuous zone (the southeast, north of the 30°F mean annual air isotherm) and half is in the continuous zone (the northwest, between the 25°F and 20°F isotherms). In the discontinuous zone, permafrost is found in peat plateaus and palsas which are prevalent, but does not occur in intervening wet depressions nor in beach ridges or river banks. The correlation of permafrost in this area with positive peatland microrelief terrain features is discussed in terms of negative budgets. Climate is considered the most important factor influencing the formation and continued existence of permafrost, although drainage and thin snow cover contribute to the initiation of these features. There does not appear to be any obvious explanation of why these features occur in some peatland areas and not in others with apparently similar conditions. Possible reasons for this, including the influence of vegetation cover, are mentioned.

HBL - *Keywords:* remote sensing; climate; river banks; palsas and peat plateaus; patterned terrain; permafrost; beach ridge, interior; zonations, regions and districts

Brown, R.J.E. and Williams, G.P. 1972. The freezing of peatland. Nat. Res. Counc., Div. Build. Res., Tech. Pap. No. 381. (NRCC 12881) 24 p. + tables, figures, etc.

Compares the freezing conditions at Mer Bleue bog, Ottawa (seasonal freezing only) with conditions at sites near Thompson, Manitoba (discontinuous permafrost). The authors discuss various aspects of the geotechnical significance of freezing peatlands with respect to off-road transport, pipeline development and construction of temporary structures.

- *Keywords:* human impact; peatland, ecology; permafrost

Carleton, T.J., and Maycock, P.F. 1978. Dynamics of the boreal forest south of James Bay. Can. J. Bot. 56:1157-1173.

"Ordination models of approximate environmental and dynamic relationship between eight boreal tree species were constructed based upon principal components analysis and Kruskal's nonmetric multidimensional scaling. The assumptions, inherent in these models are stated and discussed. The data consisted of 152 forest stands from the closed-crown boreal forest zone of Ontario and Quebec south of James Bay. Sequential forest succession, as demonstrated by similar techniques for a section of the Wisconsin evergreen-hardwood forest, is not common in the region of boreal forest studied. However, for those species in common between this and the Wisconsin study, similar dynamic pathways are indicated despite differences in sample size and field technique. Tree species developmental pathways, as indicated by 'succession vectors' on the ordination models, are, for the most part, short and circular with the exception of *Abies balsamea* (balsam fir). This reflects the reestablishment of similar, relatively monospecific forest stands following catastrophic forest destruction by fire and (or) other agencies. Where catastrophe does not intervene, deciduous primary forest species may be succeeded by an understory of *A. balsamea* or by *Picea mariana* (black spruce). Equally, some forest stands of primary establishment may become decadent with little or no subsequent tree growth. These observations are discussed with respect to the general notion of forest succession."

HBL - *Keywords:* boreal forest; gradient analysis; fire

Chapman, V.J. 1974. Salt marshes and salt deserts of the world. Cramer, Lehre, 2nd ed., 392 p. (complemented with 102 p.)

An extensive treatise and compilation of research on the salt marsh and salt desert environments throughout the world. In spite of very minimal mention of the expansive Hudson-James Bay saltmarshes, there is much information of relevance to the HBL marshes.

- *Keywords:* salt marsh

Cody, W.J. 1954. *Salicornia europea* in the James Bay region. Rhodora. 56:61-62.

Notes on this disjunct halophyte refer to distributional theories of Potter, LaRocque and Boivin. It is felt by the author that past notes and collections in the area have not indicated its probable common distribution in suitable habitats around most of the shores of James Bay.

HBL - *Keywords:* floristic notes; plant migration; salt marsh

Coombs, D.B. 1952. The Hudson Bay lowland, a geographical study. MSc. thesis, McGill Univ., Montreal, P.Q. 227 p.

A compilation of past literature, diagrams, and selected photographs, providing a wealth of general information on the HBL, covering more detail than the 1954 paper. The area is described as a flat coastal plain of 125,000 sq. mi. (325,000 sq. km) (a surface area larger than that of the British Isles, lying between the same parallels of latitude). Because of its size, the material is considered generally in two frameworks: physical geography (geology, topography, hydrology, soils, climate, natural vegetation, fauna) and human geography (historical development and occupation of the region, cultural environment, natural resources and economic development, cultural landscape).

The Lowland lies mostly within the boreal forest zone of Canada, save for a narrow treeless coastal fringe from Cape Henrietta-Maria to Churchill. Hare's (1950) Zonal Divisions are adapted and extrapolated by Coombs to identify three major forest regions, a southerly main boreal forest, a central and northern muskeg woodland, and a coastal forest-tundra/open boreal wetland. Beyond the treeline, a tundra community exhibiting mainly marshy and wet tundra components is a result of the neighboring ice-filled waters of the Bay. Some distinguishing plant species of the four areas are listed.

HBL - *Keywords:* beach ridges, coastal; beach ridges, interior; climate; palsas and peat plateaus; patterned terrain; treeline; zonation; boreal forest

Coombs, D.B. 1954. The physiographic subdivisions of the Hudson Bay Lowlands south of 60 degrees North. Geogr. Bull. 6:1-16.

Provides descriptive reports of some of the physical aspects of the area, dealing with it on a geographical-regional basis. Through a study of aerial photographs and field observations, four physiographic subdivisions are recognized, a Dry Zone, a Muskeg and Small Lake Zone, a Marine Clay Zone and a Coastal Zone. The southerly Dry Zone has a surface that is approximately 30% covered by muskeg and swamp, 30% by lakes and rivers, and the remaining 40% by comparatively dry land. Covering more than half of the area of the HBL, the central Muskeg and Small Lakes Zone is characterized by inadequate drainage and extensive peat deposits. Two sub-zones are described. The Marine Clay Zone occupies the northwestern portion of the HBL, existing on a widespread mantle of marine clay. Because it was possibly the last of the lowland areas to be deglaciated, and also because of the widespread occurrence of permafrost, immaturely developed surface features predominate. The fourth, and smallest, subdivision is the strip of Coastal Zone where broad tidal clay and silt flats and low gravel and shale beach ridges occur. Between ridges, brackish water or well developed salt marshes may exist. Similar conditions are found on Coastal Zone islands.

HBL - *Keywords:* climate; peatland, distribution and extent; beach ridges, coastal; zonations, regions and districts

Cottam, C. and Munro, D.A. 1954. Eelgrass status and environmental relations. J. Wildl. Manage. 18(4):449-460.

A discussion of the occurrence of *Zostera marina* in the world with very minor mention of its occurrence in Hudson and James Bay.

HBL - *Keywords:* floristic notes; offshore

Cowell, D.W., Jeglum, J.K. and Merriman, J.C. 1978. Frozen ground-wetland type relationships, Kinoje Lakes, southern Hudson Bay Lowland. Third Internat. Conf. Permafrost, Edmonton, Alta., July 1978.

Relates surface vegetation, groundwater level, peat landform, depth of peat and occurrence of ice at 19 locations in an area approximately 80 km west-northwest of Moosonee. Frozen layers were encountered in early August, 1976, within five defined peatland types: 1) treed bog, 2) open bog, 3) swamp plus treed fen, 4) marsh, and

5) open fen. Most of the frozen layers that were observed were thin, relatively easy to penetrate and probably melted by fall. The dry summer of 1976 may have acted to preserve some of the frozen layers later into summer than usual, as there would have been reduced downward percolation of warm rain waters and reduced lateral movement in all systems. However, hard ice layers beneath low palsas and black spruce islands were undoubtedly permafrost.

A black spruce island was studied with a transect to determine inter-relationships of surface topography, peat depth, underlying mineral-soil topography and frozen layers. Peat depths along the transect were variable, between 30 and 110 cm, the shallowest peat depths occurring beneath the island, and indicating a rise in the underlying mineral soil topography.

The occurrence of frozen layers in wetland ecosystems is related to vegetative cover, peat type and direction and rate of water movements for this area. The shading and insulating properties of vegetative cover on a site are important, as attested by the high frequency of frozen layers in treed bog (100%, and in the treed fen plus swamp, 36%) and by the greater depth to frozen layers in a burned, open bog compared with that in an unburned, open bog.

HBL - *Keywords:* hydrology; nutrients; permafrost; soil relations

Cowell, D.W., Wickware, G.M. and Sims, R.A. 1979. Ecological classification of the Hudson Bay Lowland coastal zone, Ontario. Proc. Can. Comm. Ecol. Land Class., Victoria, B.C. Apr. 4-7, 1978. Dep. Environ., Ottawa, Ont. Lands Directorate ELC Series No. 7. p. 165-175.

The paper outlines the methodology evolving in an ecological classification of a Lowland 'coastal zone'. The coastal zone is defined on the basis of hydrologic, vegetative and physiographic characteristics. The hierarchical classification provides information on four scales, from 1977 field work, for a 4000 square kilometre area between the Albany River and the Quebec border. A mapping legend used to map the area at the Land System level (1:100,000) is described and the objectives and applications of the work are outlined.

Some preliminary data on soils, vegetation, hydrology, and physiography, collected at 154 sites within this area, are tabulated.

HBL - *Keywords:* biophysical (ecological land classification); remote sensing; zonations, regions and districts; peatland, classification, patterned terrain; peatland, ecology; hydrology; soil relations

Cowell, F.N. 1968. List of determinations of the material submitted by Mr. F.N. Cowell, collected in Polar Bear Prov. Park, near Cape Henrietta Maria. 1968. (Identified by I.M. Brodo and W.K.W. Baldwin, CAN) (MS)

31 bryophytes, 170 species vascular plants

HBL - *Keywords:* bryophytes, species lists; vascular species lists

Crum, H.A. and Schofield, W.B. 1959. The mosses of Gillam, Manitoba. Natl. Mus. Can. Bull. 160:91-106.

An extensive species list with habitat notes from around Gillam, Manitoba, on the western limit of the Hudson Bay Lowlands. A brief introduction includes aspects of the topography, geology, and surface deposits of the area.

HBL - *Keywords:* bryophytes, species lists

Curtis, S.G. 1973. The American Brant and eelgrass (*Zostera marina*) in James Bay, a preliminary report. Dep. Environ., Can. Wildl. Serv., Unpubl. James Bay Rep. Ser. No. 8. 5 p.

Concentrations of American Brant encountered during coastal surveys in autumn, 1972 are reported. As well, the importance of eelgrass as a staple in the birds' diet and the need for good data on eelgrass occurrence in James Bay are discussed.

HBL - *Keywords:* wildlife habitat relationships--waterfowl; offshore

Dai, T.S. 1970. Groundwater movement and vegetation in a northern Ontario peatland. 24th Tech. Session, Carleton Univ., Ottawa, Ont. (MS)

"Field operation showed that dye methods and piezometric techniques for measuring hydraulic conductivity are suitable for surface and subsurface water flow measurements in wetlands, respectively. These methods were applied to a series of wetland types, and the chemical composition of water and peat were also analyzed. The data indicated that pH and monovalent ions in the water and peat are positively correlated with flow rate, while Kcorr and most of the heavy metals are negatively correlated. The distribution of *Carex oligosperma, Larix laricina* and to a smaller extent *C. limosa* and *Menyanthes trifoliata* are restricted in the sites having water movement rather than in more stagnant areas in various types of wetland. Some growth experiments of these species under controlled conditions showed that plant growth was strongly affected by flow rates. It is suggested that the nutrient supply and hydrology are two major factors influencing the growth and distribution of plants in peatlands." Based on data from Dai, T.S. (1971). Studies in the ecological importance of water flow in wetlands (Ph.D. thesis, Univ. Toronto).

- *Keywords:* hydrology; nutrients; peatland, ecology

Dai, T.S., Haavisto, V.F. and Sparling, J.H. 1974. Water level fluctuation in a north-eastern Ontario peatland. Can. J. For. Res. 4:76-81.

Water level depths and changes were examined for five peatland conditions in northwestern Ontario, 24 km northeast of Cochrane, Ontario. "The deepest water level and the greatest fluctuations occurred in an ombrotrophic black spruce bog site. A sedge dominated poor-fen site was submerged following very heavy rain. Waterlogged conditions remained within 6 cm. of the surface at all times because of the influence of the water level of Dai Lake. The water level of Dai Lake varied within a narrow range because the loss of water was primarily dependent on slow seepage and evaporation. The lagg site was affected by continuous inflow, high water levels, and fast run-off, therefore a large fluctuation of water prevailed at this site".

- *Keywords:* hydrology; peatland, dynamics

Dean, W.G. 1959. Physiography and vegetation of the Albany River map area, northern Ontario - an aerial photo-reconnaissance. Ph.D. thesis, Geog. Dep., McGill Univ., Montreal, P.Q. xi + 391 p. + mapsheets.

Dean provides an extensive background on the geology, geomorphology, forestry and climate of the Albany River area in particular, and northern Ontario in general. The study is broadly divided into three parts. The first is made up of a general introductory statement, a discussion of exploration and previous work in the area, and a description of the aerial photograph interpretation methods incorporated in the study. The second part considers the physiography and consists of a review of the relief, the drainage, and the nature of the surface geology within the Albany area, in addition to a discussion of the landform features and terrain as they were interpreted from aerial photographs. "The third part is comprised of a brief description of climate, an outline of the chief characteristics of the vegetation in terms of species, cover-types, and the percentage distribution of the latter. The vegetation zones and their geographic correlations are then discussed." A further chapter is devoted to the peatlands of the Albany area.

Hare's (1954) isopleth technique is adapted and applied in various ways. Since climate is the most important single control of vegetational distribution, the principal elements, temperature and precipitation, are described not only as meteorological data, but also in terms of the local controls that influence them. Subsequently mapped vegetation subzones partially reflect the physiographic divisions. Seven zones are recognized: 1) Superior mixed subzone, 2) Upland mixed and coniferous, 3) Clay plains coniferous, 4) Ogoki mixed and wet forest, 5) Kesagami wet forest, 6) Lowland muskeg and 7) Coastal bogs and muskeg. The peatlands are described from their appearance on aerial photographs and interpreted as products of a wet environment largely dependent upon drainage conditions and upon subsurface mineral materials. The distribution of four "air form" patterns, black spruce muskeg, open muskeg, bog and vermicular bog, is considered.

HBL - *Keywords:* climate; patterned terrain; zonations, regions and districts; boreal forest; phytogeography; treeline

Doutt, J.K. 1941. Wind pruning and salt spray as factors in ecology. Ecology 22:195-196.

Discusses observations of salt pruning and pH uniformity (through salt spray deposition) on the Belcher and Twin Islands. Especially relevant to exposed Hudson Bay maritime arctic, with its prevailing onshore winds.

HBL - *Keywords:* nutrients; salt marsh; wind effects

Doutt, M.T. 1935. Twin Island: an arctic outpost. Carnegie Mag., 9:195-200.

Provides no detail, but indicates that 1500 specimens were collected for the Carnegie Museum.

- *Keywords:* biophysical; climate; microclimate; soil relations

Dutilly, A. and Lepage, E. 1948. Coup d'oeil sur la flore subarctique du Québec. Cath. Univ. America Press, Washington, Contrib. Arctic Inst. 1F.

Cites collections from Lac Mistassini to James Bay, and contains the authors' travel journal. Also cites Macoun collections and records.

HBL - *Keywords:* vascular species lists; floristic notes

Dutilly, A. and Lepage, E. 1952. Exploration sommaire de la rivière Harricana. Cath. Univ. America Press, Washington. Contrib. Arctic Inst. 3F. 30 p.

A species list comprising 2 algae, 12 fungi, and 247 vascular taxa collected in a 1946 expedition down the Harricana River from the confluence of the Davey river, 29 miles (46.4 km) north of Amos, Quebec to the Harricana estuary. Included are lists of species that appear to be at the northern, southern, western and eastern limits of their ranges.

Four taxa new to science are proposed.

The article is a reprint of one found in Naturaliste Canadien (1951) 78:(9):254-283.

HBL - *Keywords:* vascular species lists; floristic notes

Dutilly, A. and Lepage, E. 1963. Contribution à la flore du versant sud de la Baie James, Quebec-Ontario. Cath. Univ. America Press, Washington. Contrib. Arctic Inst. No. 12F. 199 p.

An extensive catalogue of species known from the south of James Bay, primarily from collections by the authors along major river routes (Bell, Nottaway, Harricana, Moose, Abitibi, Mattagami, Missinaibe, Chipie, Kenogami, Pagwa) and along the Bay's southern coast (Moosonee, Moose Factory, Point Netchi, Pointe de l'Est, Pointe Mesakonan). Previous botanical records from the area are also included in the list, encompassing portions of Ontario and Quebec's HBL, Clay Belt, and what is described as an intermediate zone. In the introduction a summary of natural resources, extent of agriculture, and physiographic features is given along with distribution and composition of forest units. Major forest vegetation associations are listed for 16 collection stations.

On the basis of a total of 4144 collections (2916 by the authors) 976 taxa are recognized for the area. These represent 277 genera, 777 species, 249 sub-species and varieties, and 78 forms. 82.4% (640) of the plants are considered to be trans-Canadian while 35.4% (275) are at their western limits, 2.4% (19) are at their eastern limits, and 1.4% (11) are considered as plants strictly of the Great Lakes region.

Data for species include geographic location of collection, collection numbers if collections made by the authors, and occasional notes on abundance and habitat. Appended is a list of 27 species that, although uncollected, probably exist in the area.

HBL - *Keywords:* vascular species lists; phytogeography; floristic notes

Dutilly, A., Lepage, E. and Duman, M. 1954. Contribution à la flore du versant occidental de la Baie James, Ontario. Cath. Univ. America Press, Washington, Contrib. Arctic Inst. No. 5F. 144 p.

A catalogue of vascular plants known to the west coast of James Bay, assembled from all past collections in the area, as well as those by Dutilly, Lepage and Duman in 1946, 1952, and 1953. The authors collected from several points along the coast, and in the interior along major riverways, travelling by canoe. Thirty-nine main collection points are described in the text, including Moosonee, Moose Factory, Shipsands Island, Albany River, Martin's Falls, Attawapiskat River, Swan River, Opinaga River, Lake River and Cape Henrietta-Maria.

Approximately 900 taxa are listed with information on geographic locations of collections, collection numbers if collections were made by the authors, and occasional notes on abundance and habitat. Craminae, Cyperaceae and Juncaceae together form 26% of the total species. Plants with a general distribution from the Atlantic to the Pacific represent about 57% of the known interior flora and about 70% of the coastal flora. Along the coast, plants apparently at their western limit in this area are three times more numerous than in places at the eastern limits of their range. Ten taxa new to science are given as a result of the authors' investigations. The vegetation, on the basis of phytogeographic affinities, is divided among four main zones: arctic, coastal, interior Paleozoic and Precambrian.

This list comprises the most intensive attempt to catalogue Lowlands vegetation and is the most complete checklist at present available.

HBL - *Keywords:* vascular species lists; phytogeography; floristic notes

Dutilly, A., Lepage, E. and Duman, M. 1958. Contribution à la flore des îles (TNO) et du versant orientale de la baie James. Cath. Univ. America Press, Washington. Contrib. Arctic Inst. No. 9F.

"Territory included the islands of James Bay and a portion of western Ungava draining towards the bay. Data are given on the population and location of trading posts, etc., within this region. The topography and geology are reviewed, with lists of the characteristic plants of 4 climatic zones. The vegetation of the different types of habitats is discussed. Data are given on collections and collection localities. The main part of the work is an annotated list of 719 spp., 25 sspp. and vars., and 96 forms, in 241 genera. About 29% consist of Glumiflores (Graminae, Cyperaccae) and Juncaceae. "Trans-Canadian" plants constitute 60%. 162 plants (16.7%) are eastern going no further than Ontario. 27 (3%) are western spp. at their extreme eastern limit; 39 (4.5%) are at their northern limit on the continent; and 111 (13%) are at their northern limit in Quebec-Labrador. Very few adventitions or naturalized plants occur, probably because of lack of railway or highway communication with the rest of the country. Most of the plants do not penetrate far into the interior, but prefer coastal habitat." (Biol. Abstr.)

Discussion of taxa is based on all collections made to that date in the area as well as at the authors' 53 sites. Proposes that a sea-arm traversed Ungava in postglacial time, allowing influx of Atlantic halophytes into James Bay without such species circum-dispersing around the entire Labrador-Quebec peninsula.

HBL - *Keywords:* vascular species lists; phytogeography; floristic notes

Dutilly, A., Lepage, E. and Duman, M. 1959. A collection of plants from Winisk, Ontario. Nat. Can. 86(10):214-218.

A collection of plants by A. Liebow, 1958. While the collection is not extensive (68 taxa), it is of interest since it comprises one of the few published records from the Hudson Bay coast of northern Ontario. No habitat or ecology notes are provided.

HBL - *Keywords:* vascular species lists; floristic notes

Ehrlich, W.A., Pratt, L.E. Barr, J.A. and LeClaire, F.P. 1959. Soil survey of a cross-section through the upper Nelson River basin along the Hudson Bay Railway in northern Manitoba. Man. Soil Surv., Soils Rep. No. 10. 48 p. + mapsheet.

A detailed soil survey of the Waboden Clay region of the upper Nelson, describing agricultural, potential agricultural, and non-agricultural soils of that area. Introductory chapters provide brief information on geology, surface deposits, topography, climate, and the extent of agriculture and forestry, for northern Manitoba, including Manitoba portions of the Hudson Bay Lowland.

- *Keywords:* wildlife-habitat relationships: waterfowl; offshore

Fabiszewski, J. 1976. Torfowiska wysokie wschnodniej Kanady ze szczegolnym uwglednieniem biologicznej roli porostow [Raised peat bogs of eastern Canada with particular consideration to the biological role of lichens]. Akademia Rolnicza, Wroclaw. Do Uzytka wewnetrz-nego. (Pol.) 21 p.

A preliminary report of studies conducted on 10 peatlands in the provinces of Ontario, Quebec and Prince Edward Island to elucidate developmental stages of raised bog and to investigate the restrictive influence of terrestrial lichens on the development of flowering plants. Included is one study site near Moosonee, in the HBL, and one to the south of HBL, but nearby, at Cochrane.

The young nature of the Canadian landscape forms (approximately two to three thousand years more recent than in Europe) and the climate are considered important factors accounting for the unique characteristics of Canadian peatlands in comparison with European counterparts. While a considerable number of species are common to the Canadian and European flora, the author focuses attention on some of the substituting species, and their ecological ranges. Because of the apparently more widespread distribution of a number of species (*Chamaedaphne calyculata, Rubus chamaemorus, Carex paupercula, Eriophorum russeolum,* etc.) and the occurrence of exclusively American plants (e.g., *Kalmia, Sarracenia, Smilacina, Gaultheria,* etc.), there is some difficulty in identifying communities with units described from Europe. The author feels that the homology of Canadian and European communities is clearly expressed only at the level of the higher phytosociological units, i.e., the classes and orders.

Three different classes of associations are thought to occur on the raised peat bogs in eastern Canada. The class of hollow associations (represented by one order, Eriophora (virginici)-Sphagnetalia), corresponds to the European communities of the class Scheuchzeria - Caricetea fuscae. The second class which combines the hummock communities from the growth stage, Ledo (groenlandici)-Sphagnetea, is homologous with the European class Oxycocco-Sphagnetea. The last class of communities, which groups together associations of the recession stage in the terminal phase of development of the peat bog, Sphagno-Cladonietea americana, does not, as yet, have a counterpart among the European vegetation.

The lichen flora of the peat bogs is fairly rich, numbering 162 species. Of this number, only 59 terrestrial species were found among the peat-bog proper. The rest, numbering 103 species, are mainly epiphytes occurring on marginal trees and shrubs. The majority of the terrestrial lichens are also known from European bogs.

Recession stages of the peatlands are distinguished by the massive participation of terrestrial lichens. Development of lichens is promoted by lowering of the water table and, consequently, a decrease in competition from the typical flora of the raised bog. Under laboratory conditions, restriction of germination and development of flowering plants by lichens were investigated. Using aqueous extracts from seven lichen species, germination tests were made of three species of bog plants, *Carex paupercula, Chamaedaphne calyculata,* and *Eriophorum spissum* and a control plant, *Triticum vulgare.* For example, a hummock species, *Eriophorum spissum,* was clearly most inhibited in germination and growth by *Cladonia alpestris,* while a hollow plant, *Carex paupercula,* was most inhibited by an extract from *Cladonia multiformis.* Further controlled studies on the inhibitors and peat substrates of hummocks and hollows show that these exhibit differential capacities; consequently, the author suggests that lichens can play a decisive role in the vegetation structure.

HBL - *Keywords:* bryophytes, species lists; lichen, species lists; vascular species lists; peatland, ecology; nutrients; lichen physiology

Fagerstrom, L. 1948. Vascular plants collected by I. Hustich in Ontario and Quebec. (Canada) 1946. Societas pro fauna et flora fennica. Memo 24:194-212.

A species list of 265 taxa is given from a collection of about 3000 specimens. Collections were made in four main areas: Chalk River, Powanton, Oskelanee and Moose River Basin (Renison and Moosonee). A smaller collection was made in the district about 50 miles (80.0 km) south of Timmins and in McInnis Twp. near Abitibi River. No habitat notes or descriptions are provided but collection locations are noted.

HBL - *Keywords:* vascular species lists

Field, G., Larson, D.W. and Kershaw, K.A. 1974. Studies on lichen-dominated systems. VIII. The instrumentation of a raised-beach ridge for temperature and wind speed measurements. Can. J. Bot. 52:1927-1934.

"The instrumentation of a research site on a raised-beach ridge, 5 km inland from Hudson Bay, is described. Fine thermo-couples and hot-film anemometers were used to measure air and thallus temperature, and wind speeds, respectively. Replicate sensors were monitored through automatic stepping switches of new design and strip-chart recorders. The satisfactory operation of the entire system indicates that it is not difficult to maintain this type of electronic equipment in remote sites (such as the Lowlands) and opens up considerable possibilities for ecological work in fairly inaccessible areas".

HBL - *Keywords:* microclimate

Gardner, G. 1937. Liste anotée des espèces de Pteridiophytes, de Phanérogames et d'Algues récoltées sur la côte du Labrador, à la baie d'Hudson et dans le Manitoba nord, en 1930 et 1933. Bull. Soc. Bot. Franc. 84:19-51.

List of species from 22 stations, visited during the summers of 1930 and 1933, near The Pas, Flin-Flon, and Churchill, Manitoba, Chesterfield, Inlet, N.W.T. and along the coast of Labrador. Some habitat notes are provided. Ninety-nine species from Churchill are listed.

HBL - *Keywords:* vascular species lists; algae

Gardner, G. 1946. Liste des plantes recoltées sur la côte du Labrador, dans le détroit d'Hudson, à la baie James et dans le Manitoba nord. Bull. Soc. Bot. Franc. 93:162-200.

Listings include Shipsands Island (20 spp.), Willow Island and Moose Island (42 spp.) and Moosonee (16 spp.)

HBL - *Keywords:* vascular species lists; algae

Geldart, H.D. 1887. Notes on plants collected by Capt. Markham, P.W., and Fort Churchill, Hudson Bay, and West Digges Island, Hudson's Straits, in July and August, 1886. Norfolk and Norwich Naturalists' Soc., Trans. 4:354-366.

A comparison is made of collected species from the two locations. The Churchill, Manitoba site, near the northwestern extreme of the HBL, provided 38 specimens. Notes are made on the relatively high proportion of berry-producing plants, the variability of growth-form imposed by the climatic conditions and the similarity of species listed for the two areas, and from Floeberg Beach, further north at lat. 82°27'N.

HBL - *Keywords:* vascular species lists

Gerardin, V., Ducruc, J.P., Zarnovican, R. and Jurdant, M. 1975. Recherche de régions écologiques dans le territoire de la Baie James: définition d'une méthodologie. p. 113-130 *in* Proc. Circumpolar Conference on Northern Ecology. Sept. 15-18, 1975, Ottawa, Ont. Natl. Res. Counc. in assoc. with Can. Natl. Comm./Sci. Comm. Probl. Environ.

"Where adequate climatic data is lacking, the vegetation and certain pedogenetic criteria can be used to determine distinct re gional climates. In order to reduce possible sources of variation between sampling stations, 202 phytoecological plots were chosen on well-drained till having a texture which was statistically homogenous. Based on those plots, the territorial distribution of principal plant species, their frequency being weighted by their abundance, has made it possible to delimit different macro-climatic zones. These zones are then compared with available climatic data which confirm the preliminary results."

Glooschenko, W.A. 1978. Above-ground biomass of vascular plants in a subarctic James Bay salt marsh. Can. Field Nat. 92(1): 30-37.

Vegetation studies including determination of species composition and cover were made along a transect in a subarctic salt marsh located on the southwestern coast of James Bay, Ontario, Canada. Eight vegetation zones were recognized from an intertidal colonization area dominated by *Puccinellia phryganodes* to the edge of a willow thicket at the landward end of the marsh complex. In each zone, above-ground biomass of vascular plants was determined by clipping at the time of peak biomass. Values ranged from an estimated low of 29 g/m^2 dry weight on gravel beach ridges and 157 g/m^2 in the mid-marsh to a high of 569 g/m^2 in the zone nearest the willow thicket, which was dominated by *Juncus balticus*. A weighted-mean above-ground biomass for the transect was 357 g/m^2, taking into account the biomass and the width of these zones. The biomass values found in this study were lower than those reported in the literature for salt marshes located on the Atlantic coast of North America between Georgia and Nova Scotia but were higher than those reported for Swedish salt marshes located on the Baltic Sea.

HBL - *Keywords:* salt marsh; beach ridges, coastal; productivity and biomass; tidal flats

Glooschenko, W.A. 1979. Coastal ecosystems of the Hudson/James Bay area of Canada. Geoscience and Man Series, Louisiana State Univ., Publ. in Geog. (in press).

A background paper on the coastal ecosystems of the Ontario HBL providing brief vegetation notes on some of the major associations encountered, particularly in the southern James Bay area. Four classes of coastal ecosystem are defined (salt marsh, river-influenced brackish marsh, estuarine marsh and high-energy coastal ecosystem) and a vegetation transect leading from the high-tide level inland at North Point. James Bay is discussed (see Glooschenko 1978). Some potential impacts of man on the delicate coastal habitats are listed.

HBL - *Keywords:* human impact; salt marsh

Glooschenko, W.A. and Capobianco, J.A. 1978. Metal content of Sphagnum mosses from two northern Canadian bog ecosystems. Water, Air and Soil Pollut. 10(2):215-220.

Baseline values are presented for elemental concentrations of 10 metals in Sphagnum spp. Samples were collected from a site in the HBL at Kinoje Lake (about 80 km NW of Moosonee) and a site at Porter Lake, N.W.T. In general, concentrations were similar to those reported in recent European literature.

The two Canadian sites were similar in elemental composition although minor differences noted could be attributed to a combination of regional geochemical and human activity differences.

HBL - *Keywords:* human impact; bryophytes, ecology

Glooschenko, W.A. and Martini, I.M.P. 1978. Hudson Bay Lowland baseline study. Proc. Coastal Zone 1978 Symposium. April, 1978; Am. Soc. Civil Engineers, San Francisco, Calif. p. 663-679.

The paper describes an integrated HBL baseline investigation carried out by various components of the Canadian Department of the Environment, Environmental Management Service (Ontario Region). Emphasis is on process-oriented research along the Ontario coast of the Hudson and James bays, in particular, sedimentological studies and salt marsh ecology.

Included is a brief discussion of four major coastal ecosystems in the area: salt marsh, river-influenced brackish marsh, estuarine marsh and a high-energy coastal ecosystem. Some of the dominant species of each ecosystem are mentioned, and additional consideration is given to a vegetational sequence in a broad salt marsh at North Point, James Bay.

HBL - *Keywords:* salt marsh; tidal flats; human impact; beach ridges, coastal

Glooschenko, W.A. and Sampson, R.C.J. 1978. Organochlorine pesticides and polychlorinated biphenyls on sediments from a subarctic salt marsh, James Bay, Canada—1976. Pesticides Monitoring J. 12(2):94-95.

"Sediment samples were collected from a subarctic salt marsh complex on James Bay, Ontario. Of 15 organochlorine compounds analyzed, trace amounts of mainly P, p^1 - DDE and PCB' were detected, but were not quantifiable."

HBL - *Keywords:* salt marsh; tidal flats; beach ridges, coastal; floristic notes

Griffin, K.D. 1975. Vegetation studies and modern pollen spectra from the Red Lake peatland, northern Minnesota. Ecology 56(3):531-546.

"Vegetation studies in the Red Lake peatland, a patterned fen studded with forested islands, resulted in the recognition and description of plant communities typical of the following environments: *Menyanthes* pools, furrows, sedge-strings, forest tussocks, and forest hollows. Pollen analyses of 15 surface samples taken along a transect in the same area separated two distinct local pollen assemblages. The *Larix* forest assemblage corresponds to the forest tussock and forest hollow communities, and the sedge fen pollen assemblage corresponds to the *Menyanthes* pool, the furrow, and the sedge-string communities."

- *Keywords:* patterned terrain; paleobotany, pollen spectra

Gussow, W.C. 1933. Contribution to the knowledge of the flora of northern Manitoba, etc. Can. Field-Nat. 47:116-119.

About 90 species of vascular plants from the Churchill area and from northern Manitoba are listed.

HBL - *Keywords:* vascular species lists; floristic notes

Haavisto, V.F. 1974. Effects of a heavy rainfall on redox potential and acidity of a water-logged peat. Can. J. Soil Sci. 54:133-135.

Electrochemical measurements were made on peat at various depths ranging from 0 to 50 cm of a waterlogged, floating *Sphagnum* peat mat on the shore of a small bog lake in northeastern Ontario. Oxidation-reduction potentials were reduced on average of 47 mv by heavy rainfall, significantly altering valence states of some ions. Concentrations of the reduced ion form may produce concentrations detrimental to normal plant growth. Although the area is south of the HBL, some extrapolation of results may be possible.

Keywords: peatland, ecology; nutrients; soil relations

Hamelin, L.E. 1957. Les tourbières reticulées du Québec-Labrador subarctique: interpretation morpho-climatique. Cahiers Geog. Québec. 2:87-106.

Very general considerations of the incidence of string bogs, proposing a coincidence with recent substrate deposits (often marine or lacustrine), poorly drained areas, peat depths from 2 to 4 m, and areas south of the continuous permafrost. Maintains that such patterns reflect conditions more prevalent during a post-hypsi-thermal cold spell of widespread permafrost. Hypothesizes that string bogs are governed by many processes: watersheet dynamics (winds, solifluction, orientation of vegetation), vegetation dynamics (sliding of vegetation on underlying ice, networks of ice lenses causing differential uplift of vegetation), and subsequent consolidation of pattern by rending and ice-fissuring of organic materials. Useful 'hypotheses' but still not substantiated by field studies.

- *Keywords:* patterned terrain; palsas and peat plateaus; peatland, ecology

Hamelin, L.E. 1971. De Winnipeg au Keewatin. L'excursion de l'A.C.G. Rev. Geog. Mont. 25:89-94.

A discussion of the changes in surface features, particularly of peatlands, noted during travels through northern Manitoba to Keewatin. A number of hydrographic patterns developed in organic matter in cold, continental areas of northern Manitoba are recognized: a) string bogs, linear, concentric, vermiculated, braided and punctate, and b) other patterns: internal stripes of vegetation, beaded streams, thermokarstic ponds, cuspated river banks, residual rims of palsas and tearing of riparian vegetative cover. The role of glacial retreat in developing patterning processes is discussed briefly.

- *Keywords:* patterned terrain; snow cover; permafrost

Hamelin, L.E. and Cailleux, A. 1969. Les palses dans le bassin de la Grande-Rivière de la Baleine. Rev. Geog. Mont 23(3): 329-337.

Near Great Whale, New Quebec, (55° 17'N, 77° 46'W), groups of 5 to 30 palsas or more are referred to as "silt and peat hummocks". A description is given of this phenomenon of aggregated, oval or elongated peat hummock separated by depressions, and it is shown that they are disintegrating now rather than growing.

HBL - *Keywords:* peatland, classification; phenology; wildlife-habitat relationships: waterfowl; zonations, regions and districts

Hanson, H.C. and Jones, R.L. 1976. The biogeochemistry of Blue, Snow and Ross' Geese. Illinois Nat. Hist. Surv., Spec. Publ. No. 1, South Illinois Univ. Press. XVIII and 281 p.

Using a wide scope approach, the authors examine the usefulness of feather mineral patterns in determining the geographical origins of wild, migrant, and wintering goose populations. The technique promises to supplement, or, in many cases, replace banding as a means of establishing such information. In order to tie elemental patterns (based on resolution of Ca, Mg, Na, K, P, Fe, Zn, Mn, Cu, B, Si and Al) to geographic areas, the authors examined other aspects of the nutrient chain, plants and soils, and in this report elucidate the unique local geology of each major nesting area. The patterns of minerals incorporated into the feathers thus reflect, in varying degrees, the origins of geese colonies and individuals.

Some soil and plant relationships as biogeochemical parameters are examined, including samples from the carbonate terrains of Cape

Henrietta-Maria and Cape Churchill in the HBL. Four plant species from Cape Henrietta-Maria exhibited generally higher calcium, magnesium, hydrogen, iron, copper and boron contents than did samples from Cape Churchill, Baffin Island, N.W.T. and the Caribou River delta area, Manitoba, thereby reflecting influences of substrata through this phase of the food chain. Iron derived from Superior-type formations found in the Sutton Ridge (in the vicinity of Aquatuk Lake) are believed to account for high iron levels in soils, plants and primary feathers of some blue and lesser snow geese in the Cape Henrietta-Maria colony.

HBL - *Keywords:* patterned terrain; isostasy; hydrology; permafrost; peatland, classification

Hanson, H.C. and Smith, R.H. 1950. Canada geese of the Mississippi Flyway, with special reference to an Illinois flock. Ill. Nat. Hist. Surv. Bull. 25(3):67-210.

Concerned with the ecology of Canada Geese wintering in Illinois. In determining the habitat preferences of populations of the four main flyways in the Hudson-James Bay nesting region, five muskeg types are described (well-timbered muskeg, open muskeg, lakeland muskeg, pothole muskeg and "small-pox" muskeg); though designed for a specific purpose, this report constituted one of the first classifications applied to the area. Its regional zonation correlated pothole muskeg with the majority of band recoveries and sight observations of geese. The preponderance of this muskeg type brought the authors to identify nine "production centres" for the bird populations.

Before southward migration from the breeding grounds takes place, a complex series of local flights occur. The coastal plain area is a preferred congregation spot because of the abundance of berry-producing plants, particularly *Vaccinium uliginosum, Rubus arcticus* and *Empetrum nigrum,* and the highly productive coastal species such as *Triglochin maritima, Plantago maritima* and *Carex paleacea.*

HBL - *Keywords:* nutrients; soil relations; wildlife-habitat relationships: waterfowl

Hare, F.K. 1950. Climate and zonal divisions of the boreal forest formation in eastern Canada: Geog. Rev. 40:615-635.

This ecoclimatological work, based on Thornthwaite's thermal efficiency values, draws from no weather stations for HBL except Moosonee. It proposes a major zonation based on potential evapotranspiration (with a major boundary between the "northern transition" and "main boreal" at 16.5-17.0" isopleth through northern Ontario). Hare states, "the regions farther north in the Hudson Bay Lowland are too little known to permit major correlations". He links such climatic zonation to the ranges of tree species, but does not discuss the source of that information or whether the ranges represent species ranges or tree form ranges. By either definition, the ranges cited for white cedar and balsam poplar (more generous) were premature. The zonation is independent of physiography.

Considers tundra (north of treeline), forest-tundra ecotone (north of boreal hardwoods), open boreal woodland (north of line where "open forest" becomes more common than closed forest), main boreal forest and boreal-mixed forest ecotone as the major zones.

HBL - *Keywords:* climate; boreal forest; treeline; tundra; zonations, regions and districts

Hare, F.K. 1954. The boreal conifer zone. Geog. Stud. 1:4-18

Hare criticizes the past use of the vague and unsatisfactory term "coniferous forest", and attempts to redefine the limits of the boreal coniferous forest. Limits of the arctic and forest-tundra are given in relation to thermal and climatic criteria. Within the boreal conifer zone two subzones exist, the woodland subzone in the north and the close forest subzone, both of which are thermally controlled. Accurate mapping of the boreal zones should show that the boreal forest is essentially a response to a specific climate.

- *Keywords:* patterned terrain; boreal forest; peatland, distribution and extent; peatland, classification; climate; zonation

Hare, F.K. and Ritchie, J.C. 1972. The boreal bioclimates. Geog. Rev. 62:333-365.

Considers the consistencies and discontinuities within the circumboreal environment in terms of climate and major arboreal species. The authors discuss the "specific bioclimate" represented by each zonal division, downplaying the many problems of zonal nomenclature. Meteorological satellite photography is used to show zonal differences on the basis of late winter albedo differences; the Hudson Bay Lowland appears distinctly. Various climatic parameters and biomass-energy relations are arrayed to demonstrate the interrelations and feedbacks both within and between climate and vegetation. The authors stress the need for new techniques to be brought to bear on the problem of circumboreal zonal equivalences.

HBL - *Keywords:* climate; boreal forest; treeline; tundra; zonations, regions and districts

Hare, F.K. and Taylor, R.G. 1956. The position of certain forest boundaries in southern Labrador-Ungava. Geog. Bull., 8:51-73.

Zonal subdivision of conifer-dominated forest is by air-photo interpretation (1:500,000 mapping produced from avg. 1:50,000 coverage). Physiognomic zones are suggested: i) bare rock, ii) lichen woodland or parkland, iii) closed-crown forest, iv) bog and muskeg. They are mapped as the percentage coverage by particular zones (percentages of land area). Broadly indicative of association frequency regionally.

- *Keywords:* climate; patterned terrain; productivity and biomass; zonation; snow cover; boreal forest; lichen woodland

Heinselman, M.L. 1963. Forest sites, bog processes and peatland types in the glacial Lake Agassiz region, Minnesota. Ecol. Monogr. 33:327-374.

Intensive peatland research in northern Minnesota between 1955 and 1961, on bog processes and peatland types within Lake Agassiz, was done by means of a survey of peat stratigraphy, physiography and vegetation in key areas with pronounced vegetation patterns. Bog expansion, rising water tables, site determination, the types of patterned bogs and fens, water quality, topography and peat accumulation patterns were all interrelated. The decisive influence of water movement patterns on species composition is emphasized. The key appears to be the degree of isolation from mineral-influenced ground water. The course of such waters through peatlands is typically marked by water-track vegetation types. Few peatlands in the region are the result of a single successional sequence, nor do they follow the classic basin-filling concept. Furthermore, wetland types cannot be regarded as stages in an orderly development toward mesophytism. Peat accumulation that causes peatland surfaces to rise does not necessarily promote development towards mesophytism; concurrent rising of water tables may actually promote site deterioration.

The report represents a major step towards understanding peatland dynamics in North America and contains numerous statements that are certainly applicable to the vast HBL peatlands.

- *Keywords:* flooding; hydrology; nutrients; peatlands, ecology; peatland, classification; soil relations; patterned terrain; boreal forest.

Heinselman, M.L. 1965. String bogs and other patterned organic terrain near Seney, upper Michigan. Ecology 46:185-188.

The paper describes treeless string bogs (patterned fens) at one of their most southerly locations in North America. Patterned ground has developed through paludification of a sandplain dotted with extinct dunes and sloping about 1.5 m/km.

- *Keywords:* patterned terrain; peatland, ecology; string bogs and patterned fens.

Heinselman, M.L. 1970. Landscape evolution peatland types and the environment in the Lake Agassiz Peatlands Natural Area, Minnesota. Ecol. Monogr. 40:235-261.

The vegetation and peatland types of the Lake Agassiz Peatlands Natural Area, Minnesota, are related to topography, waterflow patterns, water chemistry, and the evolution of the landscape as recorded by peat stratigraphy. "Eight peatland types are distinguished: (1) minerotrophic swamp, (2) weakly minerotrophic swamp, (3) string bog and patterned fen, (4) forest island and fen complex, (5) transitional forested bog, (6) semi-ombrotrophic bog, (7) ombrotrophic bog (raised bog), and (8) raised bog drain. Consistent differences in pH, Ca, and Mg were found between waters of contrasting peatland types. These differences agree with the division of peatland types by degree of mineral soil water influence (minerotrophy). A general topographic alignment of vegetation and peatland types agrees with the hypothesis of chemical controls. Vegetation types often have sharp boundaries related to changes in water properties, peat surface configuration, and paths of waterflow.

In addition, water sources influence properties, and the topography of a peat surface can strongly influence directions and rates of waterflow, thereby indirectly controlling sources for given areas. Minerotrophic peatland types are demonstrated as being typically oriented parallel to slopes, occupying long slopes concave in cross-section and usually terminating at outlets, whereas ombrotrophic peatland types occupy water-table divides and have divergent or even radiating waterflow patterns. Vegetation of minerotrophic types is comparatively rich in species and growth form to the depauperate, Sphagnaceae- and Ericaceae-dominated ombrotrophic types. Listed are specific indicators of minerotrophic (pH 5.8-7.0), weakly minerotrophic (4.3-5.8) and ombrotrophic (3.1-4.2) surface waters. Studies in the landscape evolution of the area yield five phases, and the author concludes that the only 'direction' is often merely a trend toward landscape diversity, and not toward site mesophytism with peat accumulation.

Heinselman feels the principles are applicable to most large peatlands on gently sloping terrain in cool continental climates (and to many in maritime climates as well), and he particularly notes the Hudson Bay Lowlands as one example.

- *Keywords:* flooding; boreal forest; hydrology; nutrients; peatland, ecology; patterned terrain; peatland, classification; soil relations.

Heinselman, M.L. 1971. Boreal peatlands in relation to environment. XVII Cong. Limnol. Proc. Leningrad, USSR. Sep. 19-26, 1971. p. 93-103 (Ch. 3.2)

A background paper on evolutionary relationships of peatlands, including discussion of chemical and physical controls, topographic evolution, and ecosystem history. Peatland evolution, says the author, eludes development towards any form of 'climax'; instead it favors virtually ceaseless change.

- *Keywords:* peatland, ecology

Herrick, R. 1977. Natural theme analysis of Natural Region 27--the Hudson-James Bay Lowlands. Dep. Ind. North. Aff., Parks Can., Parks System Plan. Div., Ottawa, Ont. 156 p.

A review piece describing geology, physiography, drainage, climate, wildlife and, briefly, vegetation of National Park Natural Region 27, the Hudson-James Bay Lowlands. By tallying the significance of numerous "natural theme elements", four localities in the HBL are denoted as "natural areas of Canadian significance": 1) The Attawapiskat River - Akimiski-Twin Islands area; 2) the Northwest Territory Islands (including Charleton Island and small east coast islands) and the Quebec coast of James Bay from Eastmain to Paint Hills; 3) the unique Churchill-Cape Churchill area in Manitoba; and 4) the unique Cape Henrietta-Maria area in Ontario.

Vegetation is described superficially within the frameworks of wetland classification, principal soil types and the forest regions (Rowe 1972) of Natural Region 27.

HBL - *Keywords:* bibliographic; biophysical; peatland, classification; treeline

Hills, G.A. 1958. Soil forest relationships in the site regions of Ontario. First North Am. For. Soils Conf., East Lansing, Mich. Bull. Agric. Exp. Stn., Mich. State Univ., p. 190-212.

A concise overview of the background, design and ramifications of the general ecological zonation system most widely used in Ontario, especially by government and forest industry. "Soil profile classes provide a basis for forest site evaluation only when placed within the limits of specific physiographic sites, described in terms of the effect of significant variations in the climate, relief and parent materials on vegetation development".

HBL - *Keywords:* biophysical; zonations, regions and districts; boreal forest

Hills, G.A. 1961. The ecological basis for land-use planning. Ont. Dep. Lands For., Res. Br., Res. Rep. 46. 204 p.

The report outlines the underlying principles of Hills' land classification approach, suggesting how these principles may be applied at a land management level. To illustrate the technique a model mapping is developed for an area near the towns of Gravenhurst and Bracebridge in the Orillia-Muskoka region. Included is a discussion of the 12 'site regions' of Ontario, as defined by Hills' criteria. The HBL is included in the Hudson Bay, the James Bay and a portion of the Big Trout Lake site regions.

HBL - *Keywords:* biophysical; zonations, regions and districts

Hofstetter, R.H. 1969. Floristic and ecological studies of wetlands in Minnesota. unpubl. Ph.D. thesis, Univ. Minn., St. Paul. 224 p.

A good summary of information on 'ribbed peatland' and 'teardrop-shaped islands' (both common peatland features in the HBL) is presented, in conjunction with research results on the vegetation, soils, hydrology, water chemistry and apparent genesis of peatlands near Red Lake, northern Minnesota.

- *Keywords:* patterned terrain; peatland, ecology; nutrients; soil relations

Holmes, E.M. 1884. Notes on recent donations to the Museum of the Pharmaceutical Society. IV. Medicinal plants used by the Cree Indians, the Hudson Bay Territories. Pharmaceut. Trans., Ser. 3, 15:302-304.

Despite the imprecision of the author concerning the area of Hudson Bay to which these comments refer, the notes on the medicinal uses of such species as *Acorus calamus* (at present known only from the Moosonee area of the Lowlands), balsam fir, juniper, *Kalmia* spp., Labrador tea, northern comandra, lobelia, iris and others are of considerable historical interest.

HBL - *Keywords:* floristic notes; medicinal use

Hulten E. 1958. The amphi-Atlantic plants and their phytogeographical connections. Kungl. Sr. Vetensk. Akad. Handl., Ser. 4, Vol. 7.

Contains complete mapping for species concerned as well as a floristic and phytogeographical bibliography by location and author.

HBL - *Keywords:* taxonomic treatment; phytogeography

Hulten, E. 1968. Flora of Alaska and neighbouring territories. Stanford Univ. Press. 1008 p.

Excellent distribution mapping and taxonomic consideration of circumpolar, subarctic and arctic species, including many of those taxa occurring in the HBL.

HBL - *Keywords:* floras; phytogeography

Hustich, I. 1949a. On the forest geography of the Labrador Peninsula. A preliminary synthesis. Acta. Geog. 10(2):-63.

An extensive discussion of the phytogeography of Labrador-Quebec, although North American ranges for all important tree species are presented, including the Lowlands. Some discussion of forest regions includes the areas of the Western James Bay Section and the Eastern James Bay Section. About 400-450 species of plants are listed for the James Bay-Hudson Bay area of the Labrador Peninsula.

- *Keywords:* boreal forest; treeline; mensuration, forest; phytogeography

Hustich, I. 1949b. Phytogeographical regions of Labrador. Arctic 2:36-43.

Takes note of a common northern European rationalization of such phytogeographic regions as convenient natural divisions for floristical statistics. Stresses the rock substrate units, the coastal/interior dichotomy, and taiga/forest differences. Suggests a classification based on 18 regions, of which the Clay Belt (peripherally), the western James Bay section and the Hudson Bay section include parts of northern Ontario.

- *Keywords:* zonations, regions and districts; phytogeography

Hustich, I. 1950. Notes on the forests on the east coast of Hudson Bay and James Bay. Acta. Geog. 11:1-83.

A series of forest-botanical notes made during a summer expedition by canoe from Rupert House to Great Whale River. In discussions of the tree and shrub species of the area, particular attention is given to the ecology and growth forms of white spruce, black spruce, tamarack and balsam fir. Geographical points are established along the maritime treeline. Twenty-four sample plots studied along the expedition route are described in some detail.

The Great Whale River mouth area was examined as a unit. A description of the climate, geology and geography of the area is supplied. The slow growth of white spruce, and the candelabrum

growth-form of black spruce are discussed. Twenty sample plots are described in detail with respect to their vegetation and its abundance.

General discussion of the east coast forests of Hudson and James bays. On a xeric-mesic scale of 1 to 10, the sample plots are classed by forest types. The question "Is the forest on the coast advancing or retreating?" is considered. Forest mensuration data are provided for the dominant conifers, and their extremely slow growth is recognized.

HBL - *Keywords:* boreal forest; patterned terrain; treeline; wind effects; isostasy; mensuration, forest; phytogeography

Hustich, I. 1953. The boreal limits of conifers. Arctic 6:149-162.

After clarifying the definitions of economic limit of forest, biological limit of forest, treeline and limit of species, Hustich maps the northerly limit of a number of circumpolar conifer genera. The existence of arctic limits is discussed in terms of the different ecological requirements of species, and the instability of phytogeographical boundaries is noted. Distribution and limits of conifer species are mapped for the Hudson Bay Lowland.

- *Keywords:* treeline; zonations, regions and districts; boreal forest; phytogeography

Hustich, I. 1955. Forest-botanical notes from the Moose River area, Canada. Acta Geog. 13(2):1-50.

The lower Moose River area near Renison, Ontario was visited by the author in periods during the summers of 1946 and 1947. From the air, the dominance of bogs, mires and swamps was described, although no palsa bogs were observed. Bog forests were particularly large and open, and the quality of soil seemed to improve towards the north, reflecting a richer vegetation. This was attributed to a rise in the coastline. The tree and bush species present were noted, along with habitat preferences. Forty 10 x 10 m plots from various locations in the study area were analyzed for plant species present. On the basis of these, a classification was made of sample plots in 10 categories along a (1 to 10) xeric-mesic gradient. A discussion of the extent and characteristics of each type follows in the report.

Tree radial growth was measured with a Swedish increment borer and values for annual growth were obtained. In general, forests were young, typically less than 150-200 years old and radial growth increased or decreased up to 50% from year to year. A comparison between black spruce, white spruce and balsam fir showed a great deal of overlap in annual thickness increment patterns.

An appendix lists 301 collected vascular plants from Renison, excluding water plants and anthropochores.

HBL - *Keywords:* floristic notes; boreal forest; mensuration, forest; vascular species lists; isostasy; peatland, dynamics; soil relations; treeline; phytogeography

Hustich, I. 1957a. Comparison of the vegetation of Fort Severn and at Big Trout Lake in northern Ontario. Arct. Inst. North. Am. (mimeogr. rep.) 44 p.

Provides information on both the geography and the vegetation of these two areas, the first being within the Lowlands. Notes on 14 sample plots, indicative of the range of vegetation types, are given with species lists (including cryptogams). The author feels that differences in vegetation pattern between the two areas can be attributed to a new, edaphically very suitable, soil favoring vegetation succession around Fort Severn. Within the Big Trout Lake area the situation is more stable, regardless of more favorable climatic conditions. An appendix lists 346 species (CAN); only 25% of these species are common to both areas.

HBL - *Keywords:* floristic notes; vascular species lists; bryophytes, species distribution; soil relations; isostasy; phytogeography

Hustich, I. 1957b. On the phytogeography of the subarctic Hudson Bay Lowland. Acta. Geog. 16(1):1-48.

The paper provides a broad outline of the phytogeographical problems that can be studied in the area. The geographical features are discussed in terms of the limits of the Lowland, Quaternary geology, the climatic influences, the existence of permafrost and the dominance of bogs, swamps, fens and shallow pools and lakes. Some 104 species additions are made to the Dutilly et al. (1954) list, primarily of species from the more subarctic area north of the James Bay basin. The distribution of dominant tree species is considered and maps of boreal limits are provided. The existence of an edaphic forest tundra lying along a narrow coastal strip from Cape Henrietta-Maria westward is determined not by the climate itself but by the edaphic conditions prevailing there. The polar limit of conifers forms the most northerly boundary for the tree species, as would be expected. Of these, black spruce forms the most widespread taiga-forest cover while white spruce, adaptable to a large range of habitats, may be found in the most extreme tree-inhibiting locations at the treeline. The good growth of young white spruce in open willow or alder thickets was noted particularly, and adaptations to vegetative propagation and formation of adventitious roots in tundra bogs and swamps was common.

The role of the rivers in creating varying and changing habitats for plant life is illustrated by more detailed examination of profiles of a small river inland and a larger river mouth. Development of the lichen woodlands is felt to be a modification of older peatland areas, particularly bogs deformed by permafrost.

Forest type development is probably immensely influenced by fire in the HBL, although little documentation of this exists. The importance of unchecked forest fires as a factor in increasing paludification, particularly in the lichen woodlands, is unknown, although Hustich postulates the sequence of events involved.

Peatland types in the lowlands are characterized by black spruce muskeg, lichen woodland, fens, string bogs, palsas and raised bogs. The evolution of peatlands here is "even more dynamic than the evolution of the forest types because the growth of the more or less exposed peat must be considered as a factor more dynamic than the slow development of the soil of the forests".

The activity of man in the Lowlands has been minor to this point. Lumbering has increased the proportion of balsam poplar, aspen, white birch and balsam fir in the forests of the southern part. The contribution of this clear-cutting to paludification is unknown. Around the larger settlements, a number of introduced or adventive plants have become established.

HBL - *Keywords:* beach ridges, coastal; beach ridges, interior; climate; fire; flooding; floristic notes; human impact; hydrology; isostasy; lichen woodland; vascular species lists; mensuration, forest; paleobotany, dating; palsas and peat plateaus; patterned terrain; peatland ecology; permafrost; riverbank; soil relations; treeline; wildlife habitat relationships: caribou, insects; wind effects; zonations, regions and districts; snow cover; phytogeography; string bogs and patterned fens; boreal forests; lichen woodland; sedge meadows.

Hustich, I. 1959. Hudson Bay Lowland, ett naturgeografiskt intressant omrade. Finska Vetenskapssocieteten (Societas Scientiarum Fennica). Arsbok-Vuosikirja. 35B(5):1,3-13.

A paper read to a meeting of the Finnish Society of Science, January 21, 1957, describing the Hudson Bay Lowland environment. Although it is a general account of features the author noted during his HBL surveys, he makes several comparisons to northern European, particularly Finnish, landscapes.

HBL - *Keywords:* phytogeography; floristic notes; patterned terrain; boreal forest

Hustich, I. 1974. Common species in the northern part of the boreal region of Canada. An essay. Rep. Kevo Subarctic Res. Stat. 11:35-41.

"The necessity to study more intensively the common species in an area is stressed. These species form the vegetation. The rare species, often one-third or more of a general floristic list, are from a synecological point of view in some way ornaments only. Results of a survey are given for common species in two areas: (1) the eastern central part of Quebec-Labrador and (2) a fairly similar taiga area in northern Ontario, the upper (Precambrian) part of the Severn River drainage basin. Some thoughts on the question 'why are common species common' are included".

- *Keywords:* floristic notes; vascular species lists; phytogeography

Ireland, R.R. and Cain, R.F. 1975. Checklist of the mosses of Ontario. Natl. Mus. Can. Publ. Bot. No. 5, 67 p.

A rough index to the moss species of Ontario, listing species by counties and districts, with 430 species reported for the province.

HBL - *Keywords:* bryophytes, species lists

Jefferies, R.L. 1977. The vegetation of salt marshes at some coastal sites in arctic North America. J. Ecol. 65:661-672.

Salinity and vegetation cover and biomass data are provided for seven arctic coast salt marshes in Alaska and Canada. Although no sites in or near the HBL are included there appear to be close similarities to some HBL coastal salt marsh vegetation types.

- *Keywords:* salt marsh

Jefferies, R.L., Jensen, A. and Abraham, K. 1979. Vegetational development and the effect of geese on vegetation at La Pérouse Bay, Manitoba. Can. J. Bot. (In press).

"The salt marshes at La Pérouse Bay, Manitoba are described. Unconsolidated, water saturated sediment is colonized by *Hippuris tetraphylla*, *Puccinellia phryganodes* and *Carex subspathacea*. These sediments undergo frost-heave and on elevated mounds *Elymus arenarius* var. *mollis* and *Salix brachycarpa* become established. This last species is the dominant species of the low willow tundra which is the characteristic vegetation of the coastal strip. Where drainage is impeded in the upper marsh, relatively high salinities occur and species such as *Salicornia europaea* agg. and *Triglochin maritima* are present in the area.

"A population of 10,000 to 20,000 lesser snow geese in summer feed on *Puccinellia phryganodes, Carex subspathacea, Potentilla egedii* and *Elymus arenarius* var. *mollis*. The birds strip the shallow turf of *Puccinellia* in low lying areas between clumps of willow. This terracing of the surface creates depressions between mounds of willows which become filled with water and ice. The role of geese in producing these ponds in the upper levels of salt marshes does not appear to have been reported previously. The ponds are subsequently colonized by *Carex aquatilis* and *Triglochin maritima*. The salt marsh gives way to an extensive freshwater marsh dominated by species of *Salix, Eriophorum angustifolium, Calamagrostis neglecta* and *Dupontia fisheri*. The results are compared with data from other salt marshes in the Hudson Bay and in the Arctic."

HBL - *Keywords:* wildlife-habitat relationships: waterfowl; salt marsh; sedge meadows

Jeglum, J.K. 1971. Vegetation environment and growth of black spruce in peatland transects in northeastern Ontario. Am. J. Bot. 58 (5 pt. 2): 482; Peat Abstr., Spring 1972.

"From quadrats along transects in two areas near Cochrane, and one near Kenogami, measurements were obtained of species cover, peat depth to water level, moist-peat pH, water samples for subsequent chemical analyses, and heights and ages of dominant Black Spruce for the determination of site index. The vegetation includes four broad groups; very moist forest, Black Spruce muskeg, swamp, and open muskeg. The types are described in terms of vegetation, physiography, moisture and fertility regimes, other measurements of the environment, and forest productivity."

- *Keywords:* nutrients; peatland, ecology; soil relations; mensuration, forest

Jeglum, J.K. 1974. Relative influence of moisture-aeration and nutrients on vegetation and black spruce growth in northern Ontario. Can. J. For. Res. 4:114-126.

An evaluation of the relative influence of some environmental measures on vegetational variation and tree growth in black spruce forests of northern Ontario. Results of a principal components analysis suggest that nutrient regime is more important than the moisture-aeration regime, while results of correlation of site index and habitat measures suggest that moisture-aeration has a greater influence on tree growth. "For particular components of vegetational variation and for segments of the total data, the proportional influence of the two gradients varies. Moisture-aeration and nutrient regimes explain a large proportion of the variation in minor vegetation and tree growth on black spruce peatlands".

- *Keywords:* nutrient dynamics; peatland, dynamics; peatland, classification; soil relations; mensuration, forest

Jeglum, J.K. 1975. Vegetation-habitat changes caused by damming a peatland drainageway in northern Ontario. Can. Field-Nat. 89(4):400-412.

"A striking example of road damming in wetlands is found 3 miles (5 km) south of Kenogami, Ontario, where Highway 11 crosses a narrow, slowly drained, peatland valley. Below the road dam is forested peatland, somewhat less wet than before the damming but probably not much changed from the original condition, with a central treed bog zone and swamps at the margins. Above the road dam is an open, floating-to-spongy, mostly *Sphagnum*-dominated mat which is bog in the poorest central areas and fen in the less poor marginal areas near small collecting pools and beaver channels. Measures of vegetation and habitat from quadrats along transects above and below the road dam suggest that there is continuous variation between fen and bog, and between swamp and treed bog. The open and treed bogs are interpreted as minerotrophic transitional bogs. Implications of the changes caused by the road dam for other road building and damming activities in northern Canada are discussed".

- *Keywords:* flooding; gradient analysis; human impact; hydrology; nutrients; soil relations; peatland, classification; peatland, ecology

Jeglum, J.K., Boissonneau, A.N. and Haavisto, V.F. 1974. Toward a wetland classification for Ontario. Can. For. Serv., Sault Ste. Marie, Ont., Inf. Rep. O-X-215. 54 p.

"This paper reviews the various wetland and peatland classifications for Ontario, and proposes a complete hierarchical classification for the Northern Clay Section stressing vegetational physiognomy and dominance of vegetation. The proposed classification hierarchy consists of formations, subformations, physiognomic groups, dominance types and site types. The approach lends itself to use at a number of different scales in ground studies and air photo interpretation by those concerned primarily with vegetational aspects of wetlands--foresters, wildlife biologists, geographers and ecologists".

A standardization of terminology in Ontario, including excellent bibliography, class keys, and ground and aerial photography, this report is applicable largely north of the Clay Belt.

- *Keywords:* remote sensing; patterned terrain; peatland, classification; peatland, ecology

Jeglum, J.K. and Boisonneau, A.N. 1977. Air photo interpretation of wetlands, Northern Clay Section, Ontario. Can. For. Serv., Sault Ste. Marie, Ont. Report O-X-269. 44 p. + Append.

"The hierarchical classification for wetlands in Ontario proposed by Jeglum et al. (1974) is evaluated for the interpretability of five levels of classification from black and white air photos of scale 1:15,840. Evaluations are based on ground knowledge and photo interpretation for sixteen areas in the Northern Clay Section. It is suggested that the classification, based on vegetational physiognomy and dominance, is admirably suited to air photo interpretation, as the choice as to the level to which interpretation will be carried out can be adapted to the scale and type of photos available as well as the time and resources available for ground truthing". ..."It is recommended that wetland units at the level of formation and subformation - OPEN and TREED BOG, OPEN and TREED FEN, MARSHES and SWAMPS, be adopted and mapped on ongoing provincial forest inventory mapping programs".

- *Keywords:* remote sensing; peatland, classification; patterned terrain

Johnson, E.J. 1949. Pollen analysis of peat underlying a treeless heath area in the forest-tundra transition near Churchill, Manitoba. M.A. thesis, McMaster Univ., Hamilton, Ont. 28 p.

Investigations within a treeless heath "barrens" determined, for two peat borings, the frequencies of certain pollens at nine successive depths. Results are presented diagrammatically. The 3 1/2 ft (110 cm) deep peat deposits exhibited permafrost except for a surface active layer of 13 in. (32.5 cm). Resulting pollen patterns were not interpreted as being representative of similar floristic action, but were felt to be due to local conditions, especially the peat. A tentative model of the past vegetational history is postulated as: "(sedge dominating the wet areas throughout) - herbaceous - ericaceous heath; birch shrub; spruce forest, probably black spruce followed by white spruce, and larch; sphagnum, causing extinction of the woods; revival of black spruce in the scattered patches of today, followed shortly by shrub immigration in other areas; rise of ericaceous plants in the sphagnum, ending in its extinction, and growth of the present lichen-ericaceous heath". Portions of this model are later described for a river flat seral succession in the Churchill area (Ritchie 1957). An appendix lists 219 species of vascular plants collected in the Churchill area.

HBL - *Keywords:* paleobotany, pollen spectra; tundra; peatland, ecology; permafrost; vascular species lists

Johnston, R.N. and Hills, G.A. 1956. The need for rehabilitation on organic terrain in Ontario with special reference to reforestation. Proc. E. Muskeg. Res. Meet., Feb. 22, 1956. Nat. Res. Counc., Assoc. Comm. Soil Snow Mech., Tech. Memo 42:46-54.

Divides the northern Ontario organic deposits into two areas: 1) the Coastal Plain Muskeg Region and 2) the Clay Belt and Till Upland Muskeg Region. The Coastal Plain Muskeg Region, occurring within the Hudson Bay Lowland, is characterized by more than 85% of the land area (50 million acres, or 20,230,000 ha) being unproductive for forestry. Discusses the effects of drainage of portions of land, and other amelioration attempts, as part of an 'anti-muskeg' campaign for improvement of forest crops.

HBL - *Keywords:* peatland, distribution and extent; hydrology; boreal forest; zonations, regions and districts

Johnston, R.N. and Sharpe, J.F. 1923. Report of James Bay Forest Survey, Moose River Lower Basin. Ont. Dep. Lands For., For. Br. 16 p. + mapsheet.

Results are given of a 1922 inventory to obtain estimates of forest resources of the Moose River lower basin. Forest types and conditions are mapped at a scale of 4 mi. = 1 in. (2.5 km = 1 cm), and supplemental information is given on physiographic features. The program involved direct mapping from over 300 flying hours (and rarely indirect mapping from photography) to delineate forest types for the area "north of the Canadian Government Railway (Transcontinental) from the Quebec boundary westward to the Moose and Mattagami Rivers and including their west banks to a depth of five miles (8 km)." Subsequent ground studies involved strip measurements of diameter classes over 4 in. (10.6 cm) DBH for commercial species: a total of 470 miles (752 km) of strip were run. In the 8,640,000 acres (3,496,490 ha) surveyed, the following forest types were recognized: mixed-type - 543,434 acres (219,920 ha) (6.2%), black spruce type - 942,000 acres (381,214 ha) (11.0%), dwarf black spruce type - 2,400,552 acres (971,470 ha) (27.9%), muskeg type - 2,452,528 acres (992,504 ha) (28.4%), burn - 1,896,272 acres (767,395 ha), jack pine - (>1%), water - 406,144 acres (164,341 ha) (4.6%). Only 17.2% of the land supports tree growth of pulpwood size. Of this area, 36.6% consists of mixed stands and 63.4% of pure black spruce.

Of the total timber in the territory, an estimated 3.7 million cords (13.4 million m^3 stacked) (29.2%) grow along the Mattagami River; 3 million cords (10.9 million m^3 stacked) (23.5%) along the Abitibi; 2.3 million cords (8.3 million m^3 stacked) (18.1%) along the Little Abitibi, and under 500,000 cords (1.8 million m^3 stacked) each along the French and the Moose (3.7% and 3.3%, respectively) leaving 2.8 million cords (10.1 million m^3 stacked) (22.2%) remote.

HBL - *Keywords:* zonations, regions and districts; maps of HBL; mensuration, forest; boreal forest; peatland, distribution and extent; remote sensing

Jordan, D.C., Coordinator. 1972. Microbial ecological study of the Canadian subarctic and low arctic regions: Phase I, The sub-arctic--James Bay and the south coast lowlands. Progress Report of a Feasibility Study, supported by the Research Advisory Board of the University of Guelph. 24 p. Mimeogr. (MS).

The feasibility of estimating microbial data under field conditions in the sub-arctic during various seasons of the year was demonstrated. Estimates were made of baseline concentrations of microorganisms, certain pesticides and heavy metals, and of the type and extent of fish diseases.

Soil studies (microbiological, physical and chemical) were done for a number of sites near Moosonee. Mercury and pesticide residue (dieldrin, PCB, DDT, DDD, DDE) were determined for two tundra and two intertidal zone samples from the Churchill area. Waters of the Moose River and other entering rivers were analyzed for physical, chemical, and electrochemical characteristics, bacterial (faecal coliforms, faecal streptococci) and fungal numbers, and trace elements. Marine water and sediment in the James Bay-Moose River Estuary were studied for chemical and physical data, and for microbial populations (total aerobics, coliforms, Salmonellae. None of the last-mentioned was observed, and no *Escherichia coli* was observed, either). A study was done of the effect of mercury on microbial activity in sediment. Included were studies of bacterial, parasitic, and neoplastic diseases of fish, and concentrations of heavy metals (As, Cd, Co, Cu, Fe, Hg, Mb, and Se) and pesticide residues (Dieldrin, PCB, DDT, DDD, and DDE).

HBL - *Keywords:* soil relations; human impact; algae; bacteria and fungi

Jurdant, M., Ducruc, J.P.· Belair, J.L. and Gerardin, V. 1975. La carte écologique du territoire de la Baie James. p. 101-112 *in* Proc. Circumpolar Conference on Northern Ecology. Sep. 15-18, 1975, Ottawa, Ont. Natl. Res. Counc. in assoc. with Can. Natl. Comm./Sci. Comm. Probl. Environ.

"Resources management of a territory as large as that of James Bay (410,000 km^2) must be based on an integrated long term plan. This facilitates the need for a natural resource inventory or an ecological inventory.

Since April 1973, a multidisciplinary team of 25 people has undertaken the task of systematically mapping the ecology of the James Bay region. The methodology employed, in this cartography, has allowed us to understand certain ecological relationships which may be applied in optimizing the management of the "capital nature" of the territory."

- *Keywords:* biophysical; human impact

Kalela, A. 1962. Notes on the forest and peatland vegetation in the Canadian Clay Belt region and adjacent areas. I. Comm. Inst. For. Fenn. 55(33): 1-14.

From observations and notes made during a field trip of the IX International Botanical Congress, the author compares previously defined vegetation zones of the boreal forest of northern Quebec-Ontario to similar divisions that have been made in Europe, particularly Finland. The sharp boundary of vegetation types between the northern Clay Section and the HBL is felt to be a direct result of the change in bedrock to Palaeozoic sediments, and is much too abrupt a boundary to be climatically influenced. Peatlands in the area are described in terms of rimpis, strings, aapa bogs and mineral soil vegetation. The occurrence of palsas much further south than is the case in Finland is attributed to the more continental climate of the Lowlands. Brief notes are also presented on the Missinaibi-Cabonga Section (Rowe 1970), and on the Great Lakes—St. Lawrence Forest Region.

HBL - *Keywords:* peatland, classification; soil relations; patterned terrain; zonations, regions and districts

Kershaw, K.A. 1974. Studies on lichen-dominated systems X. The sedge meadows of the coastal raised beaches. Can. J. Bot. 52(8): 1947-1972.

A particular interbeach sequence from young meadows with few hummocks and high pH to older meadows with marked hummocks and lower pH is described at the Pen Island site in northwestern Ontario. The sequence is presented in terms of six seral plant associations, extracted from principal component ordination of plot data: 1) *Carex aquatilis* association, 2) *Carex saxatilis-Drepanocladus revolvens-Campylium stellatum-Equisetum variegatum,* 3) *Equisetum-Drepanocladus,* 4) *Drepanocladus-Salix glauca,* 5) *Dicranum-Empetrum-Cetraria,* 6) *Betula* association. The delineation of associations is not based on clear-cut ordination groupings, and boundaries are defined while intermediate points of the gradient are ignored.

HBL - *Keywords:* beach ridges, coastal; bryophytes, ecology; gradient analysis; nutrients; patterned terrain; sedge meadows

Kershaw, K.A. 1975. Studies on lichen-dominated systems. XIV. The comparative ecology of *Alectoria nitidula* and *Cladina alpestris*. Can. J. Bot. 53: 2608-2613.

"The response of net photosynthesis and respiration in *Cladina alpestris* and *Alectoria nitidula,* at 0 and 150 queinsteins m^{-2}, s^{-1}, 5, 10, 15, 20, 25 and 30°, and at all thallus moisture levels, is described. The two species have markedly contrasting responses, which correlates very well with their ecology at East Pen Island. *Cladina alpestris* is shown to occur in two physiological forms: one is restricted to beach ridge summits and the other is restricted to the lower slopes. The physiology of these two forms adapts them to either the cool, dry ridge crests or the warmer, moister ridge slopes. Marked acclimation of the temperature optimum of net photosynthesis in *Alectoria nitidula* is shown to occur between August and December. This is an acclimation of the photosynthetic mechanism of the algal component since respiration rates remain constant".

HBL - *Keywords:* lichen, physiology; lichen, ecology; beach ridges, coastal; microclimate

Kershaw, K.A. 1976. The vegetational zonation of the East Pen Island salt marshes, Hudson Bay. Can. J. Bot. 54: 5-13.

The extensive salt marsh complex at East Pen Island near the mouth of the Mintiogon Creek is characterized by a well marked sequence of species. By means of a method that yields local frequency along five transects through the marsh, all species encountered are displayed in quantitative terms. (Because of the highly stratified nature of the vegetation in the upper marsh, with 1 m tall stands of *Calamagrostis neglecta* and *Carex aquatilis* and ground vegetation of moss species, the only workable quantitative measure of species abundance that was available was percentage frequency.)

"The lower marsh is dominated by *Puccinellia phryganodes* and *Carex subspathacea,* with *Hippuris vulgaris* and *Senecio congestus* abundant in the salt pannes. The mid-marsh has well-developed swards of *Dupontia fisheri* and *Calamagrostis neglecta,* which give way to stands of *Carex aquatilis* in a well-developed freshwater marsh below the first beach ridge. The results are compared with other Arctic salt marshes, and the development of a wide freshwater marsh in the upper zone of the salt marsh is described. This feature is perhaps unique to the Hudson Bay marshes and is a function of meltwater runoff from the surface of the permafrost table. This results in the high standing water table at the top of the marsh, which is maintained by the permafrost table of the marsh itself". A generalized transect is constructed to display the averaged species sequences of three field transects, and points out the difficulty in ascertaining the boundary between salt water and fresh water. "A transit survey of the marsh relates the quadrat samples to a high-tide datum point and allows interpretation of the vegetation sequence in terms of saltwater inundation. The depth of the active layer of the salt marsh is also described". Although there is a notable absence of some HBL halophytes, a primary description of these marshes is provided and similar sequences may be extensive along the southern Hudson Bay coast.

HBL - *Keywords:* beach ridges, coastal; bryophytes, species lists; hydrology; vascular species lists; nutrients; permafrost; salt marsh; flooding

Kershaw, K.A. 1977. Studies on lichen-dominated systems. XX. An examination of some aspects of the northern boreal lichen woodlands in Canada. Can. J. Bot. 55: 393-410.

"The existence of two major types of lichen woodland in Canada, *Cladonia stellaris* woodland and *Stereocaulon paschale* woodland, is discussed in relation to their seral nature and their rarely developed theoretical climax type.

Our own observations, coupled with previous descriptions from a wider area, suggest that *Stereocaulon paschale* woodland replaces *Cladonia stellaris* woodland in a more or less continuous zone from just west of Churchill across to Great Slave Lake, immediately north and south of latitude 60°N. Both woodland types are often typical of sandy soils (pH 6 or less) and almost always represent the final recovery phase after fire. Rarely, the lichen surface is replaced by a continuous moss cover as the spruce canopy closes. The lichen surface is thus dependent on the lack of competition from higher plants, the absence of which is characteristic of the climate of this northern boreal region. *Cladonia stellaris* woodland also occurs on palsas and peat plateaux where, again, lack of higher plant competition and a suitable pH exist.

The recovery sequence after fire is a highly complex process and as yet only the following parameters have been categorized. In the early recovery phases, limited soil moisture and hence a reduced summer latent heat flux enhance the sensible heat flux. The surface conditions are analogous to those of a hot desert with very high surface temperatures and extremely large diurnal temperature fluctuations. The physiology of these initial moss and lichen colonizers presumably enables them to tolerate these harsh conditions. The establishment of a few spruce seedlings and the subsequent development of open lichen woodland modulates the harsh summer temperature regime and allows the further development of a vegetated surface. After humus accumulation, which acts as an effective mulch, summer soil moisture is elevated, enhancing the latent heat flux and correspondingly reducing the sensible heat flux. This probably allows the full development of mature lichen woodland with its almost monospecific ground cover of either *Cladonia stellaris* or *Stereocaulon paschale*. Limited data suggest that the net photosynthetic responses of these two species is favored by the relatively warm mesic conditions established by the open spruce canopy. Good accumulation of snow in the winter is probably also important for protection of the lichen surface from low temperatures. The open nature of mature lichen woodland is apparently maintained by an active inhibition of spruce seedling establishment by the lichen mat, although the mechanism is not entirely clear".

HBL - *Keywords:* lichen, ecology; microclimate; beach ridges, coastal; gradient analysis; soil relations; vascular species lists; snow cover

Kershaw, K.A. and Larson, D.W. 1974. Studies on lichen-dominated systems IX. Topographic influences on microclimate and species distribution. Can. J. Bot. 52:1935-1945.

"The marked positional-relationship of two plant associations dominated by *Cladina alpestris* and *Alectoria nitidula,* occurring on lower ridge slopes and exposed ridge summits, respectively, is described. Measurements obtained under conditions of diffuse radiation over the ridge profile show a consistent trend of slower rates of evaporation over the *Cladina alpestris* association coupled with lower wind speeds and higher temperatures. Conversely, the relative drying rate of *Alectoria nitidula* on the ridgetop is much faster with higher wind speeds and lower temperatures. Examination of the metabolic response of these two lichen species to the level of thallus saturation and temperature shows an exact correlation with their spatial distribution in the field and the microclimate at these zones".

HBL - *Keywords:* fire; climate; microclimate; lichen, ecology; lichen woodland; patterned terrain; wildlife-habitat relationships: caribou; soil relations; bryophytes, ecology; tundra

Kershaw, K.A. and Rouse, W.R. 1971. Studies on lichen-dominated systems. I. The water relations of *Cladonia alpestris* in spruce-lichen woodland in northern Ontario. Can. J. Bot. 49:1389-1399.

The water relations of *Cladonia alpestris* in spruce-lichen woodland at Hawley Lake, northern Ontario are described. "The rate of drying of the lichen canopy was measured by resistance grids inserted into the canopy and monitored during the drying cycle. The effects of dew were measured in a similar fashion and shown to form an insignificant proportion of the total annual metabolism of the lichen. The lichen mat showed a very high stratified resistance to water loss and the effective mulching properties produced a high level of water availability under the lichen mat. This was confirmed using neutron attentuation techniques and the significance of this discussed in relation to the development of lichen woodland. The physiological response of the lichen to conditions of varying levels of saturation is also discussed".

HBL - *Keywords:* lichen, ecology; microclimate; lichen woodland

Kershaw, K.A. and Rouse, W.R. 1973. Studies on lichen-dominated systems. V. A primary survey of a raised-beach system in northwestern Ontario. Can. J. Bot. 51:1285-1307.

A coastal beach-ridge complex at East Pen Island, northern Ontario (56°46'N, 88°46'W) was examined using principal components analysis. Six major plant associations were subsequently recognized: 1) *Dryas-Hedysarum-Xanthoria,* 2) *Cetraria islandia-Arctostaphylos,* 3) and 4) the general lichen heaths I and II (two closely related associations with similar species components but at different abundance levels, 5) *Cladina alpestris,* 6) *Alectoria nitidula.* A demonstrable trend exists from younger beach ridges adjacent to the coastline to older ridges 8 km inland. This trend has been characterized by the major species involved and by the plant associations relating to specific ridge groups. Environmental parameters controlling vegetation patterning are suggested.

HBL - *Keywords:* lichen, ecology; microclimate; lichen physiology; beach ridges, coastal

Kershaw, K.A., Rouse, W.R. and Bunting B.T. 1975. The impact of fire on forest and tundra ecosystems. Dep. Ind. North. Aff., Publ. QS-8038-000-A1. 79 p.

This report in the ALUR series presents studies on the recovery of burnt surfaces characteristic of the lichen woodland areas to the east of Great Slave Lake. The impact of fire on vegetation development, soil properties and microclimate and the interaction between these facets are covered in detail.

Three phases of recovery after fire are delineated with the aid of principal components analysis of collected data. The ordinated results confirm also the descriptions of other workers (Scotter 1964). A very clear correlation appears between the sequence of vegetation and the microclimate development after five years.

The ability of *Polytrichum piliferum* as an early colonizer is postulated, and the slower occurrence of lichens in the sequence is attributed to dry, hot summer extremes of microclimate. Soil moisture data are used to demonstrate this. Increase of surface organic horizon thickness is described as an ongoing process of post-fire recovery. This change in organic material is instrumental in causing changes in surface thermal and moisture regimes, soil fertility and moisture holding capacity. In turn, this directly affects the species composition during fire recovery phases.

- *Keywords:* fire; microclimate; lichen, ecology; bryophytes, ecology; soil relations; peatland, ecology; tundra; gradient analysis; wildlife-habitat relationships: caribou

Ketcheson, D.E. and Jeglum, J.K. 1972. Estimates of black spruce and peatland areas in Ontario. Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-172. 29 p.

"Using available provincial inventory and land data for Ontario, estimates were made of the areas of black spruce-dominated forest, peatland and black spruce forest on peatland. Percentages of black spruce-dominated forest and black spruce forest on peatland reached the highest levels in the Clay Belt, Northern Coniferous and Central Plateau ecological sections. On a province-wide basis, it was found that black spruce-dominated forest occupies 40 percent of the productive forest land area, and that 46 percent of this is black spruce forest on peatland". Peatlands were estimated to occupy 107 million acres (43,300,000 ha) or 49% of Ontario's land area. Of this area, 92% falls within the Clay Belt, Central Plateau and northern Coniferous Sections and the Unsurveyed Region. Productive peatland black spruce occupies 18% of the total peatland areas. Well over half of Ontario's peatlands exist in the Unsurveyed Section within the Hudson Bay Lowlands.

HBL - *Keywords:* peatlands, distribution and extent; boreal forest

Kirk, M. 1940. Checklist of plants collected in the region north of Cochrane as far as Moosonee, Ontario. (MS)

Specimens at TRT (321 spp.) identified by M.C. Taylor; collected at Moosonee, Onakawana and Fraserdale.

HBL - *Keywords:* vascular species lists

Knollenberg, R. 1964. The distribution of string bogs in central Canada in relation to climate. Univ. Wisc. Dep. Meteorol. Tech. Rep. No. 14. ONR and Natl. Sci. Foundat. 44 p.

In this study the occurrence of string bogs in central Canada was mapped and compared with specific climatic parameters in the region to estimate their potential usefulness as climatic indicators. String bog distribution was determined along a series of flight lines made during June and October 1963, and techniques employed included low level flying, oblique aerial photography, air-photo interpretation, and radar films. Included were the western extremes of the HBL in Manitoba west of 90° W. String bog development is hypothesized in terms of macroclimate features and gentle slopes. The growth and persistence of the stränges is felt to be intrinsically related to spring thawing, snow cover, and the vegetation surface cover. Thermal properties of the freeze-thaw layer are expressed as functions of thermal diffusivity and freeze-thaw depths in an attempt to demonstrate a relation to the strong alternation of winter soil frost and summer thaw.

The conclusion is reached that "to the climatologist, climatic indicators such as string bogs, low center polygons, and other climatically characterized frost-soil forms yield a source of indirect climatic data when data from direct measurement has not been obtained or is otherwise not available".

HBL - *Keywords:* remote sensing; climate; hydrology; patterned terrain; peatland, ecology; zonations, regions and districts; snow cover; string bogs and patterned fens

Kozlovic, N.J. and Howarth, P.J. 1977. Biophysical mapping in northwestern Ontario from aircraft and satellite remote sensing data. Proc. 4th Can. Symp. Remote Sensing, Quebec City, May 1977. p. 27-36.

The study used a number of remote sensing techniques to investigate the natural environment of northwestern Ontario at a site near Pen Island on the south shore of Hudson Bay. On the basis of the first author's Master's thesis at McMaster University, the most useful methodologies for mapping an area of 680 sq. km were tested. Limited ground truthing was used to recognize 15 terrain classes in digital analysis on signature-file extension analysis of LANDSAT data. The results compare well with air-photo interpretation but could not have been produced without ground-truthing information.

HBL - *Keywords:* remote sensing

Lamoureux, J.P. and de Repentigny, L.G. 1972. Contribution à la flore des marécages intertidaux de la Baie de Rupert (Qué.). Can. Wildl. Serv., Valleyfield, Quebec. (MS).

Eighty-three species of vascular plants collected from seven stations; not annotated.

- *Keywords:* salt marsh; tidal flats; offshore

Lamoureux, J.P. and Zarnovican, R. 1972. Approximation relative à la végétation riparienne de la Baie de Rupert, Qué. Can. Wildl. Serv., unpubl. James Bay Rep. Ser. Rep. No. 2. Valleyfield, Que. 126 p.

A study of riparian vegetation of Rupert Bay, Quebec based on 19 transects. Concludes that "Braun-Blanquet" associations do not exist in such vegetation. No environmental parameters are presented.

- *Keywords:* salt marsh; tidal flats; offshore

Lamoureaux, J.P. and Zarnovican, R. 1974. Les marécages côtiers de la Baie aux Oies, Québec. Can. Wildl. Serv., unpubl. James Bay Rep. Ser., Rep. No. 13. 99 p.

Autecology, synecology and distribution of plant species in the intertidal zone of the Baie aux Oies, near Fort George, Quebec. Important ecological factors such as nature of substrate, oxygen content of water, salinity, water depth, substrate chemistry, and vegetation cover and height are considered in this sophisticated approach to coastal surveying.

Vegetation data are subjected to various modes of ordination and classification which show that, ecologically, the vegetation (despite its various discontinuities) represents a single unit, which can be subgrouped almost arbitrarily along the various gradients. The principal ecological factors (slope, species dominance, dissolved oxygen content of water, salinity, substrate material), will reflect, through vegetational changes, any imposed impacts upon the coastline system. (A collection of 80 species appears in the Appendix).

- *Keywords:* salt marsh; tidal flats; nutrients; gradient analysis; soil relations; wildlife-habitat relationships: waterfowl

Larson, D.W. 1975. Aspects of the ecology of coastal raised-beach ridges in northwestern Ontario. Ph.D. thesis. McMaster Univ., Hamilton, Ont. xi + 163 p.

"The structure of lichen-dominated vegetation is described within a series of raised beach ridges found along the strip of coastal tundra in northwestern Ontario. The patterns of distribution of the most abundant species correlated with the topographic influences of individual beach ridges more than with the influences of the general development sequence of vegetation from the coast of Hudson Bay, inland.

The importance of topography to the structure of this vegetation was examined by comparing ridge-top and bottom positions of raised beach ridges in terms of edaphic factors, snow cover and microclimatic factors. A new experimental system was developed to test for adaptation of net photo-synthetic rates in the lichens *Alectoria ochroleuca* (Hoffm.) Massal. and *Cetraria nivalis* (L.) Ach. to the contrasting ridge surfaces from which they were collected. Morphological adaptations to these beach ridge surfaces were also examined.

Seasonal patterns of net photosynthesis in both species showed that intra and interspecific differences in seasonal acclimation were important to the observed patterns of distribution in the field. Thallus morphology was found to provide optimal water relations for photosynthetic production. Experiments showed further that the potential for control of evaporative loss is present in lichens.

This study shows that the patterns of distribution observed in the field, are consistently related to the topographic relations of individual beach ridges. These patterns are also consistent with both the physiological and morphological requirements exhibited by the plants, and with the defined physical characteristics of the surfaces on which they grow".

HBL - *Keywords:* beach ridges, coastal, gradient analysis; lichen, ecology; lichen, physiology; lichen, species lists; vascular species lists; tundra; soil relations; microclimate; snow cover

Larson, D.W. and Kershaw, K.A. 1974. Studies on lichen-dominated systems. VII. Interaction of the general lichen heath with edaphic factors. Can. J. Bot. 52: 1163-1176.

"The patterns of variation in vegetation and the more apparent environmental parameters within and between the ridges of a recently-formed Hudson Bay coastal raised-beach system 1.5 km wide are presented and analyzed using principal-component analysis and correlation coefficients".

The vegetation is dominated by a number of species, each having a unique distribution perpendicular to the coastline. Cover and biomass data of nine species common to the strand system are related to ecological parameters. *Cetraria nivalis* and *Cladonia mitis* exhibit higher performance on progressively older ridges in the system that have thicker peat layers and higher levels of surface moisture. Other species such as *Cetraria cucullata, C. islandica, Dryas integrifolia* and *Alectoria ochroleuca* exhibit higher performance on more recent ridges which have lower soil moisture contents. However, variations independent of any age sequence commonly occur across individual ridges, indicating the importance of environmental factors.

HBL - *Keywords:* beach ridges, coastal; gradient analysis; lichen, ecology; vascular species lists; microclimate; isostasy; productivity and biomass; tundra

Larson, D.W. and Kershaw, K.A. 1975a. Studies on lichen-dominated systems. XI. Lichen heath and winter snow cover. Can. J. Bot. 53: 621-626.

"Several tundra beach ridges, adjacent sedge meadows and forested areas some distance inland were examined in midwinter, late winter and early spring to assess the potential importance of variations in snow cover to underlying vegetation. Sites were at Pen Island and Fort Severn, northern Ontario. Tops of beach ridges were found to be nearly snow-free all winter and were fully exposed early in the spring. Sedge meadows and forested areas had a thicker cover. The vegetational characteristics of each area appear adapted to the winter snow conditions".

HBL - *Keywords:* beach ridges, coastal; beach ridges, interior; lichen, ecology; lichen, species lists; tundra; snow cover; microclimate

Larson, D.W. and Kershaw, K.A. 1975b. Studies on lichen-dominated systems. XIII. Seasonal and geographical variation of net CO_2 exchange of *Alectoria ochroleuca*. Can. J. Bot. 53: 2598-2607.

"By using a new gas-exchange method, the seasonal changes in net photosynthetic rates of *Alectoria ochroleuca* were examined in relation to thallus moisture content, thallus temperature, and light intensity. These experiments were run using samples collected from both the top and bottom positions of a raised-beach ridge and showed very little intraspecific variation. Collections made from other geographical locations, however, showed that considerable intraspecific variation was possible within this species.

At the Pen Island site, *A. ochroleuca* shows patterns of net photosynthesis adapted to the xeric ridge-top environments on which it is most abundant.

Rapid seasonal acclimation to temperature and changes in the response to light intensity were found for both ridge-top and ridge-bottom collections of *A. ochroleuca*. The significance of these findings is discussed".

HBL - *Keywords:* lichen, physiology; beach ridges, coastal; lichen, ecology; microclimate; tundra

Larson, D.W. and Kershaw, K.A. 1975c. Studies on lichen-dominated systems. XVI. Comparative patterns of net CO_2 exchange in *Cetraria nivalis* and *Alectoria ochroleuca* collected from a raised-beach ridge. Can. J. Bot. 53: 2884-2892.

"Seasonal patterns of net photosynthesis in *Cetraria nivalis* that was collected from the top and bottom positions of a raised-beach ridge were examined in relation to those for *Alectoria ochroleuca* for the same site. While seasonal acclimation is pronounced in *C. nivalis* to an extent equal to that found in *A. ochroleuca, C. nivalis* showed significant intraspecific difference in these patterns. *Cetraria nivalis* that was collected from the bottom position of the beach ridge is more active metabolically than the ridge-top collections. *Cetraria nivalis* is most abundant on the lower slopes of these ridges. A comparison of the physiological data matrices for both ridge-top and ridge-bottom collections of *A. ochroleuca* and *C. nivalis* partly explains the patterns of species distribution that are observed in the field".

HBL - *Keywords:* beach ridges, coastal; microclimate; lichen, ecology; lichen, physiology; tundra

Larson, D.W. and Kershaw, K.A. 1975d. Acclimation in arctic lichen. Nature (London) 254: 421-423.

Seasonal response of net assimilation rate was investigated for arctic lichens and rapid acclimation to temperature, light and thallus moisture content was found. Systems were constructed to follow variables of net assimilation rate of lichens from Arctic tundra at East Pen Island, Hudson Bay. It appears, from preliminary evidence, "that these organisms can adjust reversibly their patterns of physiological response to suit the atmosphere of their rather severe habitats".

HBL - *Keywords:* beach ridges, coastal; tundra; lichen, ecology; lichen, physiology; microclimate

Larson, D.W. and Kershaw, K.A. 1976. Studies on lichen-dominated systems. XVIII. Morphological control of evaporation in lichens. Can. J. Bot. 54:2061-2073.

Using controlled wind-tunnel studies on arctic and subarctic species of lichens, including populations from the Pen Island area, time-dependent and moisture content-dependent changes in evaporation rate were examined. It was concluded that, although the control of water relations in lichens is of a different nature from that in higher plants, the control is nonetheless present.

HBL - *Keywords:* beach ridges, coastal; tundra; lichen, physiology

Lavertiere, C. and Guimont, P. 1975. Le milieu bio-physique de la Baie de Reupert. Société de développement de la Baie James, Direction de l'Environnement. 159 p.

A biophysical description of Rupert Bay, Quebec is presented. Vegetation units are mapped along 21 transects oriented from intertidal areas into upland forests. No quantified consideration of abiotic influences or species composition is presented.

- *Keywords:* salt marsh; tidal flats; biophysical

Lechowicz, M.J. and Adams, M.S. 1974. Ecology of Cladonia lichens I. Preliminary assessment of the ecology of terricolous lichen-moss communities in Ontario and Wisconsin. Can. J. Bot. 52: 55-64.

The ecology of lichen-moss ground layer communities in Ontario and Wisconsin was investigated using principal component and Bray and Curtis ordination techniques. The information supplied for northern Ontario sites is that of Ahti and Hepburn (1967). "...lichen and moss relations along macroscale environmental and successional gradients were considered. Species relations along gradients of moisture and exposure were recognized". The Ontario ordination emphasizes broad habitat similarities between the species *Cladonia mitis, C. rangiferina* and *C. uncialis*.

HBL - *Keywords:* lichen, ecology; gradient analysis; soil relations; lichen woodland; wildlife-habitat relationships: caribou

Lehoux, D. and Rosa, A. 1973. Descriptions des principales unites physiographiques de la région de la Baie James. Dep. Environ., Serv. Can. Faune, Ottawa, Ont. Unpubl. James Bay Rep. Ser.

Deals with habitat preference of waterfowl, and divides the region east of James Bay into four "physiographic" units: forested upland, bog, bay shoreline and littoral wetlands. No botanical detail.

- *Keywords:* biophysical; zonations, regions and districts; peatland, classification; wildlife-habitat relationships: waterfowl

Lepage, E. 1945. The lichen and bryophyte flora from James Bay up to Lake Mistassini. The Bryologist 48:171-186.

Includes James Bay materials collected at Moosonee and Rupert House, 1943.

HBL - *Keywords:* bryophytes, species lists; lichen, species lists; vascular species lists; floristic notes; phytogeography

Lepage, E. 1954. Nouveautés dans la flore de la Baie James. Nat. Can. 81:255-261.

Nine taxa are described: seven forms, one varietal taxon and one hybrid taxon (*Andromeda polifolia* X *A. glaucophylla* = *A. jamesiana*). The article is of taxonomic interest only.

HBL - *Keywords:* floristic notes; taxonomic treatments

Lepage, E. 1959. Checklist of vascular plants. p. 30-114 *in* Botanical excursion to the boreal forest region in northern Ontario and Quebec. Natl. Mus. Can., Guide Book.

Lepage presents a checklist of 932 species from the James Bay area, and 866 from the Northern Clay Belt, compiled for members participating on Field Trip 7, Boreal Forest Excursion of the Ninth International Botanical Congress, 1959. The catalogue includes compilations and collections listed earlier in Baldwin (1958), Dutilly, Lepage and Duman (1954, 1958) and Marie-Victorin (1964). Additions and revisions to the list are made in Baldwin et al., *Ed*, (1962).

HBL - *Keywords:* vascular species lists; phytogeography; boreal forest

Lepage, E. 1966. Aperçu floristique du secteur nord-est de l'Ontario. Nat. Can. 93:207-246.

Paper based on collections made at 26 sites during a journey from Winisk to the mouth of the Ekwan River via the Shamattawa River: 356 taxa collected, many mapped for eastern Canada.

HBL - *Keywords:* vascular species lists; phytogeography; floristic notes

Low, A.P. 1887. Preliminary report on an exploration of country between Lake Winnipeg and Hudson Bay. Geol. Nat. Hist. Surv., Annu. Rep. 1886, F.

15 notable species cited.

HBL - *Keywords:* floristic notes

Lumsden, H.G. 1958a. Checklist of plants collected at site 415, south of Cape Henrietta-Maria, June 24, 1957. (MS)

52 species collected, identified by A.E. Porsild, stored at Ont. Min. Nat. Resour., Maple, Ontario.

HBL - *Keywords:* vascular species lists

Lumsden, H.G. 1958b. Checklist of plants collected at Little Cape, mouth of Sutton River, July 3, 1957. (MS)

37 species collected, identified by A.E. Porsild, stored at Ont. Min. Nat. Resour., Maple, Ontario.

HBL - *Keywords:* vascular species lists

Lumsden, H.G. 1974a. (Compiled by J.L. Riley). List of plants collected at Forks of the Brant, the Lower Brant, Winisk, Site 415, 416, and Cape Henrietta-Maria Peninsula, 1969-71. (MS)

100 species collected, identified by A.E. Porsild, stored at Ont. Min. Nat. Resour., Maple, Ont.

HBL - *Keywords:* vascular species lists

Lumsden, H.G. 1974b. Evolution and dynamics of peatlands. Submission to a meeting to determine the research needs in the Hudson Bay Lowlands, Dec. 13, 1974. Ont. Min. Nat. Resour., Maple, Ont. (MS)

A review of the evolution of different patterns of peatland, e.g., fens, raised bogs, and some of the general factors influencing peat development. Aspects of seepage, high water tables, permafrost aggradation and degradation, fire and many imposed impacts are discussed briefly with particular reference to the Lowlands.

HBL - *Keywords:* beach ridges, interior; fire; human impact; patterned terrain; peatland, ecology; permafrost

McFarlane, I.C. 1957. Guide to a field description of muskeg, (based on the Radforth Classification System). Nat. Res. Counc., Assoc. Comm. Soil Snow Mech., Tech. Memo 44. 36 p.

Because of its biological origin, organic terrain (or "muskeg") is extremely complex. Nevertheless, it comprises about 12% of Canada's land area and creates considerable difficulties for transportation and engineering. Standardization of terminology is thought to be essential and the booklet condenses classification and description techniques developed by N.W. Radforth. The technique identifies nine vegetal cover classes referring not to species of plants but to qualities of vegetation such as degree of woodiness, stature, external texture, and certain easily recognized growth habits. Sixteen topographic features, and 16 categories of subsurface organic material are provided in tabular form. The system has been applied by a number of workers describing peatlands within the HBL.

- *Keywords:* vascular species lists; bryophytes, species lists; lichen, species lists

Macoun, James M. 1885. List of plants collected at Lake Mistassini, Rupert River, and Rupert House, 1885. Annu. Rep. Geol. Surv. Can., 1:36-440.

A list of 306 species from the east shore of James Bay.

HBL - *Keywords:* floristic notes

Macoun, James M. 1888. Note on the flora of James Bay. Bot. Gaz. 13:115-118.

Discusses the gradual disappearance of southern plants as they reach their northern limits and the great contrast between the subarctic tundra of the islands and the northern forest of the nearby mainland. Mentions several dozen species he considered most notable.

HBL - *Keywords:* vascular species lists; treeline; tundra; floristic notes; zonations, regions and districts

Macoun, James M. 1889. List of plants collected on the Rupert and Moose Rivers, along the shores of James Bay, and on the islands in James Bay during the summers of 1885 and 1887. Annu. Rep. Geol. Surv. Can., 3:63J-74J.

Collected by J.M. Macoun, 1885 and 1887. Extensive listings but little locational data: 207 species, James Bay; 346, Moose River; 296, Rupert River; a total of 509 different species.

- *Keywords:* remote sensing; peatland, classification

Macoun, John. 1881. List of plants collected in 1880. Appendix II *in* Report on Hudson's Bay and some of the lakes and rivers lying to the west of it, by Robert Bell. Report of Progress for 1879-1880. Geol. Nat. Hist. Surv. Can. p. 59-69c.

A list of 261 taxa, including some bryophytes and lichens, collected mainly within the Lowlands, from the York Factory and Hayes River area.

HBL - *Keywords:* vascular species lists

Macoun, John. 1884. Plants collected on the coasts of Labrador, Hudson's Strait and Bay, by Dr. R. Bell in 1884. Geol. Surv. Can., Report of Progress, 1884. Appendix 1: 38DD-47DD.

52 species reported from York Factory and Fort Churchill, and a larger number from further north and from Labrador.

- *Keywords:* vascular species lists

Macoun, John. 1904. (Summary of Mr. Spreadborough's collections of plants from James Bay.) Geol. Surv. Can., Summary Rep. 16:178A.

Brief mention of additions to the known flora, noting a collection of 278 species by W. Spreadborough, along the James Bay coast, in 1904.

HBL - *Keywords:* vascular species lists

Macoun, John. 1905. List of plants collected by D.B. Dowling at the mouth of the Ekwan and Albany Rivers, 1901. (misprinted as 1891). Annu. Rep., Geol. Surv. Can., 14:60F.

41 species listed.

HBL - *Keywords:* vascular species lists

Macoun, John. 1906. List of plants collected by W.J. Wilson along the shores of James Bay and in the valley of the Kapiscau River. Annu. Rep. Geol. Surv. Can. 15:241-243A.

48 species collected along the coast from Moose River to Kapiskau River, 77 species from the Kapiskau drainage basin near the mouth, for a total of 111 different species.

HBL - *Keywords:* vascular species lists

Maikawa, E. and Kershaw, K.A. 1975. The temperature dependence of thallus nitrogenase activity in *Peltigera canina*. Can. J. Bot. 53:527-529.

"Comparative rates of nitrogen fixation in the lichen *Peltigera canina* from subarctic (northern Ontario, 56°46'N, 88°46'W) and temperate (10 mi. west of Hamilton, Ontario) habitats have been examined using the acetylene reduction method. Maximum acetylene reduction at thallus saturation and with 20,000 lx illumination takes place at 16°C, in subarctic material and at 21°C in temperate material. This adaptation in nitrogenase activity to temperature of *P. canina* is discussed in relation to low levels of soil nitrogen in arctic systems".

HBL - *Keywords:* lichen, physiology; soil relations; lichen, ecology

Majcen, Z. 1973. Organic terrain and wetland classification of the James Bay region: preliminary attempt. Dep. Environ., Reg. Ecol. Stud. Sect., Report SJBR-8.

An attempt to categorize wetland vegetation types of the eastern James Bay region on the basis of relief, microrelief, moisture regime, geographic location (in some cases), surface deposits and parent rock. Five dominant categories are recognized: minerotrophic, transitional ombrotrophic, palsas and sinkholes, and further subdivisions of these are made. Species commonly occurring together in the field were noted at the lowest division, the Group level. Though preliminary, it was thought by the author to be useful for making a more detailed classification at a later date, based on plant analyses, aerial and field photographs, and environmental data for each sampling location.

- *Keywords:* peatland, classification; patterned terrain; soil relations; nutrients; peatland, ecology

Marie-Victorin, F.R. 1938. Phytogeographical problems of eastern Canada. Contrib. Lab. Univ. Montreal, 30.

Discusses briefly (p. 549-553) some instances of bicentric, James Bay-St. Lawrence distributions and hypothesizes on their inclusion in a type of senescent flora which dominated areas in the early post-glacial period. Also proposes his 'rainbow' theory of disjunct east-west distributions.

HBL - *Keywords:* plant migration; salt marsh; phytogeography

Marr, J.W. 1948. Ecology of the forest-tundra ecotone on the east coast of Hudson Bay. Ecol. Monogr. 18:117-144.

Primarily a study of tree growth without environmental or vegetational context. Ascribes the limit of tree species to the slow development of soils occupied by tundra, concluding that the tundra of the area would support trees if soil conditions were ameliorated. Of little relevance to Hudson Bay Lowlands, as much of the physiographic constraints and abiotic factors are quite different, but of interest in terms of northern tree growth patterns.

- *Keywords:* treeline; mensuration, forest

Maycock, P.F. 1968. The flora and vegetation of the southern Manitounuk Islands, southeast Hudson Bay, and a consideration of phytogeographical relationships in the region. Nat. Can. 95:423-468.

"Data on the flora and vegetation of the Southern Manitounuk Islands are presented and discussed relative to nearby areas. Range extensions for several species of interest in the region are also provided."

A phytogeographical analysis of the southern Manitounuk flora is undertaken and comparisons are drawn with that of the adjacent mainland (300+ species; Baldwin 1948). The suggestion is made that the the geographical distributions of the species present rather than imcomplete climatic data should dominate considerations of arctic/subarctic/temperate characterizations. "Attention is drawn to a decidedly abrupt transition from a flora which is boreal in its phytogeographical affinities to one which is subarctic to one which is arctic, all within a distance of only 11 miles in the Great Whale River region of southeast Hudson Bay".

- *Keywords:* climate; floristic notes; treeline; tundra

Maycock, P.F. 1976. 'Phytosociological matrices of the site regions of Ontario'. Ont. Min. Nat. Resour., Parks Plan. Br. (MS)

Based on point-quarter phytosociological field work throughout Ontario. The data on the Central and Northern Boreal Forest Regions are relevant to the Lowlands.

HBL - *Keywords:* biophysical; zonations, regions and districts; climate; boreal forest; peatland, classification; tundra.

McClure, H.E. 1943. Aspection in the biotic communities of the Churchill area, Manitoba. Ecol. Monogr. 13(1):1-35.

During the summer of 1936 an ecological survey was made of the invertebrate fauna of Churchill, at the mouth of the Churchill River near 59°N. Weekly collections were made at seven aquatic habitats and 14 terrestrial habitats throughout the tundra and forest within a 4.8 km radius of the town.

Descriptions of the flora at each of the 21 stations are given, and the flowering dates of 63 species are noted. The author feels that plant succession on the tundra follows at least 10 lines of development. Stages in this development include *Eriophorum* sedge associations in low places, followed by dwarf arctic willows, and subsequently mixed tundra (late sub-climax). *Arenaria* associations on sand followed by *Agropyron-Draba* associations on sand blended through an association of *Draba-Cerastium* into mixed tundra. Coexistence of tundra and subarctic *Picea mariana-Larix laricina* stands is briefly considered.

Other minor successional developments are postulated, and 80 plant species are cited.

HBL - *Keywords:* floristic notes; insects; tundra; treeline; phenology; patterned terrain; wildlife-habitat relationships: insects

McEwen, J.D. 1964. European peatland literature and its possible application to northern Ontario. Ont. Dep. Lands For. Res. Inf. Pap. (Forestry) No. 29. 45 p. + mapsheet.

A review of selected literature from the United Kingdom and Europe covering effect of ground cover on trees, mycorrhizal relations, nutrient status of organic sites, treatments of ground cover, and drainage. Implications of the work are applied to a vegetational cover map (1:1,000,000) of the upper Albany River from 1952.

HBL - *Keywords:* boreal forest; mensuration, forest; hydrology; nutrients; river bank; peatland, distribution and extent; zonations, regions and districts

McInnes, M.W. 1908. Les parties supérieures des Rivières Winisk et Attawapiskat. Trav. Comm. Geol., Ottawa, Ont. Compt. Rend. Somme 1904.

Information on the occurrence of larch sawfly damage along the river routes is presented.

HBL - *Keywords:* insects

McKay, S.M. and Arthur, M.D. 1975. Vegetation survey of Shipsands Island and Puskwuche Point, southwestern James Bay. Ont. Min. Nat. Resour., Policy Res. Br., Off. Sci. Advisor. 97 p. + appendices.

A survey of James Bay coastal flora at Shipsands Island (51°22'N, 80°28'W) and Puskwuche Point (51°48'N, 80°40'W) was conducted during July and August, 1974. Along transects perpendicular to the shoreline, vegetation parameters were measured and water samples, soil samples and plant material were collected for chemical analysis.

Shipsands Island is influenced by both the Moose River's fresh water and the slightly saline tidal water of James Bay. Vegetation of the tidal flats varied, with each shore of the island having distinctive assemblages of plants adapted to conditions of the area. High levels of nutrients deposited during spring floodings result in a relatively productive and diverse flora. A meadow vegetation is viewed in successions from grass-sedge, to rush form, to a willow form, to a willow-orchard-type meadow. Willow-alder thickets characterized by dense herbaceous growth are particularly common in the southern parts of the island. Well developed sand dunes, sparsely vegetated, exist on the mid-eastern shore. Inland pools, within meadow and thicket areas, are also discussed. Five scattered balsam poplar groves (clones?) have become established on the island, on higher, drier sites.

Puskwuche Point, a Y-shaped gravel spit, was divided into northern and southern study sections. Several vegetation units were described in the southern section: 1) open beach flats supporting few vascular plants, 2) a first beach ridge, a sparsely covered gravel knoll, 3) a brackish sward, open to the south to tidal water and regularly flooded, 4) a second raised beach, supporting several distinct plant associations along its slopes and ridges, 5) a freshwater sward allowing a gradual influx of non-aquatic species along its inshores, 6) a third beach ridge. In the northern section the sequence surveyed along four transects was: 1) open beach, supporting a number of quite salt-tolerant species that gradually increase in abundance to a ground cover of 60%. Near high tide, level tufts of *Puccinellia* help support other species, and pools or dry pannes develop, 2) first raised beach, not well developed in sections, but supporting a variety of habitat types along its crest, 3) brackish sward, 4) second raised beach.

A floristic comparison of Puskwuche Point and Shipsands Island showed a species overlap of only 30%, although 50% similarity existed between tidal flats and meadows. Halophytes are considered briefly in terms of relative salt tolerance and it is concluded that few are truly obligatory. An index for the degree of drainage of Shipsands Island sites is given in the relationships of soil and water K/Na ratios and soluble chlorine.

Seven appendices provide vegetation importance values, vegetation zone measurements, annotated species lists, plant chemical analyses, soil sample analyses, water sample analyses, and a list of fauna observed.

HBL - *Keywords:* salt marsh; tidal flats; beach ridges, coastal; soil relations; vascular species lists; flooding; isostasy; phytogeography; sedge meadows

McKay, S.M. and Riley, J.L. 1975. Checklist of plants collected on Shipsands Island Waterfowl Sanctuary, Moose River, 1972, 1974. (MS)

More than 190 species listed.

HBL - *Keywords:* vascular species lists

Mills, G.F. 1976. Biophysical land classification of northern Manitoba. *in* J. Thie and G. Ironside, *Ed.* Proc. 1st. Meet. Can. Comm. Ecol. (Bio-phys.) Land Class., May 25-28, 1976. Petawawa, Ont.

"A systematic biophysical classification of northern Manitoba was initiated in July, 1974. Development of the system took place over the first year and at present an operational program has completed a field inventory of some 85,000 km^2 (33,000 mi^2). The objective of this land classification is to classify and map terrain in terms of land-forms, surface deposits, vegetation, soils, drainage, permafrost, associated aquatic systems and climate. The inventory is designed to provide an ecologically sound basis for making land use decisions concerning forestry, agriculture, recreation, wildlife, community development and hydrology. The methodology for data collection, compilation and presentation is described. An example of the methodology illustrating the hierarchical nature of the system is taken from the Hayes River area in northeastern Manitoba (within the HBL). The strength of this methodology appears to lie in an integrated approach to data presentation enabling a more complete description of the land element of the terrain. Some anticipated uses and limitations of the data, together with estimated costs of the inventory, are presented".

HBL - *Keywords:* biophysical; permafrost; patterned terrain; boreal forest; agriculture

Mills, G.F., Veldhuis, H., Forester, D.B. and Schmidt, R. 1976. A guide to biophysical land classification in Manitoba. Dep. Resour. Transp. Serv., and Can. Man. Soil Surv. North. Resour. Inf. Prog. 25 p. + Biophysical Land Class. Mapsheet 54C, Hayes River, Manitoba. (scale = I:125,000).

This discussion of the application of biophysical classification in Manitoba by the NRI program involves a mapping technique incorporating all of the salient factors required by most future developers on environment-landforms, climate, soils, permafrost, vegetation, and water bodies. Ecologically significant land units (Land Region, Land District and Land System) are used as mapping units at 1:125,000.

The guide is a handbook to the mapping program. A good part of the Manitoba HBL has been surveyed systematically. Included are notes on soil, topography and landform, elevation and drainage for the Land Districts and Land Regions, as well as a list of vegetation, and vegetational characteristics of the Land Regions of the Hayes River mapsheet. A glossary of terms on mineral and organic soil landform classes, bedrock classes, erosional modifiers, textural classes and surface form categories is appended.

The map itself makes use of an equation which provides all of the information for a given Land System in symbolized form, based on the classes and terms established for the biophysical investigation. These Land Systems are then identified within broader categories of Land Districts, and finally within the Land Regions.

HBL - *Keywords:* biophysical

Moir, D.R. 1954. Beach ridges and vegetation in the Hudson Bay region. Proc. North Dak. Acad. Sci. 8:45-48.

A low-lying zone of glacier-worked marine clays, the Hudson Bay Coastal Plain, is characterized by series of conspicuous low beach ridges paralleling the coast and extending inland in recognizable form from 60 to 100 miles (96-160 km). The ridges are particularly well developed along the south coast of the Bay. Because the area continued to undergo crustal recoil as a result of glaciation, the land continually rises at a rate of approximately 3 ft (1 m) per century. Six further factors augment the formation of the ridges. Because of their nature, the ridges support progressively more established vegetation from the coast inland. Near the shore, small sand dunes, where vegetation is not able to become established, are common.

Common species of the coastal and forested beaches are listed. Three stages in the establishment of vegetation on beaches of successively longer emergence are described briefly.

HBL - *Keywords:* beach ridges, coastal; isostasy; tidal flats

Moir, D.R. 1958. A floristic survey of the Severn River drainage basin, northwestern Ontario. Ph.D. thesis, Univ. Minn. IV + 261 p.

Primarily a catalogue of more than 600 species collected by Moir, Macoun, Cringan and Hustich. On the basis of species distribution, Moir describes the major aspects of representative communities from south to north along the drainage system. Notes on physiography, soils and climate of the area are included.

HBL - *Keywords:* vascular species lists; floristic notes

Morton, J.K. 1968. Plants recorded from the Moosonee area in July 1968. Univ. Waterloo, Dep. Biol., Waterloo, Ont. (MS)

203 species noted or collected.

HBL - *Keywords:* vascular species lists

Munroe, E. 1956. Canada as an environment for insect life. Can. Entomol. 88(7):372-476.

A general article providing some brief mention of larch sawfly infestations in the HBL, and indicating possible significant effects on growth of this species.

HBL - *Keywords:* insects; boreal forest

Neal, M.W. and Kershaw, K.A. 1973a. Studies on lichen-dominated systems. III. Phytosociology of a raised-beach system near Cape Henrietta-Maria, northern Ontario. Can. J. Bot. 51: 1115-1125.

"A modified version of the Braun-Blanquet technique for the analysis of plant associations was applied to an area of lichen-dominated raised-beach system near Cape Henrietta-Maria in subarctic northern Ontario. Eleven plant associations were extracted which appear to follow ecological gradients related to water availability, soil pH, and the presence/absence of a peaty substratum. It was concluded that this type of association analysis fulfilled all the major objectives of a preliminary survey".

HBL - *Keywords:* beach ridges, coastal; gradient analysis; lichen, ecology; vascular species lists; lichen, species lists; bryophytes, species lists

Neal, M.W. and Kershaw, K.A. 1973b. Studies on lichen-dominated systems. IV. The objective analysis of Cape Henrietta-Maria raised-beach systems. Can. J. Bot. 51:1177-1190.

"A principal-component ordination technique was applied to Domin-based data from the Cape Henrietta-Maria raised-beach systems. Eight of the 11 associations originally extracted by Braun-Blanquet methods were retained while the remaining three showed good reason to be grouped into one. Multiple regression trend surface analysis was applied to select dependent variables mapped onto the ordination and showed significant large-scale variations in the distribution of those points that were related to ecological factors".

HBL - *Keywords:* beach ridges, coastal; gradient analysis; lichen, ecology; tundra

Norris, G., Telford, P.G. and Vos, M.A. 1976. An albian microflora from the Mattagami formation, James Bay Lowlands, Ontario. Can. J. Earth Sci. 13(2):400-403.

"The Mattagami Formation is of variable thickness, consisting of several hundred feet of interbedded sands, clays and lignites. Spores and pollen from near the top of the formation indicate a late Middle or Late Albian age. Other palynological studies suggest that deposition of the lower part of the formation commenced in Aptian or Early Albian times".

HBL - *Keywords:* tundra; climate; human impact; zonations, regions and districts

Payette, S. 1974. Classification ecologique des formes de croissance de *Picea glauca* (Moench.) Voss et de *Picea mariana* (Mill.) BSP. en milieux subarctiques à subalpins. Nat. Can. 101:893-903.

"White spruce (*Picea glauca* (Moench.) Voss) and black spruce *Picea mariana* (Mill.) BSP.) are characterized by many growth-forms in the forest-tundra. This paper describes the most frequent growth-forms and gives their origin and formation. These growth-forms may be individuals or agglomerated into krummholz. They express a climatic gradient determined by exposure to cold and erosive winds and by snow conditions during the coldest period of winter time. Desiccation and icing may act also in the genesis of growth-forms. From exposed to protected sites, we observe the successive dominance of mat, infra-nival, supra-nival skirted, verticillate, flag and tree growth-forms. These growth-forms are not static since the environment is normally fluctuating and they can evolve according to the importance of ecological changes".

- *Keywords:* wind effects; snow cover; treeline; climate

Payette, S. 1975. La limite septentrionale des forêts, sur la côte orientale de la Baie d'Hudson, Nouveau-Québec. Nat. Can. 102: 317-329.

Distribution of tree species on the east coast of Hudson Bay are reported, and a discussion is given on the treeline problem. Based on the present forest distribution, the writer distinguishes two ecoclimatic regions, both characterized by specific treelines. In the maritime region, white spruce forest is found at the treeline to about 56°30'W, while in the continental region black spruce forest reaches the treeline at, at least 57°45'N, 76°10'W. Based on observations, the forest tundra zone is delimited into two phytogeographical subzones: forested subzone and shrub subzone (or krummholz). In the past the extent of the forest tundra zone has been underestimated, "the krummholz subzone having always been neglected. In fact, this subzone is characterized by the actual ecological forest limit."

- *Keywords:* treeline, zonations, regions and districts; climate

Payette, S. 1976. Succession écologique des forêts d'épinette blanche et fluctuations climatiques, Poste-de-la-Baleine, Nouveau-Québec. Can. J. Bot. 54:1394-1402.

"The stand structures of three white spruce (*Picea glauca* (Moench) Voss) climax forests of the hemiarctic zone in New Quebec are described. The forests have a similar structural pattern, characterized by important and irregular variations in the number of individuals per age, diameter, and height classes. These variations are synchronic and suggest that the climate strongly influences the forest regeneration. The discontinuous trend in the curves may possibly be related to changes in seed production and seedling establishment. Synchronism between the 300-year dendro-chronological curve and the stand age-structure is apparent. The hollow parts of the age curves are related to unfavorable climatic periods and the peaks to favorable ones. These climatic fluctuations are probably responsible for either a decrease or an increase in white spruce seed production important to hemiarctic forest regeneration. Finally, the writer suggests a theoretical age-structure curve for climax forests in the maritime forest-tundra near Poste-de-la-Baleine, New Quebec".

- *Keywords:* snow cover; treeline; climate; zonations, regions and districts; tundra

Payette, S. and Filion, L. 1975. Écologie de la limite septentrionale des forêts maritimes, Baie d'Hudson, Nouveau-Québec. Nat. Can. 102:783-802.

"White spruce (*Picea glauca* (Moench) Voss) and black spruce (*Picea mariana* (Mill.) BSP.) growth-forms and stands have been mapped in detail in the Richmond gulf area, where forests reach their maritime northern limit. It has been found that, 1) the dominance of white spruce is related to the high frequency and intensity of fog coming from the Hudson Bay, 2) the prostrated black spruce growth-form in the most maritime parts of the study area is not only associated to [sic] climatic exposure but also to inhibitive effects of excessive atmospheric moisture on growth, 3) black spruce shows a better competing capacity than white spruce under more rigorous climatic conditions, 4) along the climatic gradient, we observe a gradual change within white spruce formations in forest cover percentage, tree aggregation and occurrence of different growth-forms and 5) the disappearance of white spruce in the coldest segment of the climatic gradient. The ecological characteristics of the coniferous formations suggest their relationship within the climatic gradient. White spruce stand structure emphasizes the episodic nature of forest regeneration induced by recent climatic change in the forest-tundra. Finally, ecological opportunity seems to be a workable concept in the ecology of range limits".

- *Keywords:* treeline; climate; phenology; mensuration, forest

Payette, S., Filion, L. and Ouzilleau, J. 1973. Relations neige-vegetation dans la toundra forestière du Nouveau-Québec, Baie d'Hudson. Nat. Can. 100:493-508.

During winter, 1973, a snow study was undertaken at Poste-de-la-Baleine and Richmond Gulf, Nouveau-Québec. "There exists a strong relationship between snow cover properties and vegetation in the forest-tundra. Within defined topographic units, low vegetational structures, such as herbaceous and cryptogamic formations, have denser and more variable depth of snow cover than high vegetational structures, such as shrub and tree formations. These differences depend on the process of snow saturation in the environment; this process is influenced by the nature and the spatial pattern of structural types of vegetation. Pattern of snow distributions is similar to pattern of major structural elements of the hemi-arctic landscape. Soil conditions at Poste-de-la-Baleine and in the forest subzone at Richmond Gulf seem more restrictive than snow conditions for regional expansion of forest formations. But snow influence is more pronounced in the krummholz subzone of Richmond Gulf".

- *Keywords:* snow cover; treeline; climate; tundra

Payette, S., Ouzilleau, J. and Filion, L. 1975. Zonation des conditions d'enneigement en toundra forestière, Baie d'Hudson, Nouveau-Québec. Can. J. Bot. 53:1021-1030.

Snow depth and snow density data from various forest-tundra coniferous stands are presented in this paper. A latitudinal pattern in snow conditions is observed in the forest-tundra environment, as predicted from the facts that are obtained when this phytogeographical region is subdivided, first, into a forested subzone in the southern part and a shrub subzone (or krummholz) in the northern part, and second, into a maritime ecoclimate area near Hudson Bay and a continental ecoclimate area inland. Climatic conditions of the forest-tundra are reflected in snow conditions, and this determines the specific ecological distribution of coniferous stands.

- *Keywords:* climate; treeline; tundra; zonations, regions and districts

Payette, S., Samson, H. and Legarec, D. 1976. The evolution of permafrost in the taiga and in the forest-tundra, western Quebec-Labrador peninsula. Can. J. For. Res. 6:203-220.

"Major permafrost land forms of the discontinuous permafrost zone of Hudson Bay and James Bay, Quebec-Labrador Peninsula, are described and interpreted with an ecological perspective. These landforms are not fossil permafrost bodies; they are presently evolving under aggrading and degrading developmental stages". A survey led to identification and characterization by vegetation cover of the most important and frequent permafrost land forms. Along reconnaissance transects, starting near sea level and going inland to higher altitudes in similar sedimentation basins from southern to northern latitudes and from littoral ecosystems to continental ones, representative toposequences show zones of different natures and distributions of permafrost. The following zones are recognized: intertidal zone, supralittoral clay basin, terrestrial clay basin, terrestrial peat and clay basin, medium altitude sand basins, and dissected clay plains. Four major palsa-bog patterns are defined: polygonal, longitudinal, transversal and concentric. The distribution of landforms occurs within distinct complexes. Degrading stages associated with thermokarst activity are similar for all these land forms, and the aggradation and degradation processes of permafrost lenses are discussed.

- *Keywords:* permafrost; treeline; climate; palsas and peat plateaus; patterned terrain; zonations, regions and districts

Persson, H. and Sjörs, H. 1960. Some bryophytes from the Hudson Bay Lowlands of Ontario. Sv. Bot. Tidskr. 54:247-268.

Collections and habitat notes made at the confluence of the Muketei and Attawapiskat Rivers, near Cape Henrietta-Maria, near Hawley Lake, on the Sutton Ridge, and near Winisk. Collections include some 35 Hepaticae, 30 Sphagna and 97 Musci.

HBL - *Keywords:* bryophytes, species lists; floristic notes

Pielou, E.E. and Routledge, R.D. 1976. Salt marsh vegetation: latitudinal gradients in the zonation patterns. Oecologia 24:311-321.

"Zonation patterns of salt marsh vegetation were examined at latitudes ranging from 44°40'N at Halifax, Nova Scotia, to 58°50'N at Churchill, Manitoba. It was found that in all areas examined the landward boundaries of the species' zones were more nearly coincident (i.e., more clustered) than their seaward boundaries. A conspicuous latitudinal trend was found: the clustering of both landward and seaward boundaries increased with increasing latitude. Evidence that between-species competition influences the locations of zone boundaries was also obtained. Possible implications of the results in terms of a relationship between intrapopulation, polymorphism and latitude are discussed".

HBL - *Keywords:* salt marsh; gradient analysis; climate

Pierce, W.G. and Kershaw, K.A. 1976. Studies on lichen-dominated systems. XVII. The colonization of young raised beaches in NW Ontario. Can. J. Bot. 54:1672-1683.

"The colonization of young raised-beach ridges and the subsequent development of lichen-heath vegetation is described for the Hudson Bay coastal tundra. The sequence of development of lichen-heath was quantified both on a coastal intraridge sequence as well as an interridge, inland sequence of comparable age. Corresponding gradients of elevation, soil peat thickness and organic matter were found along the developmental sequence, but definite trends in soil pH and available nutrients are absent. Superimposed upon the distributions of major species along the developmental sequence are marked changes in abundance over the beach-ridge profiles which reflect the adaptations of species to environmental factors related ridge microtopography".

HBL - *Keywords:* beach ridges, coastal; tundra; soil relations; lichen, ecology; isostasy

Pollard, R.A. 1970. Studies on the hydrology of string mires. 24th Tech. Sess., Carleton Univ. (MS)

"Two minerotrophic wetlands in boreal northern Ontario exhibit surface patterning generally described as string mire. Among patterned wetlands, this type is most common and is characterized by alternate firm, drier areas and soft, waterlogged areas oriented so [sic] to be consistently perpendicular to overall subsurface water movement. Dry ridge areas, or stränge, were studied to determine their influence on inter-pool hydrology. Stränge range in height from low, mudbottom communities, close to the water table, to higher, drier central ridges. Stränge vegetation, especially *Sphagnum* spp., reflects this change in height above water table. Peat permeability was examined in the field with a piezometer. Hydraulic conductivity values ranged from .00007 cm/sec to .0155 cm/sec in dry peats, and from .00185 cm/sec to .0175 cm/sec and greater values, in wetter peats. Values at a 50-60 cm depth were consistently greater than those at a 90-100 cm depth. In drier stränge the greatest values were obtained in the higher, central ridges. These results are similar to those obtained for ridges in a third poor fen site. Studies are being carried out to determine the influence of peat composition on stränge hydrology and ensuing relationships to stränge chemistry".

- *Keywords:* peatland, ecology; hydrology

Polunin, N. 1939. Notes on some plants collected in the Canadian eastern arctic by Dr. Potter in 1937. Rhodora 41:37-42.

Collections made further north, relevant in showing the possibility of a northern migration route for James Bay plants which had been cited previously as evidence by Potter for an inland marine connection.

- *Keywords:* plant migration

Polunin, N. 1948. Botany of the Canadian eastern arctic. Part III. Vegetation and ecology. Natl. Mus. Can. Bull. No. 104. 304 p.

A treatise on the habitat conditions of plant growth, and phytosociology of the Canadian eastern arctic. The furthest "southern" habitat discussed is Chesterfield Inlet. Salt marshes are included. Although this publication deals with areas north of the HBL, it is of interest because of its phytogeographical extension of HBL studies to the arctic.

- *Keywords:* salt marsh; tundra; plant migration

Polunin, N. 1951. The real arctic: suggestions for its delimitation, subdivision and characterization. J. Ecol. 39:308-315.

Considers as arctic those lands north of the most northern of: i) a line 80 km north of northern limit of coniferous forest or continuous taiga, ii) the present northern limit of trees 2-8 m tall, ignoring the local outliers, or iii) the Nordenskiold line (V = 9-0. 1K, V = mean of warmest month, K = mean of coldest month, all °C. These exclude the Hudson Bay coast, but stress the southern and maritime nature of its arctic affinities.

- *Keywords:* tundra; treeline; climate

Polunin, N. 1959. Circumpolar arctic flora. Clarendon Press, Oxford.

A basic source of phytogeographical information on Lowland species.

HBL - *Keywords:* phytogeography; floras

Porsild, A.E. 1932. Notes on the occurrence of *Zostera* and *Zannichellia* in arctic North America. Rhodora 34:90-94.

A note extending the known ranges for the species at that time. In 1929, "the writer found *Zostera* occurring abundantly in James Bay, where its occurrence had already been suspected......" *Zostera* grew in extensive beds along the west coast of Akimiski Island in water 4-8 ft (1.2-2.4 m) deep at lowest tide. (*Zannichellia* is noted from Alaska.)

HBL - *Keywords:* phytogeography; floristic notes; offshore

Porsild, A.E. 1964. Illustrated flora of the Canadian arctic archipelago. Natl. Mus. Can., Bull. 146. 218 p. (revision of 1957 ed., reprinted 1973).

Although this manual of 352 species of flowering plants and ferns comprising the known vascular flora of the arctic archipelago considers areas mostly north of the HBL, it has wide application as a key and taxonomic guide to arctic species in the Lowlands. It contains brief descriptions, line drawings and maps showing the northern Canadian ranges of all species. Note: a detailed discussion of taxonomy, as well as ecology, and local and general distribution of archipelago plants is given in Porsild, A.E. 1935 (revised 1955). Vascular plants of the western Canadian arctic archipelago. Natl. Mus. Can., Bull. 135. 226 p.

HBL - *Keywords:* vascular species lists; floras; phytogeography; taxonomic treatments

Potter, D. 1932. Botanical evidence of post-Pleistocene marine connection between Hudson Bay and the St. Lawrence basin. Rhodora 34:69-89, 101-112.

"The occurrence of various halophytes of the St. Lawrence region and on the southern shore of Hudson Bay but not on Hudson Straits or in northern Labrador, is explained by the hypothesis of simultaneous and nearly connectant marine invasions in the St. Lawrence Basin and the Hudson Bay region after the recession of the Wisconsin ice sheet. The paper includes a table showing the occurrence of marine deposits and a bibliography". (Biol. Abstr.) Potter lists 94 species from Charleton Island and 340 from the southern end of James Bay, including the Abitibi River and the estuary of the Moose River. Distribution maps are provided for several species.

- *Keywords:* vascular species lists; salt marsh; plant migration; isostasy

Potter, D. 1934. Plants collected in the southern region of James Bay. Rhodora 36:274-284.

A catalogue of species collected along the southern coast of James Bay during the summer of 1929. Included are collections from locations along the Abitibi River, from Coral Rapids to its mouth, from the mouth of the Moose River and along the coast from the Moose River to the Rupert River, as well as collections from eastern portions of the Bay.

HBL - *Keywords:* vascular species lists

Potzger, J.E. and Courtemanche, A. 1954. A radiocarbon date of peat from James Bay in Quebec. Science 119:908.

Peat material submitted for radio-carbon dating was collected with a Hiller-type borer from the bottom level of a bog near Rupert River, Smoky Hills Rapid Bog, 18 mi. (29 km) east of Rupert House (51°28'N, 78°45'W). An age determination of 2350 (+ 200) yr B.P. marked the beginning of organic matter deposition.

- *Keywords:* paleobotany, dating

Potzger, J.E. and Courtemanche, A. 1956. A series of bogs across Quebec from the St. Lawrence valley to James Bay. Can. J. Bot. 34:473-500.

The study includes 19 bogs between 45°07'N and 51°59'N, spaced at about 50 mi. (80 km) intervals from the St. Lawrence valley across the Laurentian Shield to James Bay (Jack River). Up to lat. 47°N, five major climatic changes are recognized, based on pollen profiles. Since the region around James Bay was covered by the sea following northward wasting of glacial ice, indications from the profiles are that the muskeg condition north of lat. 47°N is due to more recent paludification and a moister climate following a warm-dry period.

- *Keywords:* peatland, ecology; paleobotany, pollen spectra

Prevett, J.P., Marshall, I.F. and Thomas, V.G. 1979. Fall foods of lesser snow geese in the James Bay region. (MS) 26 p. (submitted to J. Wildl. Manage.).

Food materials were collected from the esophagi of lesser snow geese (*Anser c. caerulescens*) shot by hunters at two areas on the James Bay and one on the Hudson Bay coasts of Ontario. Estimates of food selectivity by the geese were made by comparing indices of ingestion to the abundance and distribution of vegetation in coastal marshes. Although 40 species were eaten, 90% of the identified diet was made up of nine species in four families (*Equisetaceae, Juncaginaceae, Gramineae* and *Cyperaceae*). "The species, and relative quantities of each in the diet, varied between localities, even when close together. All parts of most plants were consumed, the proportion of roots increasing as autumn progressed. Species which appeared to be eaten selectively at most localities were *Triglochin palustris* and certain species of *Eleocharis* and *Carex*. Most grasses seemed to be selected against."

HBL - *Keywords:* wildlife-habitat relationships: waterfowl

Radforth, N.W. 1955a. Paleobotanical method in the prediction of subsurface summer ice conditions in northern organic terrain. Trans. R. Soc. Can. 48, series III, section V:51-64.

Frost behavior was examined during the summer months in the region of Churchill, Manitoba over a period of three years. Subsurface ice forms were characterized as follows: 1) Discontinuous forms: vertical free lift, vertical confined lift and displacement fault; 2) Continuous forms: polygon differential, pond hole, ridge elevation; boulder locus and multiple knoll. These "contour pattern types" were subsequently defined by a topographic description, subsurface macroscopic and constituents and evaluation by the Radforth Classification System coverage formulas.

HBL - *Keywords:* permafrost; peatland, ecology; patterned terrain

Radforth, N.W. 1955b. Organic terrain organization from the air (altitudes less than 1,000 ft.). Handbook No. 1. Dep. Natl. Def., Def. Res. Bd., Ottawa, Ont. DR No. 95. 49 p. + tables.

Provides a method of interpretation and classification of organic terrain based primarily on airform pattern and taking into consideration size, tone, density, texture and abundance of surface features. Methods for predicting subsurface ice forms and for predicting terrain construction from aerial patterns are included.

HBL - *Keywords:* peatland, classification; remote sensing; permafrost; patterned terrain

Radforth, N.W. 1956. Range of structural variation in organic terrain. Trans. R. Soc. Can. 49, series III, section V:51-67.

Examination of peat samples within a 200 mi. (320 km) radius of Churchill, Manitoba led to the detailed categorization of peat structure based on texture, peat decomposition stage, and general plant source. Structural variation makes definite application of the categories more difficult although biological trends and natural adjustments in the development of organic terrain are reflected by such variation. Some implications on bearing capacity of peats of different vegetal coverage and topography are indicated.

HBL - *Keywords:* peatland, classification; peatland, ecology

Radforth, N.W. 1958. Organic terrain organization from the air. (altitudes 1,000 to 5,000 ft.). Handbook No. 2. Dep. Natl. Def., Def. Res. Bd., Ottawa, Ont. Report No. DR124. 24 p.

The concept of air form pattern is proposed, based entirely on visual interpretation of terrain organization of peatlands from 1,000 to 5,000 ft (300-1500 m approx.). Six form patterns were selected as primary patterns: planoid, apiculoid, vermiculoid, cumuloid, polygoid, and intrusoid, and vermiculoid was further subdivided into three categories. At heights exceeding 1,000 ft (300 m) pattern becomes distinctive through shape, size, density and texture and, in some cases, color is described as a useful tool. Air form patterns are explained in terms of ground characters of plants, peat constituents and presence of water. The problems of access are considered in suggestions for mapping ground routes through the six land-types, providing broad, generalized descriptions of the difficulties each poses to passage.

HBL - *Keywords:* peatland, classification; remote sensing; permafrost; patterned terrain

Radforth, N.W. 1973. The muskeg of the Hudson Bay Lowlands. p. 83-102 *in* Proc. Symposium on the Physical Environment of the Hudson Bay Lowland. March, 1973, Univ. Guelph.

Lowland muskeg patterns as they relate to topographical-vegetal constitution are appraised but hydrologic development is explained as participatory. Methods of peatland classification are discussed and pattern analysis, based on air form characteristics, is considered to be a suitable approach. A plea is made to discourage energy developments from land-water resources which ignore effects on reacting systems (especially hydrologic) in muskeg. In making a case for future evaluation of Lowland muskeg, the author points out the possibility of a classification based on the heat relationships of peat.

HBL - *Keywords:* peatland, classification; remote sensing; hydrology; permafrost; patterned terrain

Radforth, N.W. and Bellamy, D.J. 1973. A pattern of muskeg - a key to continental water. Can. J. Earth Sci. 10:1420-1430.

"The paper investigates the relationships that exist between the airform pattern, hydrology, and ontogeny of the muskegs of Canada. A new interpretive classification based on the concept of hydro form is proposed and some practical examples of its application are given".

- *Keywords:* remote sensing; hydrology; peatland, classification

Railton, J.B. and Sparling, J.H. 1973. Preliminary studies on the ecology of palsa mounds in northern Ontario. Can. J. Bot. 51:1037-1044.

"Peat mounds with frozen permafrost cores, or palsas, occur in areas with sporadic permafrost in subarctic and boreal parts of Canada. In northern Ontario, the surface vegetation of palsas is characterized by the presence of *Cladonia alpestris, C. rangiferina,* and *C. sylvatica* with occasional stunted *Picea mariana* which are surrounded by *Ledum groenlandicum* and *Vaccinium vitis-idaea*. From vegetational analysis, hummock and palsa morphology, and radiocarbon dating, evidence is given for a recent origin under climatic conditions similar to the present. The largest palsas appear to be about 200 years old. Details of energy exchange during July are given for mature, partially eroded, and collapsed palsas. The formation of palsas may be dependent on changes in surface albedo associated with vegetational change from *Sphagnum fuscum* to *Cladonia* spp. dominated communities where the albedo was found to increase from 13.8% to 21.3%. However, evidence is presented that decreased penetration of heat during summer associated with the drying of surface peat may be important in palsa formation. Lower thermal conductivity of the peat at this time would insulate the ice core from insolation. Collapse of palsas was attributed to surface and marginal erosion and high heat penetration to the core associated with wetter peat conditions on the palsa".

HBL - *Keywords:* palsas and peat plateaus; permafrost; microclimate; paleobotany, dating; soil relations; snow cover

Raup, H.M. 1943. The willows of the Hudson Bay region and the Labrador peninsula. Sargentia IV:81-135.

A major monograph centering on the Lowlands and Labrador-Quebec, with perspectives on the history of the collections made in the area. A key, appropriate for well developed flowering or fruiting specimens, is given for identifying the many *Salix* spp. occurring in this region.

HBL - *Keywords:* taxonomic treatment; floristic notes; phytogeography

Riley, J.L. and Moore, C. 1973. Preliminary vegetation survey of Shipsands Island Waterfowl Sanctuary, 1972. Ont. Min. Nat. Resour., For. Res. Br., File Rep. 5-73.

Six main community types were established. Those species pioneering the tidal flats and the interior portions of the island are described. Water chemical analyses were taken and the analyses are appended. Postulations on roles of succession, competition, the influences of tidal washes and salinity, and topography are included in a discussion of the results. (Plant collections represented 36 families and 119 species of plants.)

HBL - *Keywords:* vascular species lists; salt marsh; tidal flats.

Ritchie, J.C. 1956a. The native plants of Churchill, Manitoba. Can. J. Bot. 34:269-320.

Some associational discussion, but primarily a well annotated catalogue of 270 species of varied geographic affinity, mostly boreal but with strong arctic and subarctic representation.

HBL - *Keywords:* vascular species lists; boreal forest; floristic notes; phytogeography

Ritchie, J.C. 1956b. The vegetation of northern Manitoba. I. Studies in the southern spruce forest zone. Can. J. Bot. 34:523-561.

Plant community types are described for two study areas in northwestern Manitoba, Tod Lake and McBride Lake. "It is shown that the predominant and stable forest of mesic sites is dominated by *Picea mariana,* with a ground vegetation composed chiefly of weft-form mosses". However, other moist forest types are also noted to exist, such as the closed spruce/willow/alder mixed forest or the open pine/birch/willow type. Two physiographic types of *Pinus banksiana* forests are described, as well as a highly local unique community of *Betula papyrifera* var. *neoalaskana* on an organic ridge. Muskeg vegetation displayed only minor variation in structure and floristic composition over the areas of investigation. Three intergrading zones of bog vegetation in addition to the peat bog/muskeg ecotone were noted. Within these zones a mosaic of vegetation units can be recognized which, by their relative abundance, characterize the three main units. "It would appear that the Southern Spruce Forest, which has been distinguished in eastern Canada, might be applied with justification to the present area".

- *Keywords:* floristic notes; boreal forest

Ritchie, J.C. 1956c. Additions and extensions to the flora of Manitoba. Rhodora 58:321-325.

A list of species, with collection notes, from McBride and Tod Lakes in northwestern Manitoba. A total of four additions and 16 extensions are presented with a discussion of the apparent affinity for many of the members for the rare high ridge habitats. Most of the species are considered as outliers of their normal ranges.

- *Keywords:* floristic notes; phytogeography

Ritchie, J.C. 1957. The vegetation of northern Manitoba II. A prisere on the Hudson Bay Lowlands. Ecology 38:429-435.

Presents a description of succession in the HBL, from a meadow phase (on freshly exposed flats) through intermediate phases (shrub, invading forest of *Picea glauca* and *Larix laricina,* closed forest) to *Picea mariana* open forest. The species characterizing the mound-hollow complex of the black spruce forest are listed. The principal process described involves increasing deposition of organic matter. At the early stages, growth of *P. glauca* and shrubs is favored, but increasing organic thickness later insulates sufficiently to cause a rise of the permafrost mound, with drainage becoming poor and *Sphagnum*-colonization creating an acid situation.

This coincides with a pollen sequence suggested by Johnson (1949). It is emphasized, however, that this occurrence is not universal in this region.

HBL - *Keywords:* sedge meadows; floristic notes; permafrost; hydrology; soil relations; riverbank; peatland, ecology

Ritchie, J.C. 1959. The vegetation of northern Manitoba. III. Studies in the subarctic. Arctic Inst. North. Am. Tech. Pap. No. 3 (56 p.)

A phytogeographic study of the subarctic forest region of northern Manitoba, including a portion of the western Lowlands, as exemplified by a study area at the confluence of the Big Spruce River and Seal River (59°00'N, 96°45'W). Plant communities are described within four main types: 1) black spruce lichen forest, which varies in structure and composition, depending upon whether it occurs on slopes or summits, and upon its seral status, 2) black spruce muskeg and peat bog which occur in hollows, 3) local communities associated with streams, and 4) a rare, treeless vegetation which is confined to a local area of patterned ground. In addition, 257 plant species are listed, with habitat notes.

- *Keywords:* phytogeography; floristic notes; peatland, ecology; patterned terrain; fire

Ritchie, J.C. 1960a. The vegetation of northern Manitoba. IV. The Caribou Lake region. Can. J. Bot. 38:185-199.

"Based on the findings of one season of field work, an account is given of the vegetation and flora (vascular plants) of the immediate vicinity of the Caribou Lake in northeast Manitoba. The plant communities are grouped according to physiographic position. Their chorology is presented in the form of a map which was compiled from interpretation of vertical aerial photographs of the area. The appearance of the various vegetation types on the aerial photographs is described.

The prevalent vegetation of the mesic site is a tundra community dominated by ericoid shrubs. There is strong evidence that much of this treeless vegetation occupies sites where trees once grew: they have been removed by fires. Recent alluvium bears stands of *Picea glauca* (white spruce) which shows good growth. Shallow, wet peats are covered by black spruce stands with shrubs and mosses, chiefly *Sphagnum*. Deeper peats, usually with shallow active layers bear heath of sedge-cottongrass tundra".

- *Keywords:* remote sensing; floristic notes; zonations, regions and districts; patterned terrain; phytogeography; tundra

Ritchie, J.C. 1960b. The vegetation of northern Manitoba. V. Establishing the major zonation. Arctic 13 (4):210-229.

Because the area is occupied by two distinct physiographic regions, the continental part of the Hudson Bay Lowland and the Canadian Shield, the zones of vegetation found in each area are treated separately. Within the HBL, a tentative classification of areas is proposed, and characteristics of the zones are described. Recognized are transition type, moss-muskeg type, treeless bog type and lowland complex. In the Shield region, the following are proposed zonations: tundra, open coniferous forest, and closed coniferous forest. A map, prepared from aerial photography and ground-surveys, outlines the extent of each of the eight zones. Only the "closed coniferous forest" applies to the Shield regions of Ontario's Hudson Bay watershed. Zones were delineated on aerial photography by tone (Munsell color charts) and texture appearance.

HBL - *Keywords:* remote sensing; zonations, regions and districts; peatland, classification; tundra; boreal forest; fire

Ritchie, J.C. 1960c. The vegetation of northern Manitoba. VI. The lower Hayes River region. Can. J. Bot. 38:769-788.

"This contribution provides descriptions of the chief cover types of a small portion of the Lowlands near the confluence of the Hayes and Nelson rivers.

On the mineral substrata of alluvial and marine deposits the chief types of vegetation are salt marsh, shrub (dominated by *Salix* spp.), forest of *Populus balsamifera,* and forests of *Picea glauca.* They often form discrete zones in the order mentioned, and it is likely that this is a seral as well as a spatial relationship. On the extensive peat substrata there are bog and fen types". Two bog sub-communities are described, lichen muskeg and moss muskeg. "Locally, areas of lichen muskeg have been destroyed by fire and are now occupied by willow communities. In wet inland areas, moss muskeg and lichen muskeg communities are associated with palsa and string-bog features. On shallower peats, usually near the shores and rivers, fens predominate, with *Larix laricina* and *Betula glandulosa* as the dominant phanerophytes.

All these types have been distinguished on vertical aerial photographs, and their photographic characteristics are summarized. A detailed vegetation map illustrates their chorology".

Possibly a more appropriate scale for mapping than that of Bates and Simkin, with useful summary of air photo features (with sample photographs) and consideration of the cover/sociability of

the species of the mapped zonation. The shoreward progress of seral sites here parallels temporal evolution of the landscape.

HBL - *Keywords:* remote sensing; peatland, classification; floristic notes; palsas and peat plateaus; zonations, regions and districts; permafrost; riverbank; salt marsh; sedge meadow

Ritchie, J.C. 1962. A geobotanical survey of northern Manitoba. Arctic Inst. North Am., Tech. Pap. 9. 48 p + map.

The spatial arrangements of vegetational and floristic units of the area are displayed in map form. The methods of mapping the vegetation and landforms, and general notes on the climate and landforms, are given. Comparisons between the vegetation of various areas in northern Manitoba are made, particularly between the Precambrian Shield and the Hudson Bay Lowland. A checklist of 580 species, 239 of which (41.2% of total) are confined in Manitoba to the HBL, appears in an appendix; in all, 373 species are noted for the Manitoba HBL.

HBL - *Keywords:* remote sensing; biophysical; climate; flooding; lichen woodland; hydrology; vascular species lists; riverbank; salt marsh; phytogeography; patterned terrain

Ritchie, J.C. 1967. Holocene vegetation of the northwestern precincts of the glacial Lake Agassiz basin. *In* Mayer-Oakes, W.J., *Ed.* Life, Land and Water. Proc. 1966 Conference on Environmental Studies of the Glacial Lake Agassiz. Dep. Anthrop., Univ. Man.

Surficial lake sediments in nine landform-vegetation regions of Manitoba's Western Interior of Glacial Lake Agassiz were core sampled to provide main pollen types. Holocene pollen assemblages are discussed in terms of modern counter-parts, e.g., *Shepherdia canadensis*, a plant common to alluvial deposits in the HBL was found in high concentration in a number of the pollen counts. The present geographical affinities of the species of the assemblages are both boreal-subarctic and temperate, reflecting some immigration of dominant species from southern refugia to northern areas following glacial retreat.

HBL - *Keywords:* paleobotany; pollen spectra; plant migration

Roberts-Pichette, P. 1972. Annotated bibliography of permafrost-vegetation-wildlife-landform relationships. Dep. Environ., For. Manage. Inst., Ottawa, Ont. Inf. Rep. FMR-X-43.

"This bibliography contains almost 500 titles chiefly from post 1945 North American, European and USSR literature on the arctic and subarctic regions of the world. Although concerned primarily with land sensitivity in the north, titles of taxonomic ecological, geological, geographical, meteorological, and permafrost studies and reviews have been included. Quotations have been selected to give special emphasis to the ecological problems resulting from man's increased activities in the North and also to the accumulating of information on how to repair, reduce and circumvent environmental damage".

- *Keywords:* permafrost; wildlife-habitat relationships: caribou; climate

Rouse, W.R. 1973. The microclimatology of the different terrain units in the Hudson Bay Lowland. p. 69-82 *in* Proc. Symposium on the Physical Environment of the Hudson Bay Lowland. March, 1973, Univ. Guelph.

"The microclimate of terrain units is discussed in terms of the basic sub-divisions into dry upland areas, wet lowland zones and shallow lakes.

Net radiation shows marked differences over the major terrain types responding primarily to differences in surface albedo. During summer the net radiation is greatest over the lakes and decreases moderately over the lowland wet zones and strongly over the upland site.

Preliminary energy balance measurements show that daytime evaporation is greatest from the wet vegetated zones and least from the upland areas. The lakes have a large heat storage term and their day heat flux is important over all surfaces because of large ground to air temperature differences, differences which are accentuated by cold air advection from over the Hudson Bay ice pack.

Destruction of the vegetation by man through burning and the use of tracked vehicles has served to lower surface albedos, raise soil temperatures, lessen the evaporation rates and create changes in the soil moisture regime".

HBL - *Keywords:* beach ridges, coastal; climate; microclimate; soil relations; peatland, ecology

Rouse, W.R. and Kershaw, K.A. 1971. The effect of burning on the heat and water regimes of lichen-dominated subarctic surfaces. Arctic Alpine Res. 3:291-304.

Energy budget and soil moisture behavior were monitored over a 6-week period during the summer of 1970 in study plots adjacent to Hawley Lake, northern Ontario. Observations were made on an old burn area where fire had been at least 16 years previously, on a new burn at least three years old, and on a mature lichen woodland.

"Experimental evidence.....indicates that the burning of lichen has a pronounced effect on the ground water regime. Soil moisture measurements.....indicate that the soil moisture under the lichen-dominated surface was at least 40% greater than in either of the burned areas. This suggests that a mature lichen cover offers a high resistance to the evaporation of soil moisture. The nature of the evaporation region was determined using the energy budget (Bowen Ratio) approach over each surface. These data were augmented by measurements of the moisture content of the lichen made at three levels within the canopy. The evidence indicates that lichen-dominated surfaces act as an effective mulch in preventing evaporation from the sub-surface zone whereas the burned areas which are able to evaporate more water into the atmosphere when moist, also develop strong resistances to evaporation as the soil surface layers become drier. The role of ground lichens, in the water budget of northern lands is significant because of its extensive cover and its destruction by fire must exert an important influence on the hydrologic and atmosphere water regimes".

HBL - *Keywords:* microclimate; soil relations; fire; hydrology; lichen, ecology

Rouse, W.R. and Kershaw, K.A. 1973. Studies on lichen-dominated systems. VI. Interrelations of vegetation and soil moisture in the Hudson Bay Lowlands. Can. J. Bot. 51:1309-1316.

Soil moisture measurements are presented for the summer of 1971 for nine sites spaced inland from the Hudson Bay coastline adjacent to East Pen Island. The sites show a great variation in natural vegetation from a sparsely vegetated young raised beach to older beach ridges dominated by thick mats of lichen. The sites include a non-vegetated blowout in a sand dune and areas which have been damaged by caterpillar tractors and by burning.

Differences in soil moisture between sites are very pronounced and are closely related to the organic content of the soils. There are also substantial variations in the rate of soil moisture withdrawal during the summer and this is reflected in differences in the seasonal evapotranspiration rates. The soil moisture characteristics are widely variable in the surface soils at the different sites but virtually the same at soil depths below 30 cm.

HBL - *Keywords:* microclimate; soil relations; human impact; fire; beach ridges, coastal; beach ridges, interior; permafrost

Rousseau, C. 1974. Géographie floristique de Québec-Labrador: distribution des principales espèces vasculaires. Québec, Univ. Laval, Trav. et Doc. du Cen., 7(XIII).

A summary containing useful discussion of floristic problems relevant to the Lowland, as well as a vast bibliography and extensive references to aid in revised mapping of species distributions.

Discounts Boivin's hypothesis (1952) of plant migration because no intermediate stations have shown up on former glacial lakes, and supports the notion of a trans-Labrador sea, despite a parallel lack of intermediate stations. Entertains the hypothesis of xerothermic extension and subsequent regression, despite a lack of recorded disjunct northern populations in warmer-than-normal habitats.

HBL - *Keywords:* plant migration; taxonomic treatment; phytogeography; floras

Rousseau, J. 1952. Les zones biologiques de la peninsula Québec-Labrador et l'hemiarctique. Can. J. Bot. 30:436-474.

A brief consideration of the zonation of Hustich (1949) and Hare (1950) with an apt characterization of hemiarctic zones as an "emulsion" of arctic and subarctic habitats, rather than a gradually changing homogenous assemblage. Suggests that aquatic habitats are useful vectors of change because of their widespread but limited nature.

- *Keywords:* phytogeography; zonations, regions and districts

Rousseau, J. 1966. La flore de la Rivière George, Nouveau-Québec. Nat. Can. 93:11-59.

Strictly an annotated checklist.

- *Keywords:* phytogeography

Rousseau, J. 1968. The vegetation of the Quebec-Labrador peninsula between 55 and 60 degrees north. Nat. Can. 95:469-563.

Extensive listings of arctic (320 spp.) and hemiarctic (555 spp.) collections made prior to 1950 by the author. Follows the zonation of Hustich (1949) and Hare (1950), with a brief discussion of subarctic zones which parallel those most common in northern Ontario. Subarctic zones are divided by hydrographic basin. Contains a valuable bibliography.

- *Keywords:* tundra; phytogeography; zonations, regions and districts

Rowe, J.S. 1972. Forest regions of Canada. Dep. Environ., Can. For. Serv., Ottawa, Ont. Publ. No. 1300. 172 p. + map.

Provides a general description of the forest geography of Canada, and for all defined forest regions includes descriptive data on geology, topography, soils and climate. Outlines the HBL (p. 20 - Forest Region B. 5) and its distinguishing characteristics.

The text is a revision of a 1959 edition, and an elaboration of W.E.D. Halliday's (1937) regionalization of Canadian forests.

HBL - *Keywords:* boreal forest; treeline; zonations, regions and districts

Rowe, J.S. and Scotter, G.W. 1973. Fire in the boreal forest. Quaternary Research 3(3):444-464.

Reviews the effects of fire in North American boreal forests, describing the significant effect on vegetational composition, soil chemical properties and thermal regime, and on animal populations through the particular mosaic of habitats created. The effects of landscape on fire, the presence of organic terrain, and drought are also discussed. In a general sense, fire is considered a normal ecological process in the boreal forest.

- *Keywords:* fire; boreal forest; soil relations

Russell, R.H. 1975. The food habitats of polar bears of James Bay and southwestern Hudson Bay in summer and autumn. Arctic 28(2):117-129.

Reports results of a summer and fall survey of polar bear (*Ursus maritimus* Phipps) food habits on some islands of James Bay and the coastal mainland of southwest Hudson Bay. Scat analyses indicated that birds, primarily Anatidae, were the most common food of bears in James Bay, while marine algae and grasses were the foods most often eaten by mainland bears. For mainland bears, percentage volumes of plant food items in scats were: mosses - 2%, marine algae - 37%, grasses - 41%, rushes - 1%, debris - 2%, with trace amounts of lichen, mosses, mushrooms, eelgrass, sedges, and berries, fruits, leaves and stems of shrubs and broad-leaved herbs. It was felt that the diet of the bears from James Bay islands provided a better preparation for winter, although indications were that bears in both regions were generally in good physical condition.

HBL - *Keywords:* wildlife-habitat relationships: polar bears; algae

Savile, D.B.O. 1968. Flora and fauna of land areas, Part I. Land plants p. 397-416 *in* Beals, C.S., *Ed.* Science, History and Hudson Bay, Vol. I.

A popular general treatment of the vegetation around Hudson Bay, including the Lowland. The main vegetation zones are outlined and some of the most notable and conspicuous plants are described. The zones defined are: 1) boreal, 2) transitional, 3) treeline, and 4) above the treeline. The Quaternary history of the region is described in relating the present distribution of species and vegetation types.

The influence of the Bay on plants by its modifications of climate is also discussed in terms of lower summer temperatures, increased precipitation, and in some cases salt-spray or exposure. A table lists some of the more characteristic plants of the area, their common and botanical names and a brief description. The fact that the arctic and subarctic limits are here pushed further south than in any other continental region is emphasized.

HBL - *Keywords:* zonations, regions and districts; phytogeography; floristic notes; climate; permafrost; patterned terrain

Schofield, W.B. 1958. The salt marsh vegetation of Churchill, Manitoba. Natl. Mus. Can. Bull., 160. Biol. Ser. 42. p. 107-132.

"A large collection of vascular plants made in the vicinity of Churchill, Manitoba, made it possible to investigate more fully the various theories advanced to explain the distribution of halophytes on Hudson Bay shores". The obligate halophytes of James Bay described by Dutilly, Lepage and Duman (1954, 1958) are divided into phytogeographic groups and compared with similar affinities discerned for the maritime and non-maritime vascular flora of Churchill. Resulting patterns relate to proposed hypotheses on past migration routes of salt-marsh species. The degree of ice-shoving along the Labrador coast would have made post-glacial movement of maritime strand species difficult because of scarce habitat even during the xerothermic period, whereas suitable interior sites were common. Schofield supports the notion but not the specifics of an inland marine connection, noting 20 species with disjunct James Bay-St. Lawrence Gulf ranges. Also noted are the precarious nature of such pioneer habitats as uplifting strands and marshes, and the eventual cessation of their formation.

HBL - *Keywords:* salt marsh; phytogeography; plant migration; tidal flats; vascular species lists; bryophytes, species lists

Schuster, R.M. 1951. The hepaticae of the east coast of Hudson Bay (notes on nearctic hepaticae, II). Natl. Mus. Can. Publ. No. 122, Biol. Ser. 4., Cat. No. 601-323. 62 p.

A list of 74 species of liverworts, including 35 previously unreported from the region studied.

- *Keywords:* bryophytes, species lists

Scoggan, H.G. 1951. Botanical investigations along the Hayes River route, northern Manitoba. Natl. Mus. Can., Bull. 123. p. 139-161.

Included are historical sketch notes on the river route and some information on the 1951 status of population and economic development. Species lists are generally subdivided according to habitat-types, and major plant communities. In all, 435 species are listed: 60 species collected from confluence of Fox and Hayes; 22 from north of there on the river; 60 from Hay Island; 43 from Marsh Point; 80 from rivershore just above Hudson's Bay Co. post; 80 from wetlands and forest near the Hudson's Bay Co. post; 60 from the openings around the post.

HBL - *Keywords:* vascular species lists; floristic notes

Scoggan, H.G. 1957. Flora of Manitoba. Natl. Mus. Can. Bull. 140. Biol. Ser. No. 47. 619 p.

A manual and key to the vegetation of Manitoba, including distribution of species, notes on common habitats, and location and dates of Manitoba collections. A great number of species common only to the Hudson Bay Lowland area of Manitoba are included within the text, and the distributional records of others extending into the Lowland are noted. In addition, Scoggan provides information of historical, geographical and climatic interest. Major vegetation types, and their characteristic species, are discussed in the introduction.

HBL - *Keywords:* phytogeography; taxonomic treatment; vascular species lists; zonations, regions and districts; floras

Scoggan, H.G. 1959. The native flora of Churchill, Manitoba. Guide Book. Natl. Mus Can. vi + 51 p.

A checklist of 354 species, annotated with geographical affinities and distributional types. Typical vegetation of various terrain types is characterized from visitors to the area who use the guide book. Also provided are historical notes on Churchill and the Hudson Bay region and information on the physical features of the Hudson Bay area, and on the climate of Churchill.

HBL - *Keywords:* phytogeography; floristic notes; vascular species lists; zonations, regions and districts; tundra; salt marsh; tidal flats, sedge meadows

Scotter, G.W. 1971. Fire, vegetation, soil and barren-ground caribou relations in northern Canada. p. 209-230 *in* Charles W. Slaughter, Richard J. Barney and George M. Hansen, *Ed.* Fire in the northern environment--a symposium. Proc. Symp. sponsored by Alaska For. Fire Counc. and Alaska Sect., Soc. Am. For., Univ. Alaska, College (Fairbanks), Alaska, Apr. 13-14, 1971. Pac. Northwest For. Rge. Exp. Stn., USDA For. Serv., Portland, Oregon.

Although sampling areas existed west of the Hudson Bay Lowland, the barren-ground caribou range extends well into the Lowland. Four areas in northern Canada were selected for studying the effects of fire on lichen rangelands. There were 1,250 known forest fires that burned over 5,005,872 acres (2,025,806 ha) of potential winter range between 1961 and 1964. Standing crop of useable forage and high-value lichens was determined for six age-classes, and was correlated with density per acre (hectare) of moose and barren-ground caribou pellet groups. Moose apparently preferred habitats in early stages of succession, but barren-ground caribou favored those in later stages.

- *Keywords:* fire; wildlife-habitat relationships: caribou; lichen woodland

Setchell, W.A. and Collins, F.S. 1908. Some algae from Hudson Bay. Rhodora 10 (June, 1908):114-116.

A listing of 28 species collected by William Spreadborough and D.C. Eaton, nearly all of them well known circumpolar algae.

HBL - *Keywords:* algae

Shafi, M.I. and Yarranton, G.A. 1973. Vegetational heterogeneity during a secondary (post-fire) succession. Can. J. Bot. 51: 73-90.

"Areas of boreal forest in the Clay Belt of northern Ontario, burned at a range of times from 0 to 57 years before the present, were examined. Four stages of succession were indicated from results; initial heterogeneity, early phase, heterogenous phase and late phase. Initial heterogeneity, attributed to burning intensity, persists for a year, but is succeeded by a more homogeneous phase dominated by species which survive the fire in various ways. The heterogenous phase is dominated by environmentally differentiated mosaic elements; it is succeeded by the late phase as a canopy develops and as ephemeral species, which colonized the disturbed area, disappear. The late phase is dominated by jack pine in sandy areas and by black spruce in peaty areas".

Such a situation can perhaps be extrapolated for in the HBL, since few investigators have considered this phenomenon in the Lowland, and since the study was done in an adjacent area.

- *Keywords:* fire; boreal forest

Simkin, D.W. 1965. A preliminary report of the Woodland Caribou Study in Ontario. Ont. Dep. Lands For. Res. Br., Sec. Rep. (Wildlife) No. 59. 75 p.

The present and potential values of the species *Rangifer tarandus* in Ontario are discussed. Ecology, social behavior, population density and fluctuation, and management tactics are dealt with in terms of northern Ontario's estimated 13,000 animals.

Within the Hudson Bay Lowland, food availability is one major factor limiting their existence. Food habit studies in the HBL show that during spring and summer, ground (and tree) lichens, particularly *Cetraria cucullata, Cladonia arbuscula, C. mitis* and *C. rangiferiana,* were the most important food items. As summer progresses, herbacious vegetation such as willows (*Salix* spp.), bog birch (*Betula glandulosa*), bog bean (*Menyanthes trifoliata*) and cottongrass (*Eriophorum* spp.) is utilized as it becomes available, but even then lichens are quite important. During the winter, lichens supplemented by deciduous browse form the bulk of the diet. Marked differences exist in availability of food and food eaten between populations on the Shield and those living in the HBL. Basic differences in habitat-type used by caribou are illustrated by a detailed description of 24 vegetation plots 100 sq. yd (0.84 sq. m) in size.

HBL - *Keywords:* wildlife-habitat relationships: caribou

Sjörs, H. 1959. Bogs and fens in the Hudson Bay Lowland. Arctic 12(1):3-19.

The processes governing the formation of bogs and fens are outlined. An important factor controlling the composition of peatland vegetation is the origin of the water supply, be it solely precipitation (involving ombrotrophy), or additionally, mineral-soil-percolated water bearing nutrients (minerotrophic). The great variability of peatland configurations is discussed, the author stating that "the strange patterns formed by the (geographic) features are more difficult to interpret than the features themselves". Near the Attawapiskat River, the occurrence of alternating layers of fine silt and humus in the soil resulted from occasional spring flooding caused by ice-jamming downstream. The hummock-hollow complex of large bogs supports a number of typical species which can be used to characterize it, its acidity and degree of minerotrophy. Raised bogs develop seepages which often take the form of strips of fen. Although the water in these seepages comes from an ombrotrophic bog, water movement is more rapid and an increase of minerotrophy occurs. Black spruce islands exist in the southern lowlands and are typified by a permafrost core. Further north, in areas of more extensive permafrost, as around Hawley Lake, are knolls of palsa, relatively devoid of tree growth.

HBL - *Keywords:* climate; floristic notes; palsa and peat plateaus; nutrients; peatland, classification; peatland, ecology; permafrost; soil relations

Sjörs, H. 1961a. Surface patterns in boreal peatlands. Endeavour XX (80):217-224.

A description and analysis of the dynamics of local and regional distribution of peatland patterns. Aspects of the boreal zone, its extent and the percentage of peatlands within the zone are discussed. The concepts of ombrotrophy and minerotrophy are related to principal plant communities and the occurrence of patterns in areas without permafrost. Photographic examples of variations are given. The flark-ridge pattern in particular is discussed. Palsa formation and collapse is theorized. In light of the pattern-forming processes that occur, the author concludes that "succession in peatland includes much more than the normal successions starting in a wet habitat that are described in ecological textbooks".

HBL - *Keywords:* peatland, classification; patterned terrain; peatland, ecology; nutrients; palsas and peat plateaus; peatland, distribution and extent; permafrost; soil relations

Sjörs, H. 1961b. Forest and peatland at Hawley Lake, northern Ontario. Natl. Mus. Can., Bull. 171. p. 1-31.

Vegetation and peatland dynamics near Hawley Lake, about 50 mi. (80 km) south of Winisk, in the Hudson Bay Lowland are interpreted. Except for a low row of diabase hills (Sutton Ridge), the occasionally exposed mineral soil is strongly calcareous. This is reflected in the high Ca^{2+} concentration in Hawley Lake. Forest vegetation, predominantly black spruce muskeg, is described, and presence/absence of species in sample plots is noted. Bog and fen are related to ombrotrophy and minerotrophy. Since a great number of plants needing minerotrophic water cannot normally grow under ombrotrophic conditions, these species can be employed as indicators of degree of ombrotrophy. A table of pH ranges versus plant presence/absence is employed to help determine these indicator species. Ombrotrophic conditions around Hawley Lake are confined to a number of distinctly marked roundish bogs that are slightly raised, and have a permafrost core (palsas). Sjörs defines these as "perennially frozen peat mounds of moderate size, generally much less than 100 m. across and from one to several meters high". Most palsas in the Lowland support a few stunted tamaracks, or black spruces, and the summit is frequently covered with ground lichens. The conditions of vegetation on the summit suggests a scanty winter snow cover, allowing permafrost to persist within the mounds. Sample plots on the surface of the palsa bogs were investigated, and a table of the species present versus the pH ranges is given. Three types of wet bog vegetation covered most of the rest of the area, between the palsas. A palsa was measured through the unfrozen parts along a transect in order to provide a schematic cross-sectional view. Growth by ice-sheeting on the under-surface, and collapse by erosion and biological oxidation, are discussed in some detail. The author concludes that upbuilding and degrading processes go on continually in this palsa peatland complex.

HBL - *Keywords:* peatland, classification; patterned terrain; peatland, ecology; nutrients; palsas and peat plateaus; permafrost; peatland, distribution and extent; snow cover; soil relations; vascular species lists; bryophytes, species lists; lichen, species lists

Sjörs, H. 1963a. Amphi-Atlantic zonation, nemoral to arctic. *In* North Atlantic Biota and Their History, Pergamon Press, New York.

This work compares and integrates the major biotic zonations of north, central and east Europe with those of northeast North America. The major zonations recognized are nemoral, boreo-nemoral, boreal and arctic and alpine, and each of these is broken down further into subzones. Maps of the zones and subzones are presented.

It is concluded that all zones bend southward when near cold seas, as for example the woodland-tundra and subarctic sub-zones of the boreal zone along the Hudson and James Bays. The width of the zones and sub-zones is dependent on the direction of the slope--narrow with southern slopes, wider with northern slopes. Zonations in the boreal region seem to be conditioned largely by the length of the growth period (when mean temperature is above 5.5 or 6°C).

The present zonation of vegetation is very young: it followed deglaciation less than 10,000 years ago. Hence, it is amazing how uniform the products of recombination of various floristic elements are, and how close is the zonal parallelism in northwestern Europe and northeastern North America.

A detailed account of largely well known facts of zonal, climatic and altitudinal relationships of both single taxa and whole plant communities is given here, to provide a firm basis for more speculative discussions of vegetative history.

- *Keywords:* zonations, regions and districts; plant migration; phytogeography

Sjörs, H. 1963b. Bogs and fens on the Attawapiskat River, northern Ontario. Natl. Mus. Can., Bull. 186. p. 45-133.

The bogs and fens of the central and southern portion of the Hudson Bay Lowland form nearly 100% of the total land area there. Sjörs attempts to characterize and describe the peatlands of this area, from observations made along the Attawapiskat River.

Brief descriptions are given of general drainage and topography, geology and climate of the region. The two peatland trophic types, minerotrophy and ombrotrophy, are used extensively to aid in a classification system. A table presenting water analyses from four site types shows the increasing ombrotrophy with the bog habitat.

Peatlands in the area are classified into three units: the bog, the poor fen and the rich fen. Distribution and structure of ombrotrophic and minerotrophic peatlands are related to water flow, particularly direction and rate.

Ombrotrophic bogs show variants of a weakly domed or ridge-shaped topography. Vegetational data and pH are tabled for transects across a few domed bogs. A number of ecological conditions are connected with the retardation of peat formation in wet hollows or pools, including corrosive oxidation, ice uplift, frost rifts and ice expansion, seasonal frost persistence and the intensity of run-off flow and seepages. Habitat preferences are described for the ombrotrophic flora of the HBL, including wooded bog, open bog hummock, bog hollows (three vegetation types are distinguished here), and bog-pools.

The origin of minerotrophic waters in the HBL differs from that in most other peatland districts because of a general lack of direct access to water derived from exposed mineral soils. Nevertheless, the subjacent mineral soil is very calcareous, and sufficient percolation of mineral-enriched waters occurs. As well, local minerotrophy occurs "through frost cracks, ice uplift, contact with deeper strata in deep pools...and there is probably a tendency of the run-off water of the bogs to acquire a weak minerotrophy along the 'seepages'." Three main minerotrophic patterns are defined: ridges, flarks and fen pools. The variability of pH and vegetation in minerotrophic peatlands is described in a table, and Sjörs subclassifies them, on the basis of pH ranges. Poor fen pH values are between 4.8 and 5.7 while rich fen values are between 5.8 and 7.4.

Minerotrophic indicator plants are listed for open poor fen and wooded poor fen types. The poor fen is best characterized by its bryophytes. Characteristic species of rich fen pools and flarks, ridges of rich fen, wooded rich fen and riparian rich fen are given.

Black spruce islands, apparently a phenomenon of the northern part of the main boreal zone, are associated with flat, smooth and extensive, but shallow peatland, and occur in series paralleling certain brooks or irregularly scattered in large open fen expanses. A permafrost core exists and these islands are considered a southern variety of palsa. Origin, development and collapse of these frozen mounds are theorized.

Stratigraphy of peat sections along three transects is discussed and C^{14} dating of one sample at the mineral soil/peat interface yielded an age of 4700 $\pm$ 80 years B.P.

In summarizing, Sjörs discusses peatland succession in the Attawapiskat River area, and development within the HBL peatland expanse over 2000 years ago. The origin of lakes as a dynamic situation involving ice pressures, peat erosion and wave action, seral invasions, beaver ponds and other factors is dealt with. The potential for small-scale agriculture and forestry that exists in the HBL could be a factor in helping to relieve the economic depression of the small local populations.

HBL - *Keywords:* peatland, classification; peatland, ecology; patterned terrain; lichen woodland; permafrost; nutrients; soil relations; paleobotany, dating; hydrology; peatland, distribution and extent; isostasy; agriculture; human impact; snow cover; vascular species lists; bryophytes, species lists; lichen, species lists

Smith, R.H. 1943. An investigation of the waterfowl resources of the south and east coasts of James Bay, 1943. Ill. Nat. Hist. Surv., 63 p. (MS)

Smith conducted the study within the waterfowl-inhabited coastal marshes of the James Bay area from Shipsands Island around the south and up the west coast. Considers waterfowl production, relative abundance of breeding species and factors affecting their increase. A broad vegetation description is given of the salt and fresh water habitats with notes on the most abundant plant species.

HBL - *Keywords:* salt marsh; tidal flats; wildlife-habitat relationships: waterfowl

Smith, R.H. 1944. An investigation of the waterfowl resources of the west coast of James Bay, 1944. Ill. Nat. Hist. Surv., 80 p. (MS)

A continuation of work in the coastal marshes initiated in 1943, but in an area extending from south of the Moose River northward about 450 km along the west coast to a point about 15 km above Lake River where the "arctic zone" begins. Gives an account of the vegetation and pays particular attention to the area's importance to waterfowl. Broadly defined habitat-types are correlated with the regular occurrence of certain bird species.

HBL - *Keywords:* salt marsh; tidal flats; wildlife habitat relationships-waterfowl; offshore

Sparling, J. 1973. Ontario's northern peatlands. Ont. Nat. (Sep. 1973): p. 4-9.

A general discussion of the vegetation patterning of the HBL, defining string bogs, raised bogs and palsa bogs as the three predominant landform types. A hypothetical development of a raised bog from intermediate stages since glaciation is diagrammed and aspects of accumulation, palsa development, water level effects and nutrient status are explained. The delicate balance of plant life, waterfowl, and other wildlife habitats are mentioned in relation to future development of the area, particularly effects on water level.

HBL - *Keywords:* palsas and peat plateaus; peatland, ecology; hydrology; human impact

Stirrett, G.M. 1972. (Comp. by J.L. Riley). Plants collected in the southern James Bay area, especially Hannah Bay; a check-list. (MS)

Specimens from Canadian Wildlife Service Offices, Valleyfield, Quebec, and from Department of Agriculture Herbarium, Ottawa, Ontario.

HBL - *Keywords:* vascular species lists; salt marsh

Stormer, P. 1933. Plants collected by F. Johansen in 1929, at Hudson Bay Railway and Port Churchill in Arctic Canada. Nytt mag. for Naturvidenskapene, 73:260-273.

Some 104 species of Pteridiophytes, Gymnosperms and Angiosperms are listed with some habitat notes, collection dates and reproductive status. Plants stored in Oslo University Botanical Museum.

HBL - *Keywords:* vascular species lists; phenology; floristic notes

Suffling, P. 1973. Vegetation mapping in the Hudson Bay Lowlands using ERTS-1 imagery. Can. Centre Remote Sensing, Remote Sensing Off. (Guelph), Newsl. No. 4. 3 p.

A comparison is made between vegetation patterns delineated with ERTS-1 imagery and those of Bates and Simkins (1969) for the Fawn-Winisk River area. The imagery did appear to have potential for detecting major trends or differences in the landscape. It is concluded, however, that application of this imagery will probably be limited to a number of readily identifiable features such as raised beaches, lichen woodlands, coniferous forest, lakes and streams. Permafrost features, for example, were not identifiable.

HBL - *Keywords:* remote sensing

Tarnocai, C. 1970. Classification of peat landforms in Manitoba. Can. Dep. Agric. Res. Stn. Pedol. Unit, Winnipeg, Manitoba. 45 p.

Provides a peat landform classification for organic soils in Manitoba, by integrating characteristics of morphological features of the peat landform, peat material, hydrology and water movement pattern, vegetation and ecology. Because much of the sub-arctic boreal peat area in northern Manitoba has not yet been studied in detail, the classification is preliminary. The classification is hierarchical, with bog and fen classes subdivided into subclass, type, and sunclass, respectively. Classification units are identifiable on the ground or on aerial photographs.

- *Keywords:* peatland, classification; remote sensing; patterned terrain

Tarnocai, C. 1972a. The use of remote sensing techniques to study peatland and vegetation types, organic types, organic soils and permafrost in the boreal region of Manitoba. Rep. of the 2nd meeting, Western Section Can. Soil Surv. Comm. p. 323-335.

"Multispectral imagery obtained in northern Manitoba was analyzed to determine the usefulness of remote sensing techniques in studying peatlands and permafrost. Dependable differences were found in the multi-spectral response patterns obtained from thermal infrared, near infrared color, color, panchromatic black and white, and near infrared black and white photographs of the various peatland types. These differences made possible the separation and mapping of the peat landforms, vegetation, organic soils and permafrost.

The cyclic nature of permafrost was also monitored using remote sensing data obtained in 1946, 1968, and 1971 and it was found that the area of permafrost decreased at a rate of 1 percent per year over the 25 year period studies".

- *Keywords:* peatland, classification; permafrost; boreal forest; patterned terrain; remote sensing

Tarnocai, C. 1972b. Some characteristics of cryic organic soils in northern Manitoba. Can. J. Soil Sci. 52:485-496.

"Two commonly occurring, perennially frozen, organic soils were studied, one from the southwest part of the Discontinuous Permafrost Zone and the other from the Continuous Permafrost Zone of the Hudson Bay Lowland in northern Manitoba. These soils had a characteristic domed or slightly elevated topography with a dense cover of black spruce (*Picea mariana* (Mill.) BSP.), *Ledum groenlandicum* Oeder, feathermoss, and sphagnum moss. The water content of the active layer was found to be much lower than the water (ice) content of the frozen layer. The exchangeable calcium and hydrogen and pH were higher in the frozen layer than in the active layer but no significant difference was found in the exchangeable magnesium, potassium and sodium of the two layers. The high concentration of

Ca in the frozen layer is likely due both to the transfer of soil moisture and nutrients along the thermal gradient and, as has been found previously, to the high selectivity of organic soils for calcium over magnesium and monovalent cations".

HBL - *Keywords:* permafrost; palsas and peat plateaus; nutrients; soil relations

Tarnocai, C. 1974a. Exploratory terrain study of northern Manitoba and southern Keewatin, N.W.T. Can. Soil Surv., Winnipeg, Man. June, 1974. 75 p. + map.

Results are reported from several studies carried out in the Hudson Bay Lowland of Manitoba and a portion of southern Keewatin, N.W.T., and ground truth information that was subsequently used for photo interpretation and the preparation of a map is provided. Mapping units are described under five major headings: glacial deposits, glacio-fluvial, marine, bedrock and organic deposits. The organic land-form classification follows Tarnocai (1970). Ground truth data include field notes, soil profile descriptions and analyses, and soil classifications. The interpretive map, including the Manitoba HBL north of 56°, provides detailed information on the surface features of this region.

HBL - *Keywords:* biophysical; peatland, classification; remote sensing; permafrost

Tarnocai, C. 1974b. Peat landforms and associated vegetation in Manitoba. p. 3-21 *in* J.H. Day, *Ed.* Proc. Can. Soil. Surv. Common., Org. Soil Mapping Workshop. Soil Res. Inst., Ottawa, Ont.

An elaboration of the 1970 classification by the author, utilizing the class, subclass, and type levels to describe the peat landform. At the class level, three divisions are made into bog, fen and swamp. As a further point, subdivisions of class are characterized by vegetation types which are commonly associated with particular peat landforms.

- *Keywords:* peatland, classification; remote sensing; patterned terrain

Terasmae, J. 1968. A discussion of deglaciation and the boreal forest history in the northern Great Lakes region. Proc. Entomol. Soc. Ont. 99:31-43.

Discussion of the prevailing conditions and environments in Ontario prior to the spread of vegetation northward. Includes various pollen diagrams, one of which is from coring in Lake Attawapiskat.

HBL - *Keywords:* paleobotany, pollen spectra; plant migration

Terasmae, J. 1970. Postglacial muskeg development in northern Ontario. Proc. 13th Annu. Muskeg Res. Conf., Nat. Res. Counc. Can., Tech. Memo. 99. (November, 1970). p. 73-90.

The importance of muskeg to the forester, engineer and soil scientist is discussed. Preliminary studies indicate that much of the muskeg "blanket" in northern Ontario has developed during the last 5,000 to 6,000 years or less, and this development has been caused and controlled by both geological and climatological factors. The author uses data from the Chin Lake area, 34 mi. (54 km) north of Iroquois Falls, to describe postglacial processes. He concludes that a considerably improved knowledge of the muskeg ecosystem is necessary so that we can begin to manage, utilize and conserve our environment and resources in the proper manner.

- *Keywords:* paleobotany, pollen spectra

Terasmae, J. and Hughes, O.L. 1960. A palynological and geological study of Pleistocene deposits in the James Bay Lowlands, Ontario. Geol. Surv. Can., Bull. 62.

Contributes to the glacial and forest history of the region, using pollen analysis. Included are interpretation of fossil plant assemblages and the climatic speculations inferred from them. Evidence is given of a warmer, postglacial episode (the hypsithermal interval) and also deteriorating drainage conditions owing to both a cooling of climate and a decrease in slope toward James Bay because of the greater uplift of land there.

HBL - *Keywords:* paleobotany, pollen spectra; paleobotany, dating

Thie, J. 1976. An evaluation of remote sensing techniques for ecological (bio-physical) land classification in northern Canada. *in* Proc. 1st. Meet. Can. Comm. Ecol. (Bio-phys.) Land Class. May 25-28, 1976, Petawawa, Ont.

"The use of LANDSAT satellite and airborne remote sensing imagery are evaluated in a sub-arctic and northern boreal environment near Churchill, Manitoba. Accuracy and cost-effectiveness of a number of interpretation methods are compared, including visual and automated (supervised and unsupervised techniques of LANDSAT) data and air photo interpretation".

HBL - *Keywords:* remote sensing; biophysical; permafrost

Tyritkov, A.P. 1959. Principles of geocryology. Part I. General geocryology. Perennially frozen ground and vegetation. [Transl. from Russian by R.J.E. Brown, Nat. Res. Counc. Can., Tech. Transl. 1163, 1964] 34 p.

An extensive treatise on the influence vegetation cover exerts on thermal dynamics of permafrost areas. Among the various plant species, *Sphagnum* acts as the greatest deterrent to soil thaw. This is determined by its effect on the moisture regime between the soil and the atmosphere. Organic matter in and on the soil has less of a cooling effect on the soil in winter than it has a warming (thawing) effect in the summer, because of the greater insulating ability of drier surface layers. The favorable influence of vegetation canopy on permafrost formation and persistence is discussed. Adaptations by plants in these regions to existence in a shallow active layer and to developing thermotropism for rooting mechanisms are important to their existence. The unfavorable influence of permafrost on the development of vegetation can be completely or partially removed by thermomelioration of surface soil. The use of vegetation as an indicator of permafrost presence is also mentioned. The paper provides a thorough discussion of vegetation-permafrost relationships, illustrates results of experimental observations and provides an exhaustive bibliography to that time.

- *Keywords:* permafrost; snow cover; soil relations; palsas and peat plateaus

Vitt, D.H., Achuff, P. and Andrus, R.E. 1975. The vegetation and chemical properties of patterned fens in the Swan Hills, north central Alberta. Can. J. Bot. 53:2776-2795.

Three patterned fens in north central Alberta were analyzed to elucidate vegetation patterns in vascular plants and bryophytes. Two flark associations dominated by *Menyanthes trifoliata* and *Carex limosa,* both of which had *Sphagnum jensenii* and *Drepanocladus exannulatus* phases, were recognized. The strings consist of two associations: one is dominated by *Betula glandulosa, Tomenthypnum falcifolium,* and *Aulacomnium palustre;* the other is dominated by *Picea mariana, Sphagnum magellanicum,* and *Ledum groenlandicum.* An intensive analysis of one fen reveals that these mires are 'poor fens' with a mean pH of 5.2 and Ca^{2+} concentration of 2.3 ppm. The fens occur on low drainage divides and Ca^{2+} is depleted as water flows through the fens. An ecological series of bryophytes is described in the transitions between flarks and strings.

The authors note that these 'poor fens' appear to be very similar in vegetation structure and water chemistry to those described by Sjörs (1963) for the Attawapiskat River Region, HBL.

- *Keywords:* patterned terrain; peatland, ecology; nutrients; bryophytes, ecology; gradient analysis

Walker, J. 1970. The influence of man on vegetation at Churchill. p. 266-269 *in* Prod. and Conserv. in Northern Circumpolar Lands, Int. Union Conserv. Nat. (INCN), Publ. 16, 1970.

"The vegetation types around Churchill are described. It is noted that fire has devastating consequences. At sites disturbed by man but now abandoned, adventive species are gradually disappearing and being replaced by native species. The rates of recolonization of disturbed sites (e.g., track vehicle trails) are not known but studies have been initiated". (Roberts-Pichette , P. 1972.)

HBL - *Keywords:* fire; floristic notes; human impact

Wilce, R.T. 1959. The marine algae of the Labrador Peninsula and northwest Newfoundland (ecology and distribution). Nat. Mus. Can., Bull. No. 158, Biol. Ser. No. 56, 103 p.

Collections and studies made through two ice-free seasons in Labrador and Newfoundland during which algal flora in spring, summer and autumn were observed in five major habitats (mudflats, protected shallows, moderately exposed coasts, exposed coasts and tide pools). The ecological factors operating in each are discussed. Although no collections are from Hudson Bay or James Bay, comparisons made by the author to other collections suggest close parallels to this area. Algal species are listed, and data are given concerning periodicity of the algae in each habitat.

- *Keywords:* algae; offshore

Williams, H. 1968. Hepatic collections from Sutton Ridge, Hudson Bay Lowlands, Ontario. Dep. Bot., Univ. Toronto, 8 p. (MS)

61 species collected by author and H. Sjörs at Sutton Ridge and Winisk.

HBL - *Keywords:* bryophytes, species lists

Wynne, F.E. and Steere, W.C. 1943. The bryophyte flora of the east coast of Hudson Bay. The Bryologist 46:78-87.

A list of bryophyte materials compiled from a number of collectors, and including bryophytes from Hayes Island (Moose R.)

and South Twin Island. A short discussion includes a comment on the distinctly different bryological floras between the east and west coasts of Hudson Bay. In the case of overlapping species, the relative abundance may be very different on opposite sides of the Bay. Approximately 170 spp. are listed.

- *Keywords:* bryophytes, species lists

Zoltai, S.C. 1971. Southern limit of permafrost features in peat landforms, Manitoba and Saskatchewan. Geol. Assoc. Can. Spec. Pap. No. 9, 1971. p. 305-310.

"Peat landforms indicating permafrost at present or in the immediate past were identified in the field or on aerial photographs, and traced across Manitoba and Saskatchewan. The southern limit of their occurrence coincided with the 32°F (0°C) mean isotherm, but outliers occurred in areas of greater atmospheric moisture".

HBL - *Keywords:* patterned terrain; permafrost; zonations, regions and districts

Zoltai, S.C. 1972. Palsas and peat plateaus in central Manitoba and Saskatchewan. Can. J. For. Res. 2:291-302.

"Twenty-six peat plateaus and eight palsas were examined near Flin Flon, Manitoba, at the southern limit of discontinuous permafrost. Peat plateaus in different developmental stages were identified on the basis of their morphology. The permafrost is entirely within the peat in all peat plateaus within the study area, but extends into mineral subsoil under all palsas examined. Doming in peat plateaus is largely explained by volume change due to change from unfrozen to frozen stage, and by buoyancy of the frozen mass floating on unfrozen peat. The occurrence of aggrading and degrading peat plateaus in the same area indicates that all developmental stages are permitted by the present climate".

- *Keywords:* permafrost; peatland, ecology; nutrients; palsas and peat plateaus

Zoltai, S.C. 1973. Vegetation, surficial deposits and permafrost relationships in the Hudson Bay Lowland. p. 17-34 *in*. Proc. Symposium on the Physical Environment of the Hudson Bay Lowland. March, 1973, Univ. Guelph.

"Geology and postglacial geological events combined to form a large plain with restricted surface and internal drainage. The dominant surficial deposit is peat, forming the substrate for plant growth over much of the area. The vegetation type changes from a closed boreal forest through an open spruce-lichen forest of the subarctic regions to tundra near the Bay. Permafrost, forming under a specific vegetation sequence on peatlands, is sporadic in the south but becomes widespread in the north. Peatlands change from a waterlogged fen to an elevated, relatively well drained peat plateau as the permafrost raised the peat. Wood production is greater on the permafrost peatlands than on the unfrozen, waterlogged fens. The main factor limiting plant growth is excess moisture, and severe climate near the Bay".

HBL - *Keywords:* permafrost; peatland, ecology; nutrients; palsas and peat plateaus; hydrology; patterned terrain

Zoltai, S.C. and Tarnocai, C. 1971. Properties of a wooded palsa in northern Manitoba. Arctic Alpine Res. 3(2):115-129.

"A palsa complex, 106 m in diameter, having a maximum height of 224 cm above the water table is described in detail. Permafrost occurred under the elevated, densely wooded palsa, extending into the underlying clay. The height of doming was largely due to ice accumulation in the clay and peat. The thickness of the active layer was least under the densest black spruce stands and greatest in the openings. The cumulative depth of snow was greatest in openings and least in dense stands. The volumetric moisture content of the peat in the active layer was about 30% in the fall, but this figure nearly doubled in the winter: the moisture content of the frozen core remained constant at over 90%. The peat material was largely mesic sedge peat near the bottom with mesic forest peat closer to the surface".

- *Keywords:* permafrost; palsas and peat plateaus; soil relations

Zoltai, S.C. and Tarnocai, C. 1976. Basis for regional wetland studies. Proc. 16th Muskeg Res. Conf., 1975. Natl. Res. Counc., Assoc. Comm. Geotech. Res., Tech. Mem. 116.

This report emphasizes the need for regional studies in anticipation of impact. Details are provided on work in MacKenzie District; where the wetlands of the south derive chiefly from organic infilling and peat accumulation (and water level raising), northern developmental processes include cryoturbation, deteriorating peat polygon structures, etc.

- *Keywords:* peatland, ecology; peatland, distribution and extent; permafrost

7. KEYWORD INDEX

AGRICULTURE

Ehrlich et al. 1959, Mills 1976, Sjörs 1963b

ALGAE

Gardner 1937, 1946, Jordan et al. 1972, Russell 1975, Setchell and Collins 1908, (Wilce 1959)

BACTERIA AND FUNGI

Blasco and Jordan 1976, Jordan et al. 1972

BEACH RIDGES, COASTAL

Arthur and Marshall 1976, 1977, Brokx 1967, Coombs 1952, 1954, Glooschenko 1978, 1979, Glooschenko and Martini 1978, Hustich 1957b, Kershaw 1974, 1975, Kershaw and Rouse 1973, Kershaw and Larson 1974, Larson 1975, Larson and Kershaw 1974, 1975a, 1975b, 1975c, 1975d, 1976, McKay and Arthur 1975, Moir 1954, Neal and Kershaw 1973a, 1973b, Pierce and Kershaw 1976, Rouse 1973, Rouse and Kershaw 1973

BEACH RIDGES, INTERIOR

Andrews and Webber 1969, Brokx 1967, Brown 1973, Coombs 1952, Hustich 1957b, Larson and Kershaw 1975a, Lumsden 1974b, Rouse and Kershaw 1973

BIBLIOGRAPHIC

Herrick 1977

BIOPHYSICAL (ECOLOGICAL LAND CLASSIFICATION)

Cowell et al. 1979, (Gerardin et al. 1975), Herrick 1977, Hills 1958, 1961, (Jurdant et al. 1975), (Lavertiere and Guimont 1975), (Lehoux and Rosa 1973), Maycock 1976, Mills 1976, Mills et al. 1976, Ritchie 1962, Tarnocai 1974a, Thie 1976

BOREAL FOREST

Baldwin et al. 1962, Carleton and Maycock 1978, Coombs 1952, Dean 1959, Hare 1950, 1954, (Hare and Taylor 1956), (Hare and Ritchie 1972), (Heinselman 1963, 1970), Hills 1958, Hustich (1949a), (1950), (1953), 1955, 1957b, 1959, Johnston and Hills 1956, Johnston and Sharpe 1923, Ketcheson and Jeglum 1972, Lepage 1959, Maycock 1976, McEwen 1964, Mills 1976, Munroe 1956, Ritchie 1956a, (1956b), 1960b, Rowe 1972, (Rowe and Scotter 1973), (Shafi and Yarranton 1973), (Tarnocai 1972a)

BRYOPHYTES, ECOLOGY

Glooschenko and Capobianco 1978, Kershaw 1974, 1977, (Kershaw et al. 1975), (Vitt et al. 1975)

BRYOPHYTES, SPECIES LISTS

Cowell 1968, Crum and Schofield 1959, Fabiszewski 1976, Hustich 1957a, Ireland and Cain 1975, Kershaw 1976, Lepage 1945, Macoun, J. 1881, Neal and Kershaw 1973a, Persson and Sjörs 1960, Schofield 1958, Sjörs 1961b, 1963b, Williams 1968, (Wynne and Steere 1943)

CLIMATE

Ahti 1964, Ahti and Hepburn 1967, (Allington 1961), Bates and Simkin 1969, Brown 1967, 1968, (1970), 1973, Coombs 1952, 1954, Dean 1959, Ehrlich et al. 1959, (Gerardin et al. 1975), Hare 1950, 1954, (Hare and Taylor 1956), (Hare and Ritchie 1972), Hustich 1957b, Kershaw 1977, Knollenberg 1964, Maycock (1968), 1976, Anon. 1977, (Payette 1974, 1975, 1976), (Payette et al. 1973, 1975), (Payette and Filion 1975), (Payette et al. 1976), Pielou and Routledge 1976, (Polunin 1951), Ritchie 1962, (Roberts-Pichette 1972), Rouse 1973, Savile 1968, Sjörs 1959

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Ahti and Hepburn 1967, Brokx 1967, Carleton and Maycock 1978, Hustich 1957b, Kershaw 1977, (Kershaw et al. 1975), Lumsden 1974b, Anon. 1973, Ritchie (1959), 1960b, Rouse and Kershaw 1971, 1973, (Rowe and Scotter 1973), (Scotter 1971), (Shafi and Yarranton 1973), Walker 1970

FLOODING

Arthur and Marshall 1976, (Heinselman 1963, 1970), Hustich 1957b, (Jeglum 1975), Kershaw 1976, McKay and Arthur 1975, Ritchie 1962

FLORAS

Hulten 1968, Polunin 1959, Porsild 1964, Rousseau, C. 1974, Scoggan 1957

FLORISTIC NOTES

Baldwin 1948, (1958), Baldwin et al. 1962, Beckett 1945, 1959, Bell 1886, Boivin 1952, Cody 1954, Cottam and Munro 1954, (Doutt 1935), Dutilly and Lepage 1948, 1952, 1963, Dutilly et al. 1954, 1958, 1959, Glooschenko and Martini 1978, Gussow 1933, Holmes 1884, Hustich 1955, 1957a, 1957b, (1974), Lepage 1945, 1954, 1966, Low 1887, Macoun, J.M. 1885, 1888, (Maycock 1968), McClure 1943, Moir 1958, Persson and Sjörs 1960, Porsild 1932, Raup 1943, Ritchie 1956a, (1956b, 1956c), FLORISTIC NOTES (continued)

1957, (1959, 1960a), 1960c, Savile 1968, Scoggan 1951, 1959, Sjörs 1959, Stormer 1933, Walker 1970

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Carleton and Maycock 1978, (Jeglum 1975), Kershaw 1974, Kershaw and Rouse 1973, (Kershaw et al. 1975), (Lamoureux and Zarnovican 1974), Larson 1975, Larson and Kershaw 1974, Lechowicz and Adams 1974, Neal and Kershaw 1973a, 1973b, Pielou and Routledge 1976, (Vitt et al. 1975)

HUMAN IMPACT

Beckett 1959, Brown and Brown 1970, (Brown and Williams 1972), Glooschenko 1979, Glooschenko and Sampson 1977, Glooschenko and Capobianco 1978, Hustich 1957b, (Jeglum 1975), Jordan et al. 1972, (Jurdant et al. 1975), Lumsden 1974b, Anon. 1977, Rouse and Kershaw 1973, Sjörs 1963b, Sparling 1973, Walker 1970

HYDROLOGY

(Allington 1961), Arthur and Marshall 1976, (Boelter and Verry 1977), Cowell et al. 1978, Cowell et al. 1979, (Dai 1970), (Dai et al. 1974), Hamelin 1971, (Heinselman 1963, 1970), Hustich 1957b, (Jeglum 1975), Johnston and Hills 1956, Kershaw 1976, Knollenberg 1964, McEwen 1964, (Pollard 1970), Radforth 1973, (Radforth and Bellamy 1973), Ritchie 1957, 1962, Rouse and Kershaw 1971, Sjörs 1963b, Sparling 1973, Zoltai 1973

INSECTS

McClure 1943, McInnes 1908, Munroe 1956

ISOSTACY

Arthur and Marshall 1976, Hamelin 1971, Hustich 1950, 1955, 1957a, 1957b, Larson and Kershaw 1974, McKay and Arthur 1975, Moir 1954, Pierce and Kershaw 1976, (Potter 1932), Sjörs 1963b

LICHEN, ECOLOGY

Ahti 1964, Ahti and Hepburn 1967, Andrews and Webber 1969, Kershaw 1975, 1977, Kershaw and Rouse 1971, 1973, Kershaw and Larson 1974, (Kershaw et al. 1975), Larson 1975, Larson and Kershaw 1974, 1975a, 1975b, 1975c, 1975d, Lechowicz and Adams 1974, Maikawa and Kershaw 1975, Neal and Kershaw 1973a, 1973b, Pierce and Kershaw 1976, Rouse and Kershaw 1971

LICHEN, PHYSIOLOGY

Blasco and Jordan, 1976, Fabiszewski 1976, Kershaw 1975, Kershaw and Larson 1974, Larson 1975, Larson and Kershaw 1975b, 1975c, 1975d, 1976, Maikawa and Kershaw 1975

LICHEN, SPECIES LISTS

Ahti 1964, Ahti and Hepburn 1967, Fabiszewski 1976, Larson 1975, Larson and Kershaw 1975a, Lepage 1945, Macoun, J. 1881, Neal and Kershaw 1973a, Sjörs 1961b, 1963b

LICHEN WOODLAND

Ahti 1964, Ahti and Hepburn 1967, Brokx 1965, 1967, (Hare and Taylor 1956), Hustich 1957b, Kershaw 1977, Kershaw and Rouse 1971, Lechowicz and Adams 1974, Ritchie 1962, (Scotter 1971), Sjörs 1963b

MAPS OF HBL

Bates and Simkin 1969, Brown 1967, Johnston and Sharpe 1923

MEDICINAL USE

Holmes 1884

MENSURATION, FOREST

Hustich (1949a), 1950, 1955, 1957b, (Jeglum 1971, 1973), Johnston and Sharpe 1923, (Marr 1948), McEwen 1964, (Payette 1976)

MICROCLIMATE

Beckel 1957, (Brown 1966, 1970), Field et al. 1974, (Gerardin et al. 1975), Kershaw 1975, 1977, Kershaw and Rouse 1971, 1973, Kershaw and Larson 1974, (Kershaw et al. 1975), Larson 1975, Larson and Kershaw 1974, 1975a, 1975b, 1975c, 1975d, Railton and Sparling 1973, Rouse 1973, Rouse and Kershaw 1971, 1973

NUTRIENTS, (IN WATER, SOILS, PLANTS)

Arthur and Marshall 1976, 1977, (Boelter and Verry 1977), Cowell et al. 1978, Doutt 1941, Fabiszewski 1976, (Haavisto 1974), Hanson and Jones 1976, (Heinselman 1963, 1970), (Hofstetter 1969), (Jeglum 1971, 1973, 1975), Kershaw 1974, 1976, (Lamoureux and Zarnovican 1974), (Majcen 1973), McEwen 1964, Sjörs 1959, 1961a, 1961b, 1963b, Tarnocai 1972b, (Vitt et al. 1975), Zoltai (1972), 1973

OFFSHORE

Cottam and Munro 1954, Curtis 1973, (Lamoureux and de Repentigny 1972), (Lamoureux and Zarnovican 1972), Porsild 1932, Smith 1944, (Wilce 1970)

PALEOBOTANY, POLLEN SPECTRA

Auer 1927, Baldwin et al. 1962, (Griffin 1975), Johnson 1949, Norris et al. 1976, (Potzger and Courtemanche 1956), Ritchie 1967, Terasmae 1968, (1970), Terasmae and Hughes 1960

PALEOBOTANY, DATING

Andrews and Webber 1969, Hustich 1957b, (Potzger and Courtemanche 1954), Railton and Sparling 1973, Sjörs 1963b, Terasmae and Hughes 1960

PALSAS AND PEAT PLATEAUS

Brokx 1967, Brown (1966), 1968, 1973, Coombs 1952, (Hamelin and Cailleux 1969), Hustich 1957b, (Payette et al. 1976), Railton and Sparling 1973, Ritchie 1960c, Sjörs 1959, 1961a, 1961b, Sparling 1973, Tarnocai 1972b, (Tyritkov 1959), Zoltai (1972), 1973, (Zoltai and Tarnocai 1971)

PATTERNED TERRAIN

(Allington 1961), Bates and Simkin 1969, Beckel et al. 1954, Brokx 1965, 1967, Brown 1968, (1970), 1973, Coombs 1952, Cowell et al. 1979, Dean 1959, (Griffin 1975), Hamelin (1957), 1971, (Hamelin and Cailleux 1969), (Hare and Taylor 1956), (Hare and Ritchie 1972), (Heinselman 1963, 1965, 1970), (Hofstetter 1969), Hustich 1950, 1957b, 1959, (Jeglum et al. 1974), (Jeglum and Boissonneau 1977), Kalela 1962, Kershaw 1974, 1977, Knollenberg 1964, Lumsden 1974b, (Majcén 1973), McClure 1943, Mills 1976, (Payette et al. 1976) Radforth 1955a, 1955b, 1958, 1973, Ritchie (1959, 1960a), 1962, Savile 1968, Sjörs 1961a, 1961b, 1963b, (Tarnocai 1970, 1972a, 1974b), (Vitt et al. 1975), Zoltai 1971, (1972), 1973

PEATLAND, CLASSIFICATION

(Allington 1961), Bates and Simkin 1969, Brokx 1965, 1967, Cowell et al. 1979, Hamelin 1971, Hanson and Smith 1950, (Hare and Taylor 1956), (Heinselman 1963, 1970), Herrick 1977, (Jeglum 1973, 1975), (Jeglum et al. 1974), (Jeglum and Boissonneau 1977), Kalela 1962, (Lehoux and Rosa 1973), (McFarlane 1957), (Majcen 1973), Maycock 1976, Radforth 1955b, 1956, 1958, 1973, (Radforth and Bellamy 1973), Ritchie 1960b, 1960c, Sjörs 1959, 1961a, 1961b, 1963b, Tarnocai (1970, 1972a, 1974b), 1974a

PEATLAND, DISTRIBUTION AND EXTENT

Bates and Simkin 1969, Brokx 1965, Coombs 1954, Ehrlich et al. 1959, (Hare and Taylor 1956), Johnston and Hills 1956, Johnston and Sharpe 1923, Ketcheson and Jeglum 1972, McEwen 1964, Sjörs 1961a, 1961b, 1963b, (Zoltai and Tarnocai 1976)

PEATLAND, ECOLOGY

(Allington 1961), Blasco and Jordan 1976, (Boelter and Verry 1977), (Brown and Williams 1972), Cowell et al. 1979, (Dai 1970), (Dai et al. 1974), Fabiszewski 1976, (Haavisto 1974), (Hamelin and Cailleux 1969), (Heinselman 1963, 1965, 1970, 1971), (Hofstetter 1969), Hustich 1955, 1957b, (Jeglum 1971, 1973, 1975), (Jeglum et al. 1974), Johnson 1949, (Kershaw et al. 1975), Knollenberg 1964, Lumsden 1974b, (Majcen 1973), (Pollard 1970), (Potzger and Courtemanche 1956), Radforth 1955a, 1956, Ritchie 1957, (1959), Rouse 1973, Sjörs 1959, 1961a, 1961b, 1963b, Sparling 1973, (Vitt et al. 1975), Zoltai (1972), 1973, (Zoltai and Tarnocai 1976)

PERMAFROST

Bates and Simkin 1969, Beckel 1957, Brown (1966), 1967, 1968, (1970), 1973, (Brown and Williams 1972), Cowell et al. 1978, Hamelin (1957), 1971, Hustich 1957b, Johnson 1949, Kershaw 1976, Lumsden 1974b, Mills 1976, (Payette et al. 1976), Radforth 1955a, 1955b, 1958, 1973, Railton and Sparling 1973, Ritchie 1957, 1960c, (Roberts-Pichette 1972), Rouse and Kershaw 1973, Savile 1968, Sjörs 1959, 1961a, 1961b, 1963b, Tarnocai (1972a), 1972b, 1974a, Thie 1976, (Tyritkov 1959), Zoltai 1971, (1972), 1973, Zoltai and Tarnocai (1971, 1976)

PHENOLOGY

(Baldwin 1958), Barnston 1841, Beckett 1945, Hanson and Smith 1950, McClure 1943, (Payette 1976), Stormer 1933

PHYTOGEOGRAPHY

Abbe 1948, Ahti and Hepburn 1967, (Baldwin 1958), Baldwin et al. 1962, Boivin 1952, Dean 1959, Dutilly and Lepage 1963, Dutilly et al. 1954, 1958, Hulten 1958, 1968, Hustich (1949a), (1949b), 1950, (1953), 1955, 1957a, 1957b, 1959, (1974), Lepage 1945, 1959, 1966, Marie-Victorin 1938, McKay and Arthur 1975, Polunin 1959, Porsild 1932, 1964, Raup 1943, Ritchie 1956a, (1956c, 1959, 1960a), 1962, Rousseau, C. 1974, (Rousseau, J. 1952, 1966, 1968), Savile 1968, Schofield 1958, Scoggan 1957, 1959, (Sjörs 1963a)

PLANT MIGRATION

Abbe 1948, Baldwin et al. 1962, Boivin 1952, Cody 1954, Marie-Victorin 1938, (Polunin 1939, 1948), (Potter 1932), Ritchie 1967, Rousseau, C. 1974, Schofield 1958, (Sjörs 1963a), Terasmae 1968

PRODUCTIVITY AND BIOMASS

Glooschenko 1978, (Hare and Ritchie 1972), Larson and Kershaw 1974

REMOTE SENSING

(Allington 1961), Bates and Simkin 1969, Brokx 1965, 1967, Brown 1973, Cowell et al. 1979, (Jeglum et al. 1974), (Jeglum and Boissonneau 1977), Johnston and Sharpe 1923, Knollenberg 1964, Kozlovic and Howarth 1977, (McFarlane 1957), Radforth 1955b, 1958, 1973, (Radforth and Bellamy 1973), Ritchie (1960a), 1960b, 1960c, 1962, Suffling 1973, Tarnocai (1970, 1972a), 1974a, (1974b), Thie 1976

RIVERBANK

Brokx 1967, Brown 1973, Hustich 1957b, McEwen 1964, Ritchie 1957, 1960c, 1962

SALT MARSH

Arthur and Marshall 1976, 1977, Beckel et al. 1954, (Chapman 1974), Cody 1954, Doutt 1941, Glooschenko 1978, 1979, Glooschenko and Sampson 1977, Glooschenko and Martini 1978, (Jefferies 1977), Jefferies et al. 1979, Kershaw 1976, (Lamoureux and de Repentigny 1972), (Lamoureux and Zarnovican 1972, 1974), (Lavertiere and Guimont 1975), Marie-Victorin 1938, McKay and Arthur 1975, Pielou and Routledge 1976, (Polunin 1948), (Potter 1932), Riley and Moore 1973, Ritchie 1960c, 1962, Schofield 1958, Scoggan 1959, Smith 1943, 1944, Stirrett 1972

SEDGE MEADOWS

Arthur and Marshall 1976, 1977, Beckel 1957, Beckel et al. 1954, Hustich 1957b, Jefferies et al. 1979, Kershaw 1974, McKay and Arthur 1975, Ritchie 1957, 1960c, Scoggan 1959

SNOW COVER

Beckel 1957, (Brown 1966), (Hamelin 1957), (Hare and Ritchie 1972), Hustich 1957b, Kershaw and Rouse 1973, Knollenberg 1964, Larson 1975, Larson and Kershaw 1975a, (Payette 1974), (Payette et al. 1973, 1975), Railton and Sparling 1973, Sjörs 1961b, 1963b, (Tyritkov 1959)

SOIL RELATIONS (TO VEGETATION)

Baldwin et al. 1962, Beckel 1957, Blasco and Jordan 1976, (Boelter and Verry 1977), (Brown 1966), Cowell et al. 1978, Cowell et al. 1979, (Gerardin et al. 1975), (Haavisto 1974), Hanson and Jones 1976, (Heinselman 1963, 1970), (Hofstetter 1969), Hustich 1955, 1957a, 1957b, (Jeglum 1971, 1973, 1975), Jordan et al. 1972, Kalela 1962, Kershaw 1977, Kershaw and Rouse 1973, (Kershaw et al. 1975), (Lamoureux and Zarnovican 1974), Larson 1975, Lechowicz and Adams 1974, Maikawa and Kershaw 1975, (Majcen 1973), McKay and Arthur 1975, Pierce and Kershaw 1976, Railton and Sparling 1973, Ritchie 1957, Rouse 1973, Rouse and Kershaw 1971, 1973, (Rowe and Scotter 1973), Sjörs 1959, 1961a, 1961b, 1963b, Tarnocai 1972b, (Tyritkov 1959), (Zoltai and Tarnocai 1971)

STRING BOGS AND PATTERNED FENS

(Allington 1961), (Heinselman 1965), Hustich 1957b, Knollenberg 1964

TAXONOMIC TREATMENT

Abbe 1948, Argus and White 1977, Hulten 1958, Lepage 1954, Porsild 1964, Raup 1943, Rousseau, C. 1974, Scoggan 1957

TIDAL FLATS

Arthur and Marshall 1976, 1977, Beckel et al. 1954, Glooschenko 1978, 1979, Glooschenko and Martini 1978, (Lamoureux and de Repentigny 1972), (Lamoureux and Zanovican 1972, 1974), (Lavertiere and Guimont 1975), McKay and Arthur 1975, Moir 1954, Riley and Moore 1973, Schofield 1958, Scoggan 1959, Smith 1943, 1944

TREE-LINE

Bates and Simkin 1969, Brokx 1965, 1967, Coombs 1952, Dean 1959, Hare 1950, 1954, Herrick 1977, Hustich (1949a), 1950, (1953), 1955, 1957b, Macoun, J.M. 1888, (Marr 1948), (Maycock 1968), McClure 1943, (Payette 1974, 1975, 1976), (Payette et al. 1973, 1975), (Payette and Filion 1975), (Payette et al. 1976), (Polunin 1951), Rowe 1972

TUNDRA

Beckel 1957, Beckel et al. 1954, Beckett 1945, Brown and Brown 1970, Hare 1950, 1954, Johnson 1949, Kershaw 1977, (Kershaw et al. 1975), Larson and Kershaw 1974, 1975a, 1975b, 1975c, 1975d, 1976, Macoun, J.M. 1888, Maycock (1968), 1976, McClure 1943, Neal and Kershaw 1973b, Anon. 1977, (Payette et al. 1973, 1975), (Payette and Filion 1975), Pierce and Kershaw 1976, (Polunin 1948, 1951), Ritchie (1960a), 1960b, (Rousseau, J. 1968), Scoggan 1959

VASCULAR SPECIES LISTS

Argus and White 1977, Arthur and Marshall 1976, 1977, Baldwin 1948, 1953, Baldwin et al. 1962, Cowell 1968, Dutilly and Lepage 1948, 1952, 1963, Dutilly et al. 1954, 1958, 1959, Fabiszewski 1976, Fagerstrom 1948, Gardner 1937, 1946, Geldart 1887, Gussow 1933, Hustich 1955, 1957a, 1957b, (1974), Johnson 1949, Kershaw 1976, Kershaw and Rouse 1973, Kirk 1940, Larson 1975, Larson and Kershaw 1974, Lepage 1945, 1959, 1966, Lumsden 1958a, 1958b, 1974a, Macoun, J. 1881, (1884), 1904, 1905, 1906, Macoun, J.M. 1888, 1889, McKay and Arthur 1975, McKay and Riley 1975, Moir 1958, Morton 1968, Neal and Kershaw 1973a, Porsild 1964, Potter (1932), 1934, Riley and Moore 1973, Ritchie 1956a, 1962, Schofield 1958, Scoggan 1951, 1957, 1959, Sjörs 1961b, 1963b, Stirrett 1972, Stormer 1933

WILDLIFE HABITAT RELATIONSHIPS, CARIBOU

Ahti 1964, Ahti and Hepburn 1967, Brokx 1965, 1967, Hustich 1957b, Kershaw 1977, (Kershaw et al. 1975), Lechowicz and Adams 1974, (Roberts-Pichette 1972), (Scotter 1971), Simkin 1965

WILDLIFE HABITAT RELATIONSHIPS, INSECTS

Hustich 1957b, McClure 1943

WILDLIFE HABITAT RELATIONSHIPS, POLAR BEARS

Russell 1975

WILDLIFE HABITAT RELATIONSHIPS, WATERFOWL

Arthur and Marshall 1976, Curtis 1973, (Anon. 1976), Hanson and Smith 1950, Hanson and Jones 1976, Jefferies et al. 1979, (Lamoureux and Zarnovican 1974), (Lehoux and Rosa 1973), Prevett et al. 1979, Smith 1943, 1944

WIND EFFECTS

Doutt 1941, Hustich 1950, 1957b, (Payette 1974)

ZONATIONS, REGIONS AND DISTRICTS

Ahti 1964, Ahti and Hepburn 1967, Bates and Simkin 1969, Brokx 1965, 1967, Brown 1967, 1968, 1973, Coombs 1952, 1954, Cowell et al. 1979, Dean 1959, Hanson and Smith 1950, Hare 1950, 1954, (Hare and Taylor 1956), (Hare and Ritchie 1972), Hills 1958, 1961, Hustich (1949b), (1953), 1957b, Johnston and Hills 1956, Johnston and Sharpe 1923, Kalela 1962, Knollenberg 1964, (Lehoux and Rosa 1973), Macoun, J.M. 1888, Maycock 1976, McEwen 1964, Anon. 1977, (Payette 1975), (Payette et al. 1975), Payette and Filion 1975), (Payette et al. 1976), Ritchie (1960a), 1960b, 1960c, (Rousseau, J., 1952, 1968), Rowe 1972, Savile 1968, Scoggan 1957, 1959, (Sjörs 1963a), Zoltai 1971

8. LOCATION INDEX

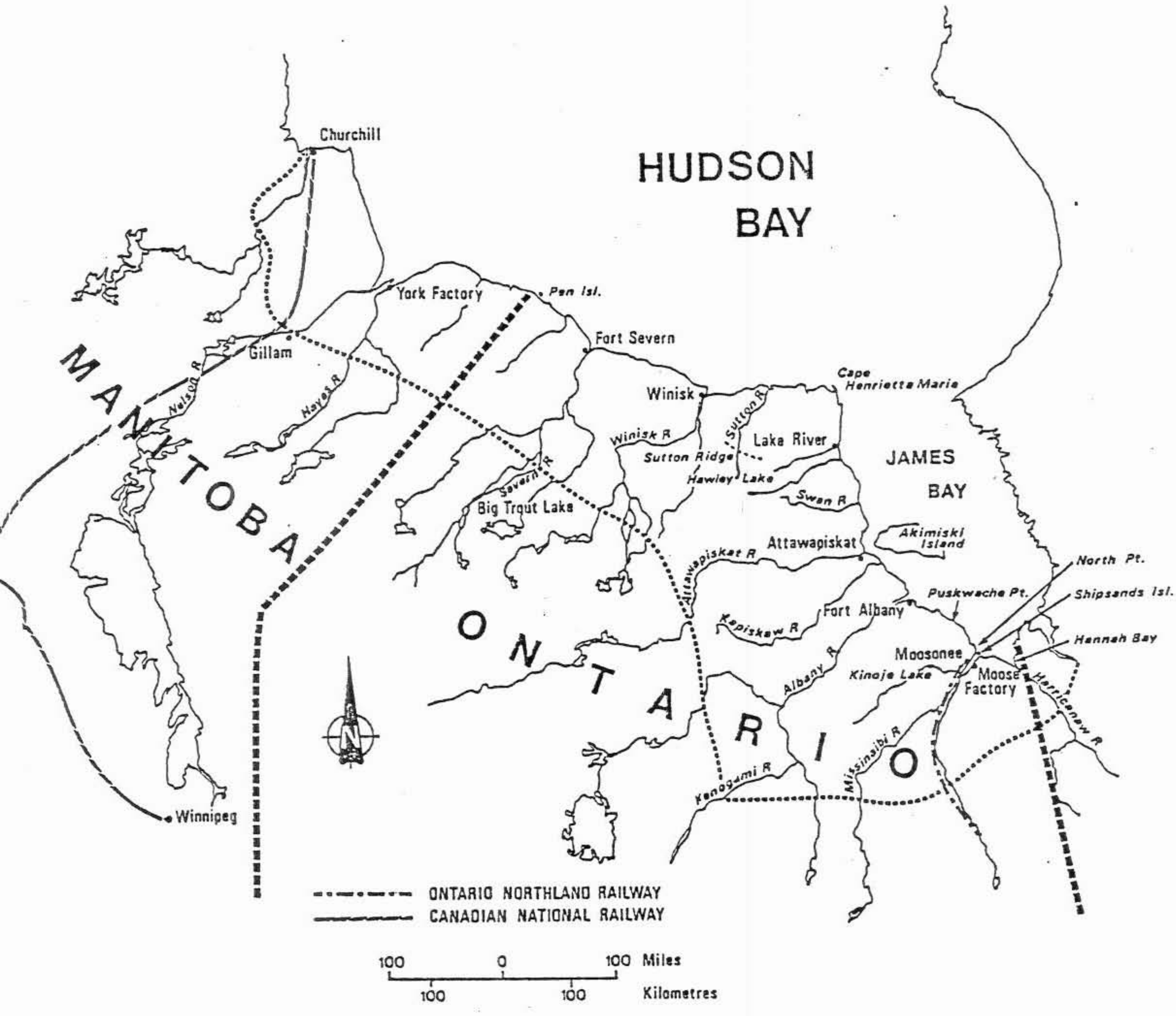

Fig. 23. Map of the Hudson Bay Lowland showing locations of selected place-names.

ABITIBI RIVER

Baldwin et al. 1962, Potter 1932, 1934 (see also MOOSE RIVER BASIN)

ALBANY RIVER

Barnston 1841, Bell 1886, Dean 1959, Dutilly et al. 1954, Hustich 1957b, Macoun, J. 1905

ATTAWAPISKAT (52°55'N, 82°24'W)

Dutilly et al. 1954, Pielou and Routledge 1976 (see also ATTAWAPISKAT RIVER)

ATTAWAPISKAT RIVER

Bell 1886, Dutilly et al. 1954, McInnes 1908, Persson and Sjörs 1960, Sjörs 1959, 1963, Terasmae 1968 (see also ATTAWAPISKAT)

BIG TROUT LAKE (53°30'N, 89°50'W)

Hustich 1957a

BRANT RIVER

Lumsden 1974a

BUOY BAY (51°18'N, 80°11'W)

Arthur and Marshall 1977

CAPE HENRIETTA-MARIA (55°07'N, 82°18'W)

Cowell, F.N. 1968, Dutilly et al. 1954, Lepage 1954, Lumsden 1958a, 1974a, Neal and Kershaw 1973a, 1973b, Persson and Sjörs 1960

CHURCHILL (58°50'N, 94°11'W)

Beckel 1957, Beckel et al. 1954, Beckett 1945, Beckett 1959, Brown, N.J. and Brown, A.W. 1970, Gardner 1937, 1946, Geldart 1887, Gussow 1933, Johnson 1949, Macoun, J. 1884, McClure 1943, Pielou and Routledge 1976, Radforth 1955a, 1955b, 1956, 1958, Ritchie 1956a, 1957, Schofield 1958, Scoggan 1959, Stormer 1933, Thie 1976, Walker 1970

EKWAN RIVER

Macoun, J. 1905

FORT SEVERN (55°56'N, 87°40'W)

Hustich 1957a, 1957b, (see also SEVERN RIVER)

GILLAM (56°21'N, 95°36'W)

Crum and Schofield 1959 (see also NELSON RIVER)

HANNAH BAY (51°10'N, 79°45'W)

Dutilly and Lepage 1963, Potter 1934, Stirrett 1972 (see also JAMES BAY, SOUTH COAST)

HARRICANAW RIVER

Dutilly and Lepage 1952, 1963

HAWLEY LAKE (54°20'N, 84°20'W)

Hustich 1957b, Kershaw and Rouse 1971, Persson and Sjörs 1960, Railton and Sparling 1973, Rouse and Kershaw 1971, Sjörs 1959, 1961b (see also SUTTON RIDGE)

HAYES RIVER

Macoun, J. 1881, Mills 1976, Mills et al. 1976, Ritchie 1960c, Scoggan 1951

HUDSON BAY LOWLAND, GENERAL - (COASTAL AND INTERIOR)

Ahti 1964, Ahti and Hepburn 1967, Andrews and Webber 1969, Argus and White 1977, Bates and Simkin 1969 (north of 52°N), Brokx 1965, 1967, Brown, R.J.E. 1967, 1968, 1973, Carleton and Maycock 1978, Coombs 1952, 1954, Cowell et al. 1979, Dean 1959, Hamelin 1971, Hanson and Smith 1950, Hare 1950, 1954, Hills 1958, 1961, Holmes 1884, Hulten 1958, 1968, Hustich 1957b, 1959, Ireland and Cain 1975, Lechowicz and Adams 1974, Maycock 1976, Porsild 1957, Raup 1943, Ritchie 1960b, Ritchie 1962, 1967, Rouse 1973, Rousseau, C. 1974, Rowe 1972, Savile 1968, Scoggan 1957, Simkin 1965, Tarnocai 1972, 1974a, Terasmae and Hughes 1960, Terasmae and Anderson 1970, Zoltai 1971, 1972, 1973, Zoltai and Tarnocai 1971

HUDSON BAY LOWLAND, GENERAL - (COASTAL)

Cottam and Munro 1954, Glooschenko 1979, Glooschenko and Martini 1978, Hanson and Smith 1950, Hanson and Jones 1976, Moir 1954, Prevett et al. 1979, Porsild 1932, Russell 1975, Setchell and Collins 1908

HUDSON BAY LOWLAND, GENERAL - (INTERIOR)

Johnston and Hills 1956, Kalela 1962, Kershaw 1977, Ketcheson and Jeglum 1972, Knollenberg 1964, Lumsden 1974b, McEwen 1964, Munroe 1956, Anon. 1973, Radforth 1973, Sjörs 1959, 1961a, 1961b, 1963, Sparling 1973

JAMES BAY - (COASTAL)

Abbe 1948, Boivin 1952, Cody 1954, Curtis 1973, Anon. 1976, Jordan et al. 1972, Macoun, J.M. 1888, 1889, Macoun, J. 1904, 1906, Marie-Victorin 1938, Smith 1944

JAMES BAY - (SOUTH COAST)

Potter 1932, 1934, Smith 1943, Stirrett 1972

JAMES BAY - (WEST COAST)

Dutilly et al. 1954, Smith 1944

JAMES BAY - (ISLANDS)

Baldwin 1953, Doutt, J.K. 1941, Doutt, M.T. 1935, Macoun, J.M. 1888, Potter 1932, Smith 1944

KAPISKAW RIVER

Macoun, J. 1906

KENOGAMI RIVER

Dutilly and Lepage 1963

KINOJE LAKE (51°38'N, 81°45'W)

Cowell et al. 1977, Glooschenko and Capobianco 1978

LAKE RIVER

Dutilly et al. 1954, Lepage 1954, Smith 1944

MARTIN'S FALLS

Barnston 1841, Dutilly et al. 1954

MISSINAIBI RIVER

Dutilly and Lepage 1963

MOOSE FACTORY

(see MOOSONEE, MOOSE RIVER BASIN)

MOOSE RIVER BASIN

Auer 1927, Baldwin et al. 1962, Dutilly and Lepage 1963, Fagerstrom 1948, Hustich 1955, Johnston and Sharpe 1923, Macoun, J.M. 1889, Norris et al. 1976, Potter 1934 (see also MOOSONEE, SHIPSANDS ISLAND)

MOOSONEE (51°20'W, 80°40'W)

Baldwin et al. 1962, Blasco and Jordan 1976, Dutilly et al. 1954, Dutilly and Lepage 1963, Fabiszewski 1976, Fagerstrom 1948, Gardner 1946, Hustich 1957b, Kirk 1940, Lepage 1945, Morton 1969, Pielou and Routledge 1976, Potter 1932, 1934 (see also MOOSE RIVER BASIN, SHIPSANDS ISLAND)

MUKETEI RIVER

Sjörs 1963

NELSON RIVER

Ehrlich et al. 1959, Ritchie 1960c

NORTH POINT (51°29'N, 80°27'W)

Arthur and Marshall 1976, Glooschenko 1978, Glooschenko and Sampson 1977

OPINAGA RIVER

Dutilly et al. 1954, Lepage 1954

PEN ISLAND (56°46'N, 88°46'W)

Field et al. 1974, Kershaw 1974, 1975, 1976, Kershaw and Rouse 1973, Kershaw and Larson 1974, Kozlovic and Howarth 1977, Larson 1975, Larson and Kershaw 1974, 1975a, 1975b, 1975c, 1975d, 1976, Maikawa and Kershaw 1975, Pierce and Kershaw 1976, Rouse and Kershaw 1973

POLAR BEAR PROVINCIAL PARK

Anon. 1977, (see also BRANT RIVER, CAPE-HENRIETTA MARIA, KAPISKAW RIVER, LAKE RIVER, SUTTON RIVER, SWAN RIVER, WINISK)

PUSKWUCHE POINT (51°48'N, 80°40'W)

McKay and Arthur 1975

RENISON (50°52'N, 80°10'W)

Baldwin et al. 1962, Hustich 1955

SEVERN RIVER

Moir 1958, (see also FORT SEVERN)

SHIPSANDS ISLAND (51°22'N, 80°28'W)

Baldwin et al. 1962, Dutilly and Lepage 1954, 1963, Gardner 1946, McKay and Arthur 1975, McKay and Riley 1975, Riley and Moore 1973, (see also MOOSE RIVER BASIN, MOOSONEE)

SUTTON RIDGE (54°30'N, 84°30'W)

Persson and Sjörs 1960, Sjörs 1961b, Williams 1968, (see also HAWLEY LAKE)

SUTTON RIVER

Lumsden 1958b

SWAN RIVER

Dutilly et al. 1954

WINISK (55°15'N, 85°15'W)

Dutilly et al. 1959, Lumsden 1974a, McInnes 1908, Persson and Sjörs 1960, Suffling 1973

YORK FACTORY

Macoun, J. 1881, 1884 (see also HAYES RIVER)