Canadian Peatlands

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Abstract: Peatlands are widespread in Canada. Postglacial environmental history and the present day abundance of water, cold temperatures, and humid climates have contributed to widespread peat formation and peatland development. Early systematic studies of peatlands began in the late 1800s and continued into the early 1900s primarily by European workers who brought expertise and new techniques such as pollen analysis to Canada. Serious studies on peatlands across the country did not begin until the 1950s. All peat-accumulating wetlands with at least 40 cm depth are defined as peatlands. About 14 % of the land surface is covered by peatlands, which is about 1.1×10^6 km^2. Peatlands are classified into bog, fen, and swamp classes, each of which is further subdivided into a number of forms and types. There are 56 such forms and subforms. Peatlands are distributed in the Boreal Wetland Region (about two-thirds), the Subarctic Wetland Region (almost one-third), with significantly less in the Mountain, Oceanic, Arctic, and Temperate Wetland Regions. Peatlands have long been used for a variety of purposes to serve the needs of Canadian society and economy. They are used in their intact state, in a slightly altered state, and in a managed state. Policies, management plans, and industry codes of practice are in place to ensure wise-use and conservation of peatlands for future generations.

Key words: Arctic region, bogs, Boreal region, Canada, fens, North America, Oceanic region, peatlands, Subarctic region, swamps, Temperate region

Introduction

Canada is noted for its abundance of water. Water was locked up in vast continental glaciers ice during Late Quaternary time. Eventually the climate gradually warmed, the ice melted, and water in glacier ice was released to large proglacial lakes and other water bodies, in substrates and soils, and underground aquifers. Plant and animals including humans gradually made their way onto the newly deglaciated waterlogged landscape from nearby refugia in Beringia in the north and from the southern part of North America. Strand flat and coastal refugia and the occasional mountain top nunatak also contributed plants and animals. As time passed, the glaciers disappeared altogether. The waterlogged land surface with the abundance of lakes and other open water bodies transformed into open water wetlands and peat landforms. Global circulation patterns over the land created climatic and meteorological conditions that either contributed abundand precipitation or minimized evaporation losses from soil surfaces or both; conditions that are ideal for peat-accumulation processes and development of peat landforms. Such a water history and the existence of abundant water today are responsible for the widespread occurrence of peatlands in Canada.

Humans have occupied Canada for as long as there has been land to live on following melting of the glaciers. Indigenous peoples did not have a profound influence on shaping the landscape because they were very much part of it. Foreign visitors and missionaries started to arrive as early as the 13th century when Vikings set foot on Newfoundland. Exploration, beginning with Jacques Cartier in the 1530s at Quebec, spread out across the land in search of a passage to Asia. There were many mapping parties traversing this new found land during this early period of exploration. Settlements such as those of the Acadians in Nova Scotia sprang up by the 1630s. With a greater continuing influx of early colonists mostly from Great Britain and elsewhere in Europe, people moved farther west. As they did so,

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Tab. 1: Surface coverage of peatland in each Ecoclimatic Province (Taken from TARNOCAI et al. 2000). Ecoclimatic Provinces correspond closely to Wetland Regions. The Interior Cordilleran Ecoclimatic approximates the Mountain Wetland Region. Other includes the Moderate Temperate and Prairie Wetland Regions.

Ecoclimatic province	Surface coverage (km²)	Percentage of total
Boreal	649,130	61.5
Subarctic	334,423	31.7
Cordilleran	29,317	2.8
Cool Temperate	17,317	1.6
Arctic	15,423	1.5
Interior Cordilleran	6,034	0.6
Other	4,660	0.4
Total	1,056,304	100

the land in general, and the peatlands specifically, started to be negatively affected by humans. Settlers reached the Great Lakes by the late 1700s and early 1800s, and continued westwards across the Prairies to the Pacific coast. Humans transformed primeval forest and pristine peatland into open and drained land suitable for habitation, agriculture and commerce. Thus began the trend in land use conversion that continues today. The land and the peatlands in some regions have become so severely altered by humans that what their original state was has become forgotten..

About 5 % or about 1.25 x 10^6 km² of Canada is covered by wetlands. This is about 18 % of the world's freshwater wetlands (TARNOCAI et al. 2001). About 1.1 x 10^6 km² or 90 % of this total is peatlands (Tab. 1; TARNOCAI et al. 2000). Peatlands have contributed much to the environmental, social, cultural, and economic fabric of the country. This paper is an introduction to the peatlands in Canada.

Several syntheses have been written about Canadian peatlands (ZOLTAI & POLLETT 1983, WETLAND WORKING GROUP 1988, GLOOSCHENKO et al. 1993, ZOLTAI & VITT 1995, RUBEC 1996). Noteworthy overviews have appeared for specific regions (e.g. WELLS 1981, GLASER & JANSSENS 1986, GLASER 1992, VITT et al. 1995, PAYETTE & ROCHEFORT 2001, RILEY 2003, MACKENZIE & MORAN 2004, ABRAHAM & KEDDY 2005, VITT et al. 2005). The second edition of a national classification was published in 1997 and a new map of peatlands in Canada was issued in 2000 (TARNOCAI et al. 2000). Geology, carbon sequestration and cycling, and biodiversity of Canadian peatlands have been summarized (GORHAM 1991, MCLAUGHLIN 2004, WARNER 2004, WARNER & ASADA 2005a). WARNER & ASADA (2005b) have identified some gaps in our knowledge requiring further research.

Fig. 1: Map showing key place names and sites referred to in the text.

Early Studies of Canadian peatlands

The indigenous peoples were the first to gain knowledge about peatlands. Many peatland Ericaceae provided fruits for food. Mammals, fish, and birds provided fur or food or both. Peoples' livelihoods also depended upon collecting materials for shelter, clothing, and commerce (e.g. WAUGH 1916).

Systematic surveys and record keeping started in the 1800s by early naturalists who made general observations and casual collections of the biota of Canada. Unfortunately, they did not distinguish peatland from nonpeatland habitat. Some of the first studies that recognized peatlands as distinct habitats were published around the turn of the 20th century (GANONG 1891, 1897, FERNALD 1911). The Geological Survey of Canada was interested in the economic potential of peatlands for fuel peat during this early period, and contracted Scandinavian geologists to undertake the first systematic field surveys of peatlands (e.g. NYSTRÖM & ANREP 1909, ANREP 1914, 1915, AUER 1930, WARNER &

BUTEAU 2000). They produced the first maps from their soil and plant surveys of peatlands in Canada (Fig. 2).

Around the same time, other studies were being performed on vegetation community structure, composition, stratigraphy and classification (MOSS 1918, RIGGS 1925, LEWIS & DOWDING 1926, LEWIS et al. 1928, OSVALD 1933, RAUP 1934). Detailed scientific investigations of peatland vegetation did not begin in earnest until the 1950s (e.g. DANSEREAU & SEGADAS-VIANNA 1952, MOSS 1953, HUSTICH 1955, 1957, SEGADAS-VIANNA 1955, RITCHIE 1956, 1957, 1962, SJÖRS 1959, 1961, 1963, ALLINGTON 1961, OSVALD 1970). The method of pollen analysis for dating and reconstructing the history of peatland vegetation and climate started in 1916 in Europe. The first pollen diagrams in Canada were from peatlands published shortly thereafter (Fig. 3; AUER 1928, 1930, BOWMAN 1931, JANSON & HALFERT 1936, HANSEN 1940). The advent of radiocarbon dating in the 1950s led to the first radiocarbon dated pollen diagram coming from a peatland (TERASMAE 1960). Canadian peatlands revealed much about the chronology of postglacial events and climate change (HANSEN 1949, 1952, 1955, POTZGER 1953, HAMELIN 1957).

Radforth and his colleagues in the 1950s developed early classification systems of

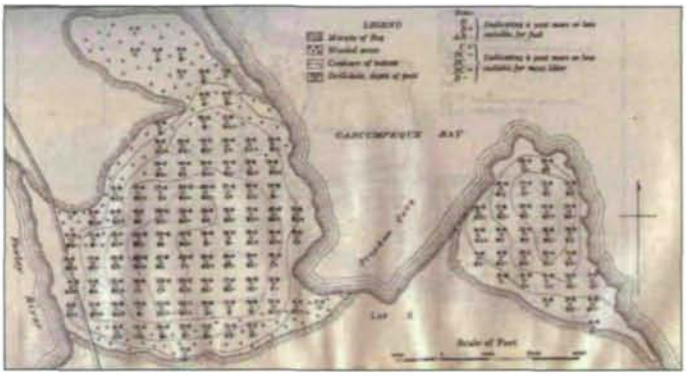


Fig. 2: Map showing depth contours and peat composition of the Black Banks peatland on the northwestern coast of Prince Edward Island. This is an example of the early maps published in 1913 by ANREP.

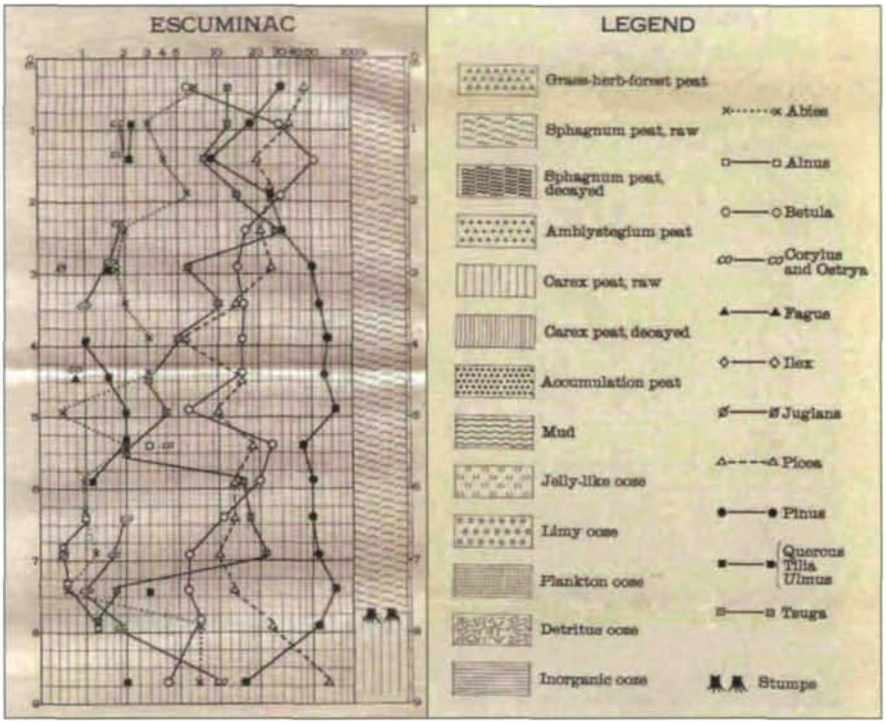


Fig. 3: An early pollen diagram showing major tree taxa from Point Escuminac, New Brunswick (AUER 1930). The stratigraphy and pollen compare well with a pollen diagram published in 1991 (Fig. 9: WARNER et al. 1991). The low proportion of *Tsuga* pollen at about 5.5 m depth in Auer's diagram is probably the "hemlock minimum" which is a distinctive feature of all pollen diagrams in eastern North America.

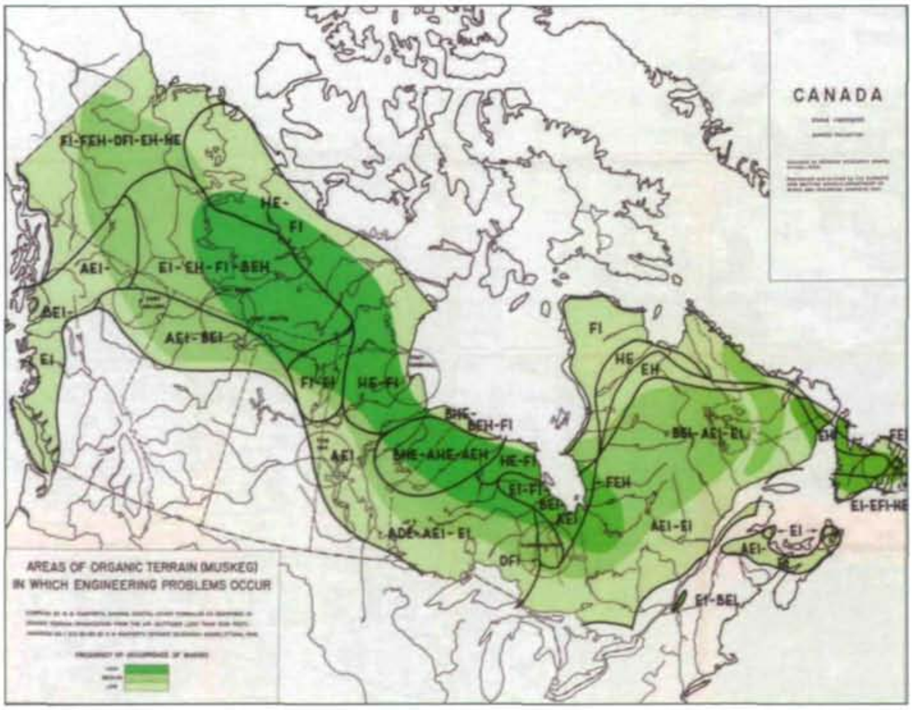


Fig. 4: Early peatland map by RADFORTH (1961). Compare with Fig. 6b.

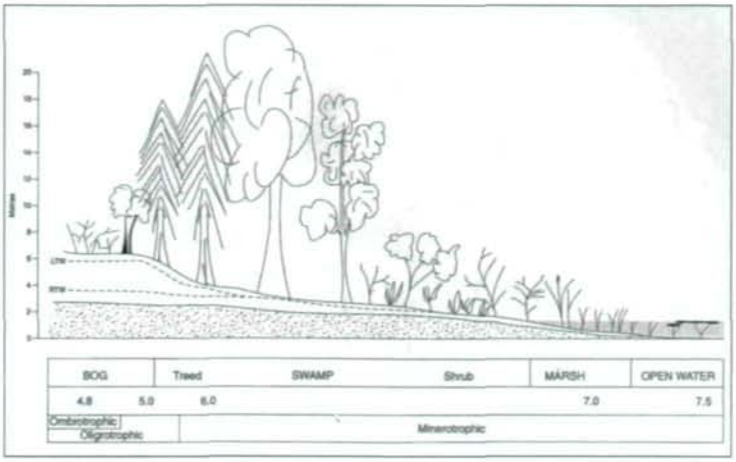


Fig. 5: A generalized diagram showing the major physiognomic units used to characterize vegetation cover in Canadian wetlands, including peatlands. Also shown are inferred pH and water types in each of the units. LWT = high water table. RWT = low water table.

peatlands and published the first map of Canadian peatlands (Fig. 4). Much of their efforts focused on the challenges of peat soils and peatlands from an engineering point of view (RADFORTH & BRAWNER 1977).

Definitions and Classification

A variety of common terms such as organic terrain, bogland, and muskeg have been used to denote peatland in Canada. The term peatland is used today to denote all areas with a minimum thickness of 40 cm of peat (WARNER & RUBEC 1997, WARNER 2003b). The term mire is not used in Canada because it is difficult to determine whether peat accumulation is active or not in order to differentiate mires and peatlands as is the done in Europe and Russia (JOOSTEN & CLARKE 2002).

There are five main wetland classes in Canada according to a national Wetland Classification System: bog, fen, swamp, marsh and shallow open water (WARNER & RUBEC 1997). Only bog, fen and swamp classes include peatlands while marsh and shallow open water do not generally include wetlands with more than 40 cm of peat. These terms are commonly misused as indicated by many bogs being labeled marshes and *vice versa* on topographic maps. Each of the wetland classes are further subdivided into forms on the basis of surface patterns, peatland form, water type, and soil composition. Physiognomy of dominant vegetation communities is used to further subdivide forms into types (Fig. 5).

All bogs are peatlands. The water table is usually at or slightly below the surface and waters are ombrogenous. Subsurface water may be frozen in permafrost terrain. The surface of bogs is raised above or is level with the surrounding terrain. The soils are moderately decomposed *Sphagnum* peat with woody twigs and roots of shrubs. The vegetation may be dominated by trees or shrubs, but many are treeless. *Sphagnum* mosses are predominant. There are 18 bog forms and subforms. Palsa, mound and lowland polygon bogs are examples in permafrost terrain and domed, peat plateau, string, and blanket bogs are examples in non-permafrost terrain.

Fens are mostly peatlands, but some may contain less than 40 cm of peat. In general the water table is at or a few centimeters below the surface. Waters are minerogenous and usually moving in non-permafrost terrain and seasonally frozen in permafrost terrain. The surface is usually level with the water table. The vegetation is characterized by brown mosses (i.e. Amblystegiaceae), herbaceous species, mostly in the sedge family (i.e. Cyperaceae), and shrubs. Consequently the soils are decomposed sedge or brown moss peat or both. There are 17 fen forms and subforms. Representative forms include palsa and snowpatch fens in permafrost terrain and string, channel, feather, and basin fens in non-permafrost terrain.

Swamps are mostly peatlands but some can have less than 40 cm of peat. The water table is at or below the surface and often floods the surface during spring melt. They do not tend to occur in the permafrost region but may reach areas of discontinuous permafrost. The waters are largely minerogenous. Soils are highly decomposed woody peat. Coniferous and deciduous trees and tall shrubs characterize the vegetation cover. The term "thicket" is commonly used and refers to tall-shrub swamps. There are 21 swamp forms and subforms. Tidal, slope, flat, discharge, and mineral-rise are examples of swamp forms.

Marshes and shallow open water wetlands do not contain significant depths of peat. Some basin and lacustrine marshes may contain more than 40 cm of peat but this is uncommon.

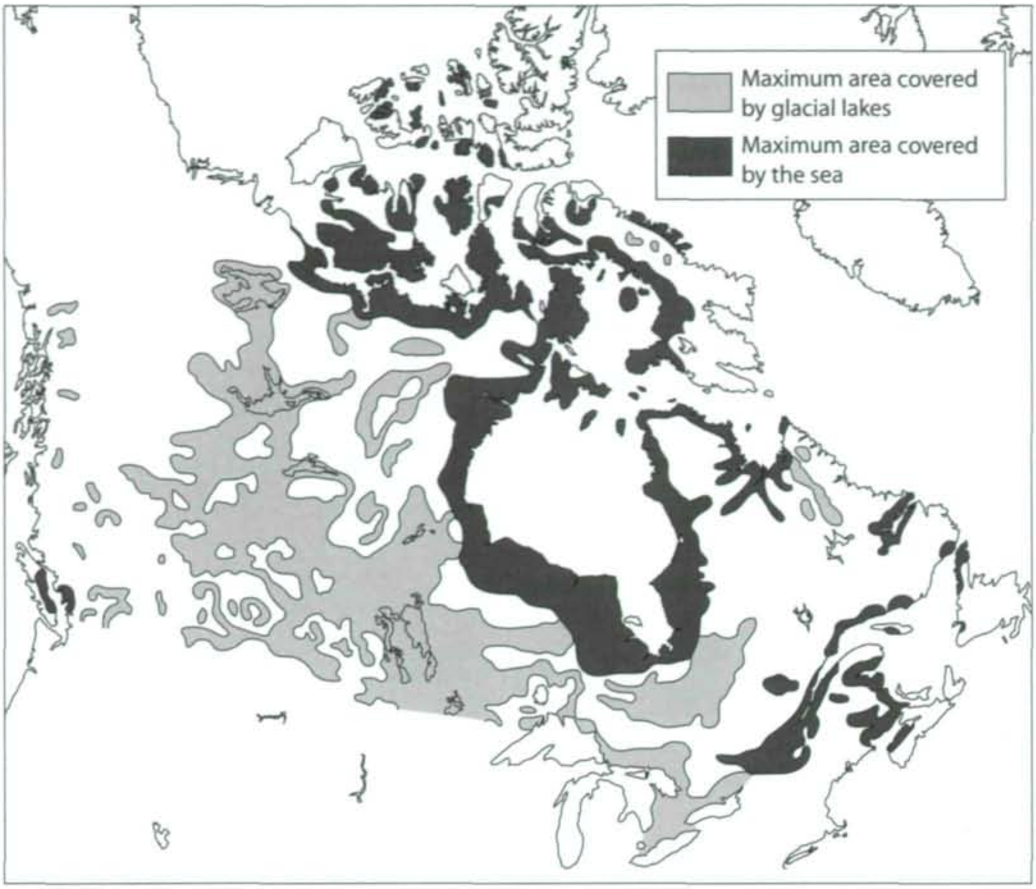


Fig. 6 (a): Map showing the extent of inland seas and proglacial lake coverage during the postglacial period in Canada (Taken from WARNER 2004).

Distribution

Peatlands occur anywhere water collects on the land surface long enough during the growing season to support the specialized plant communities adapted to living in waterlogged soils. The Laurentide ice sheet covered most of the eastern two-thirds of North America with its centre over modern-day Hudson Bay. The style and timing of deglaciation led to a vast array of glacial landforms being formed. Melting of the ice sheet created extensive proglacial lakes, large meltwater spillways, and a diversity of other drainage features as meltwater sought to find its way to the sea. The weight of the Laurentide ice also depressed the land surface sufficiently to allow seawaters to transgress to create large inland seas (FULTON 1989).

The Cordilleran ice sheet, centered over the Rocky Mountains, covered most of the northwestern part of the continent. The mountains contain typical alpine glacial landforms comprised of unconsolidated deposits in addition to bedrock basins which are good sites for collecting water suitable for peatlands. The lower elevations are covered by outwash, till, and proglacial lakes which when poorly drained contribute to peatland development. There is a striking match between the geographic distribution of inland lake and sea deposits and present day peatlands across the country (Fig. 6).

The most extensive peatland areas occur on deposits of the Tyrrell Sea around Hudson and James Bays Glacial Lake Agassiz in Central Canada, and Glacial Lake McConnell in the Northwest Territories.

As time passed, ongoing peat formation and peat landform development reached the point where geology and physical processes, once responsible for their origin, became overtaken by internal processes of peat build up and vegetation growth. The timing of this transition has varied locally and regionally across the country. It seems logical to expect that the oldest peatlands exist in the south on areas first to become free of ice cover and the younger peatlands exist in the north where deglaciation was much later. Though there may be some truth to this, the pattern of peatland age across the country is much more complex because peatland for-

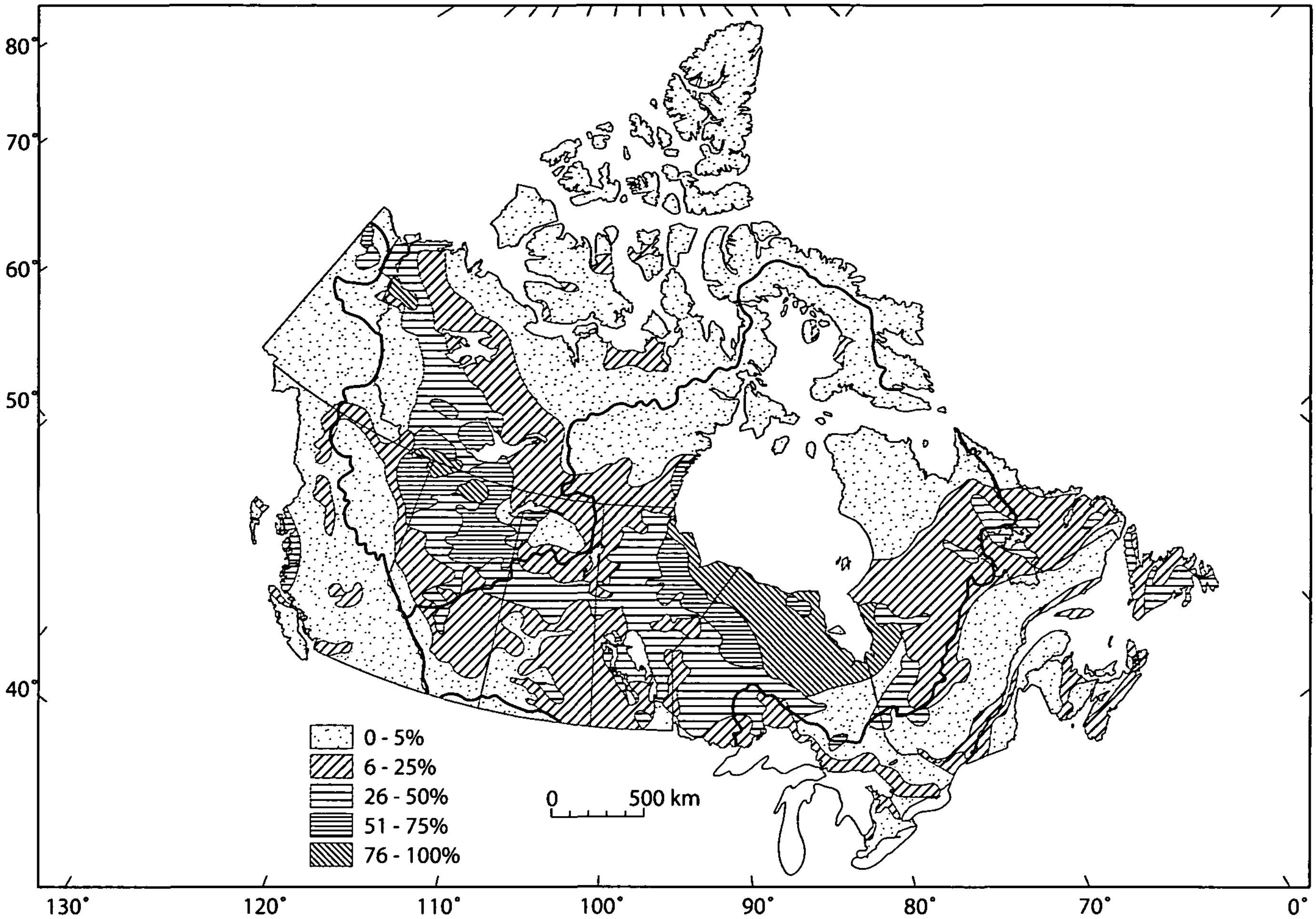


Fig. 6 (b): Map showing the coverage of peatland in Canada (taken from WARNER 2004). Note the overlap between the regions of postglacial inland water bodies and regions with greater than 50% surface coverage by peatlands.

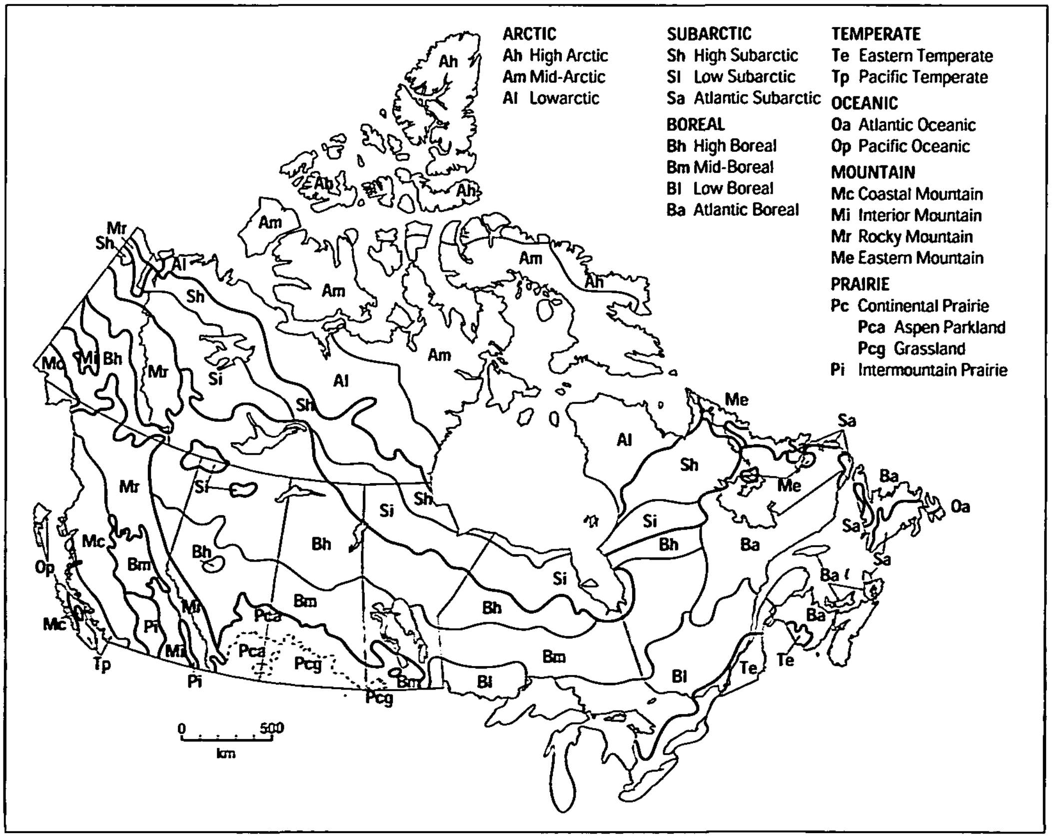


Fig. 7: Map showing the wetland regions of Canada (after WETLAND WORKING GROUP 1988).

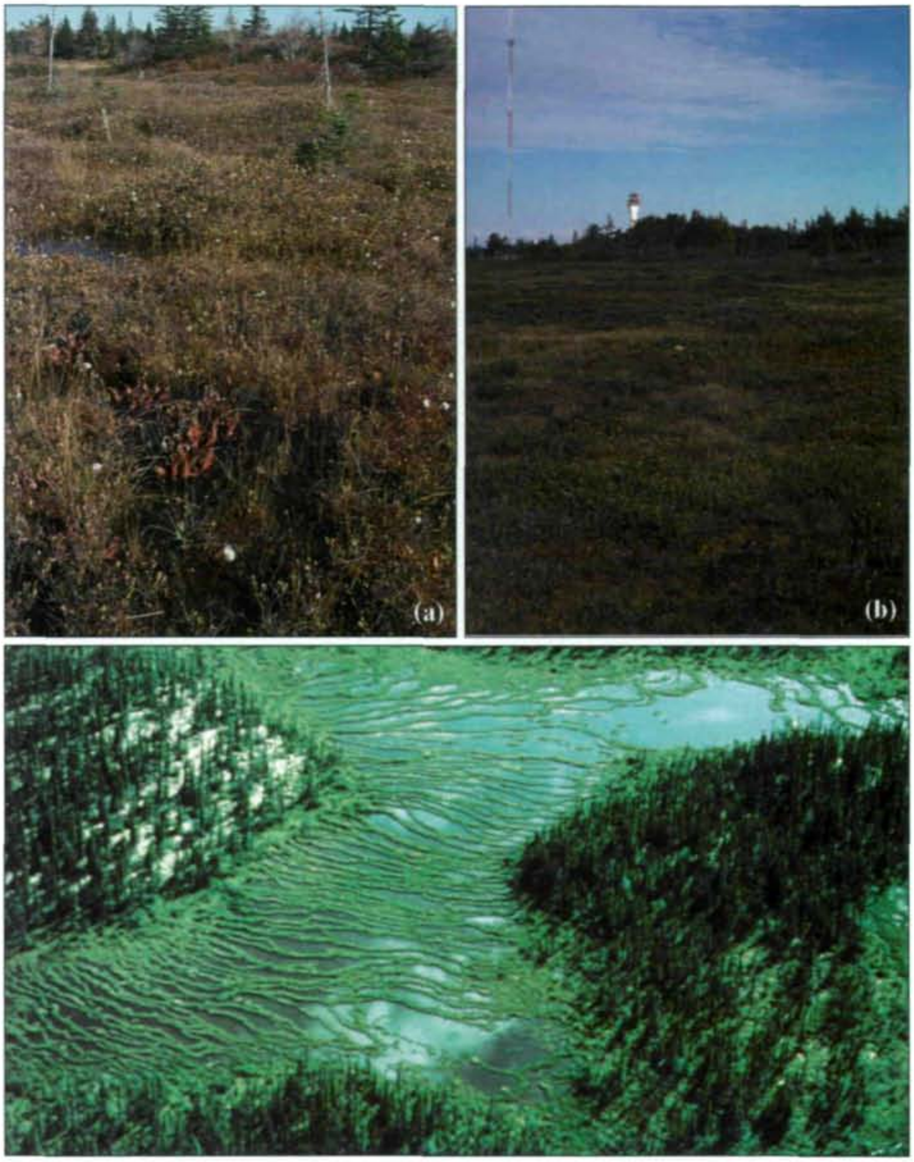


Fig. 8: Photographs of representative peatlands in the Boreal Wetland Region. **(a)**: Open fen in central Ontario, **(b)**: plateau raised bog at Point Escuminac, New Brunswick, **(c)**: aerial view of string fen in Labrador (photo by E,.D. Wells).

mation has followed more the history of water location and abundance – first controlled by geology, but later controlled more by climate, site specific hydrology, and vegetation history (e.g. WARNER et al. 1991, VITT et al. 2000, PAYETTE & ROCHEFORT 2001, GLASER et al. 2004).

Broad geographic zones with distinctive wetland types can be recognized based on similar geology, physiography, climate, peat landform features, and vegetation cover. There are seven wetland regions in Canada and all except the Prairie wetland region are important for peatlands (Fig. 7).

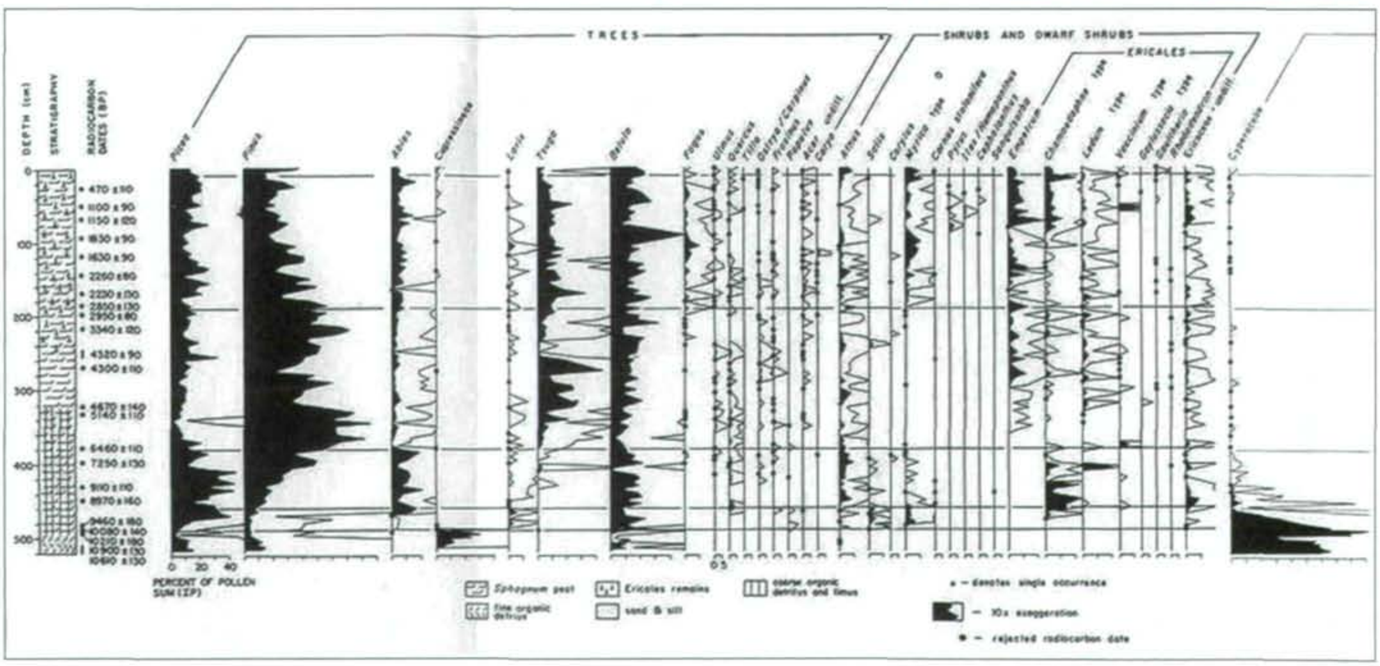


Fig. 9: Abbreviated pollen diagram from Point Escuminac, New Brunswick (after WARNER et al. 1991). This is the most comprehensively dated peatland in North America. Compare with Fig. 3.

Fig. 10: Aerial photograph taken at dusk of the south shore of James Bay in Ontario. Rapid isostatic uplift around James Bay, among the highest rates in Canada, is responsible for the widespread occurrence of bog, fen, and swamp in this region. The dark lines in the photograph represent old beach ridges covered by coniferous trees. Fens and bogs with *Sphagnum*, *Carex*, and *Eriophorum* occur between the beach ridges. (Photograph courtesy of P. Nopper, AIVA, Burlington, Ontario)..

Wetland Regions and Distinctive Peatlands

The Boreal Wetland Region forms a broad belt from about 45° to 75 ° latitude across central Canada from the Alaska-Yukon border in the west to northern Newfoundland in the east. This wetland region corresponds closely with the Boreal Ecoclimatic Province where it is estimated that 62 % is peatland (Tab. 1; TARNOCAI et al. 2000). This is about one-third of Canada and contains some of the largest peatlands in the country where land coverage is 100 %. The wetland region is characterized by the widespread occurrence of bog, fen, and swamp (Fig. 8). Many of these peatlands are associated with lakes, deltas, and large rivers because of their abundance in this region. The boreal wetland region has cold winters and warm summers. Precipitation in the form of both rain and snow is moderate in the centre of the region and year round rainfall becomes progressively higher in coastal areas closest to the ocean. Basin, raised, and plateau bogs and basin swamps are widespread (WARNER & RUBEC 1997).

Age and developmental history varies markedly across the region. The peatland at Point Escuminac, New Brunswick is a fine example of plateau raised bog on the Atlantic coast (Fig. 9).

Permafrost is not important but does occur in discontinuous patches to form such permafrost peatlands as palsas and peat plateau bogs mostly in the north-central limits of this zone. Beaver ponds and beaver-flooded peatlands are another distinctive feature in the Boreal region. The peatlands throughout the Hudson Bay and James Bay lowlands are purported to be the second largest peatland complex in the world (Fig. 10; RILEY 2004, , ABRAHAM & KEDDY 2005).

The Subarctic Wetland Region contains the next greatest extent of peatlands. Together the Boreal and Subarctic Wetlands contain 64 % of all the peatlands in Canada (Fig. 11).

This wetland region parallels the northern edge of the Boreal region across the country.

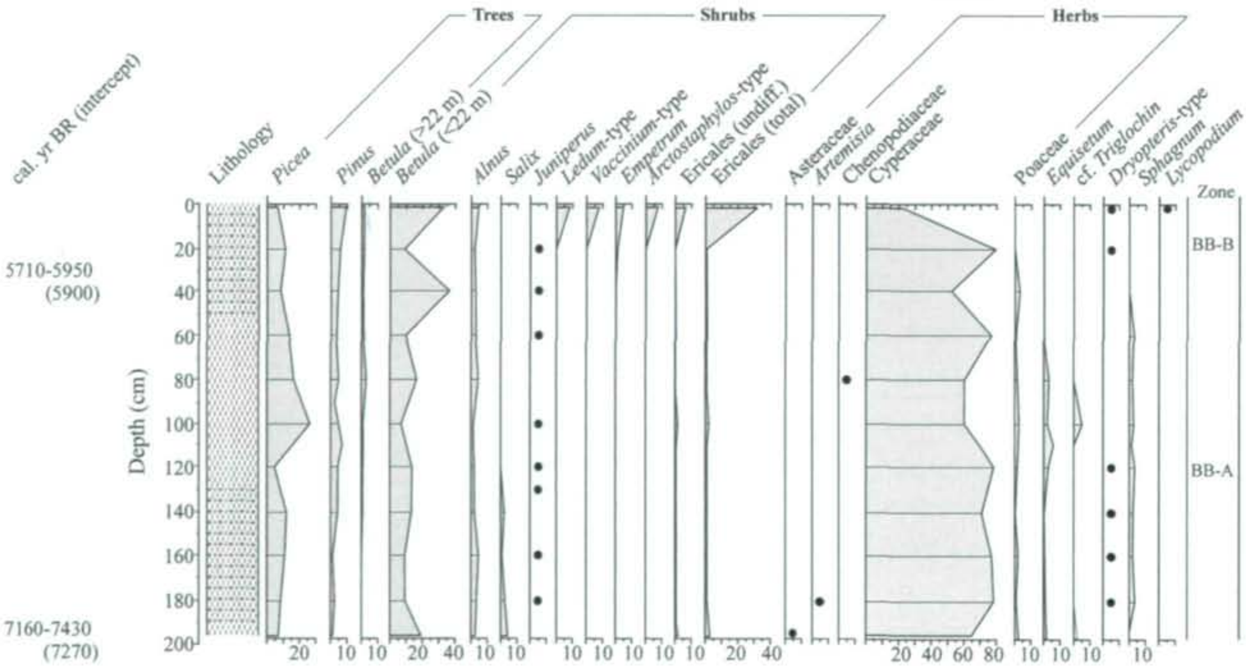
Winters are intensely cold and summers are moderately warm. Precipitation, both as snow and rain, is intermediate between the Boreal region to the south and the drier Arctic region to the north. The boundary between the limit of discontinuous and continuous permafrost cuts through the centre of the Subarctic zone. Bogs and fens are most common with swamps less important because treeline bisects this region. Permafrost did not become an important part of these peatlands until in late stages of their development (VARDY et al. 2005; Fig. 12). As the presence of trees diminishes northwards, and shrubs, herbs and mosses become dominants of the peatland vegetation. Peatland forms such as palsas and peat plateau

Fig. 11: Photographs of selected peatlands in the Subarctic Wetland Region. **(a)**: open fen and swamp near treeline in central Nunavut, **(b)**: palsa peatland in northern Alberta (Photograph by S.C. Zoltai), and **(c)**: low-centred polygonal fen in Nunavut (Photograph by S.C. Zoltai).

bogs and lowland polygon fens are common and all display the affects of permafrost.

Peatlands are not a characteristic feature of the landscape in the Arctic Wetland Region though surveys that differentiate peatlands from mineral wetlands are incomplete (Fig. 13). There are more peatlands near the southern edge and peatlands become progressively less widespread northwards. Nearly all are influenced by permafrost. Temperatures are extreme in winter and cold in summer and total precipitation is low. Peatlands oc-

Fig. 12: Pollen diagram from the Thelon-Kazan peatland in south-central Nunavut (after Vardy et al. 2005). The site is a high-centred polygon peatland. Permafrost is thought to have invaded the peatland in late Holocene time when climate became cooler. Note the extremely old peat on the surface.



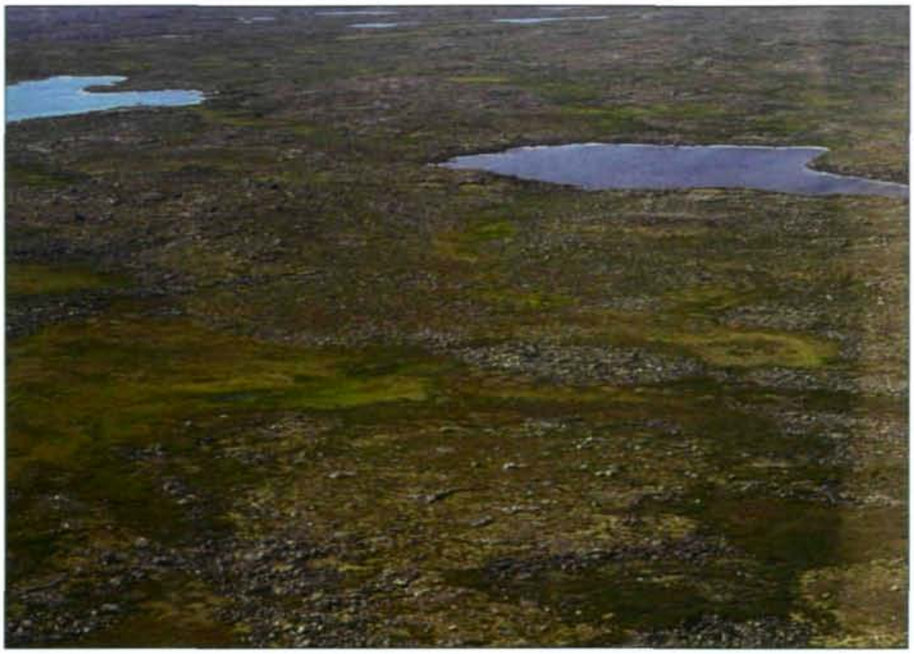


Fig. 13: Aerial view of the landscape in central Nunavut near southern margins of the Arctic Wetland Region. Fens, which may or may not have polygonal patterning and which may contain 1-2 m of peat, are represented by the green patches.

cupy small shallow basins where water is able to collect. Freeze-thaw processes are important in the peatland soils. The low amount of precipitation restricts wetlands to poorly drained depressions or to areas adjacent to lakes and rivers where additional water is available. Permafrost underlies the wetlands at shallow depths. The Arctic Wetland Region is far north of the limit of trees. Peatland vegetation consists of dwarf shrubs and herbs in drier peatlands and typical fen species in wetter sites. Fens, lowland polygon bogs, and peat mound bogs are typical.

The Mountain Wetland Region is split between the Coastal Mountains in British Columbia, the Interior Mountains in British Columbia and the Yukon, and the Rocky Mountains in British Columbia, Alberta, the Yukon, and Northwest Territories in the west and high elevations in Quebec and Labrador in the east (Fig. 14). Peatlands are not particularly widespread due to the rugged topography and comparatively few areas available for water to collect. The climate is much affected by an altitudinal gradient and consequently shares many features, especially vegetation that is typical of more northern wetland regions. Peatlands are typically confined to bedrock basins, behind ridges and in valley bottoms. The climate is cool to cold and precipitation is

Fig. 14 (a): A small basin fen in the central Coast Mountains of the Queen Charlotte Islands, British Columbia, and **(b)**: a typical open water peatland formed behind a beaver dam in the Kananaskis region, Alberta.

Fig. 15: Photographs of selected peatlands in the Ocean Wetland Region: **(a)**: sloping fen and bog complex near Prince Rupert, British Columbia, **(b, c)**: fen, bog and swamp complexes on the northeastern corner of Graham Island, British Columbia.

variable depending on location and elevation. Alpine permafrost can produce palsa bogs, peat plateau bogs and veneer bogs.

The Oceanic Wetland Region occurs immediately adjacent to the Pacific Ocean and in a small tip of southeast Newfoundland next to the Atlantic Ocean at opposite sides of the country (Fig. 15).

The climate is similar in both parts where winters are cold and summers are cool. Precipitation is high under the hyperoceanic climate on the Pacific coast and contributes to lush growth of trees, shrubs, herbs and mosses, which may grow during the winter if snow cover is not great. Precipitation is sufficiently abundant to allow soligenous peatland vegetation communities to grow and shallow pools to form on steep slopes. Bogs and fens are common.

Burns Bog is the best remaining example of a raised bog on the southern mainland coast of British Columbia (Fig. 17). Raised basin bogs are uncommon because the rugged mountainous terrain is not conducive to raised bog formation but many raised bogs developed on the flat and poorly drained surface of the Fraser Delta. The bogs on the Fraser Delta supported Canada's peat production capital prior to World War II, an industry that has long disappeared from British Columbia. Considerable effort has been directed towards protecting Burns Bog from further degradation and encroachment by intense urbanization from nearby suburbs of Vancouver.

The Temperate Wetland Region is also broken up on opposite sides of the country (Fig. 18). Mild winters and warm humid summers are characteristic and both rain and snow is moderately high. These climatic conditions have given rise to a diversity of tree, shrub, herb and moss dominated peatlands that exist mostly in bedrock and gla-

Fig. 16: Net primary productivity and carbon accumulation rates are much lower in peatlands in coastal zones of the Oceanic Wetland Region than peatlands in continental parts of the country despite some communities having relatively high and long growing season. Relatively high decomposition rates offset production, thus contributing to low overall rates of peat and carbon accumulation. (after ASADA & WARNER 2005).

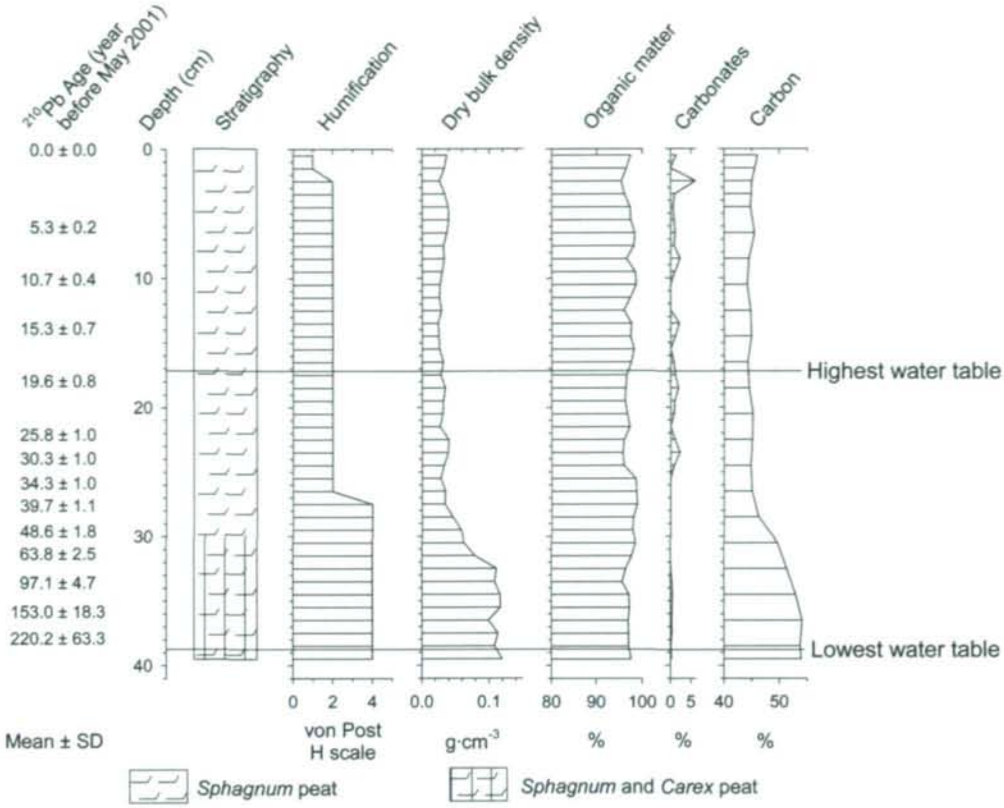


Fig. 17: Aerial photograph of Burns Bog, Richmond, British Columbia, one of the last remaining raised bogs that historically were common on the Fraser River Delta. The city of Vancouver and Coast Mountains are in the background (photograph courtesy of Waite Air Photos Inc., Mission, B.C.).

cial basins. Swamps, fens and to a lesser extent, bogs, are common. Kettle basins are common in the central Great Lakes region. Kettle lakes, which commonly occupied these basins immediately after deglaciation, gradually developed into shallow wetland and marsh during Holocene time before changing into modern day swamps and fens. Basin size and depth are important in determining which kettle basins remained as lakes and which ones developed into peatlands. (Fig. 19). Early forest clearance by European immigrants for agriculture and settlement are directly responsible for the occurrence of floating peat mats (i.e. Schwingmoor) in some kettles because forest clearance dramatically altered natural surface water runoff patterns and groundwater aquifers. Floating fen and bog mats formed in response to the new human-induced hydrological changes in the kettle basins (Fig. 20; WARNER et al. 1989).

The Wainfleet bog on the north-east shore of Lake Erie is Canada's most southern raised bog and is one of the few raised bogs in southern Ontario. The extant bog is about one-fifth its original size (WARNER & NAGY 1999).

The bog has been ditched, drained, and burned and historically supported commercial peat mining, lumbering, and a prison. Native *Picea mariana* has been extirpated from the bog and was replaced by alien *Betula pendula*. It is home to the threatened Eastern Massassaga rattlesnake (*Sistrurus catenatus catenatus*).

Fig. 18: Photographs of selected peatlands in south-central Ontario in the Temperate Wetland Region. **(a)**: deciduous swamp, **(b)**: basin fen with floating mat of *Sphagnum*, **(c)**: basin fen, and **(d)**: tall shrub basin swamp and fen complex with floating central mat showing the open water "moat".

Uses and Economic Value of Peatlands

Human society has been dependant on Canada's peatlands in three ways: (a) as peatlands as pristine sites, (b) as sites in various states of management, and (c) as modified areas for the production of materials and products.

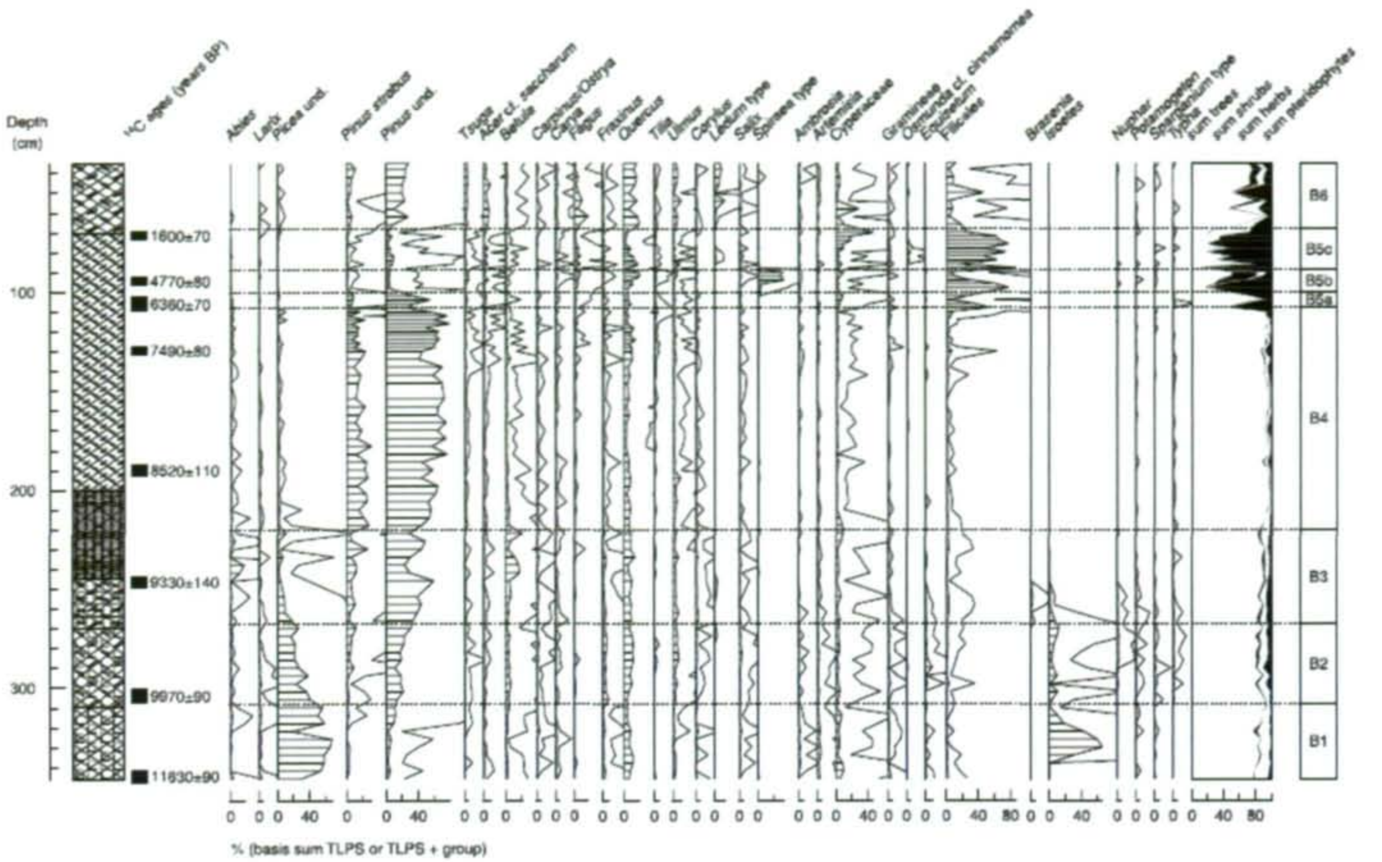


Fig. 19: Pollen diagram from the Spiraea Swamp, a typical basin swamp and fen, near Paris, Ontario, a representative basin swamp and fen complex in the Temperate Wetland Region. (BUNTING et al. 1999).

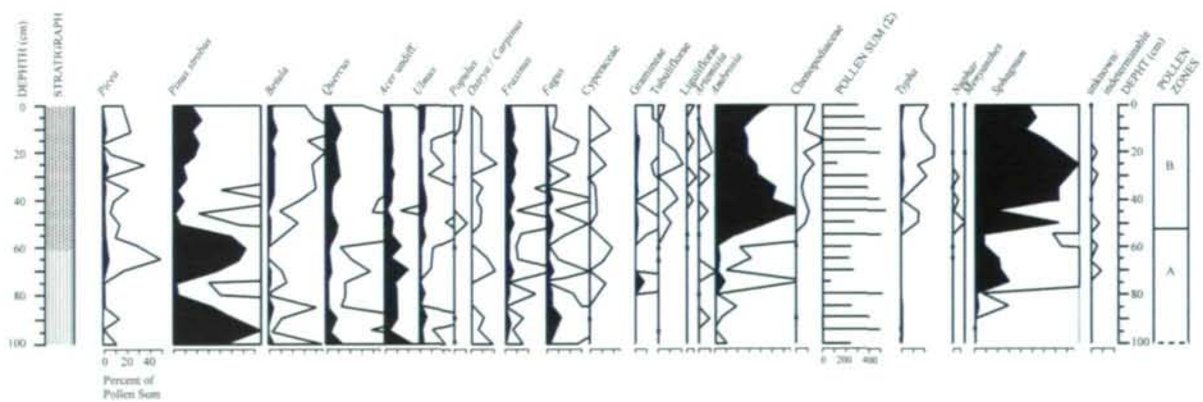


Fig. 20: *Pollen diagram through a floating Sphagnum peat mat in a basin fen near Cambridge, Ontario. Note the abundance of Ambrosia* pollen at the top of pollen diagram which correlates with the early forest clearance and settlement period corresponds to and the abundance of *Sphagnum* peat and spores in the floating mat (after WARNER et al. 1989).

In their pristine state, peatlands serve to store water supplies and protect surface and ground waters from contaminants. This value of peatlands is particularly important in the densely populated regions and in rural parts of the country where the same water sources serve people, livestock, and crops. Most of the streams and rivers have their headwaters in peatlands which if left intact can help to preserve water quality and quantity in downstream reaches and in groundwater aquifers. Peatlands also contain great quantities of carbon in their living plant communities and in the dead peat biomass deep below the surface. As such they sequester large quantities of carbon and can remove dangerous climate warming greenhouse gases from the atmosphere. Peatland


Fig. 21: Wainfleet Bog, Ontario is Canada's most southern bog. It is severely degraded and has been reduced to less than 15% of its original size. **(a)**: The most intact east side is being invaded by alien *Betula pubescens*, and **(b)**: shows the old cutover surface on west side where commercial peat mining occurred from the late 1800s to the 1980s.

habitats are important for innumerable plant, animal and microbial communities, species and genetic biodiversity. Peatlands are used for teaching, research, recreation, and hunting by tourists and local communities. The fossile record in peatlands contains an irreplaceable historical archive of environmental and human history, especially for the period of time that begins immediately after the great ice age to time when humans began to keep their own records. Indigenous peoples attach traditional and spiritual significance to peatlands.

The value of peatlands can be enhanced when managed for a specific purpose. Some of the most important areas for growing market vegetables and various other agricultural crops are on peatlands near the largest cities in Canada. Examples include the bog and fen soils on the Fraser Delta in southwest British Columbia. The Holland Marsh north of Toronto is an area of fen and swamp that was converted to agriculture by Dutch immigrants in the early 1900s. Bog, swamp and fen in the Clay Belt in northeast Ontario have been converted to cropland and pasture, and so is the case along the south shore of the St. Lawrence between Montreal and Quebec City.

There have been small scale operations and numerous attempts to drain peatlands to improve tree growth for forestry because peatlands are prime habitat for black spruce (*Picea mariana*), which is the most important tree species for pulp and paper. Peatland forestry is not widely practiced in Canada. Some of the early attempts to drain peatlands to improve tree growth started in the 1920s in the Clay Belt near the Ontario-Quebec border in northeast Ontario.

The third use of peatlands is for the production of materials and other economic commodities. Peatlands were one of the first sources of iron in Canada. Bog iron, the impure iron deposits that develop in peatlands by the chemical or biochemical oxidation of dissolved iron was noted as early as 1670 in peatlands near Trois-Rivières, Quebec. Raw iron was mined from peatlands to manufacture stoves, kettles, pots, and other iron goods in early blast furnaces. One of the first such enterprises was built in 1811 near Furnace Falls (now Lyndhurst), a few miles north of Gananoque in eastern Ontario. Another successful operation was set up in 1813 south of the village of Simcoe in southern Ontario. Bog iron was eventually replaced by more pure and economical iron ore. The Simcoe iron foundry moved in the 1840s to near Peterborough when much of the country switched to using iron ore (INWOOD 1986).

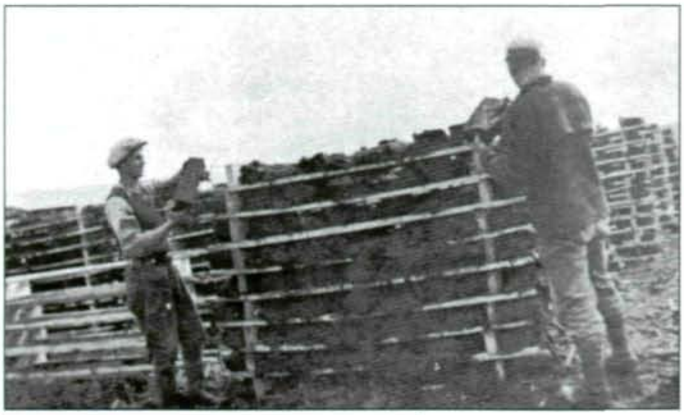


Fig. 22: Two photographs taken in the 1940s of cutting peat by hand at Riviere-du-Loup, Quebec. The peat was being harvesting for use as fuel.

There has long been an interest in the use of peatlands for fuel peat because it was popular and inexpensive in Europe. The first commercial peat operation was established on a bog in 1864 southeast of Montreal, Quebec (WARNER & BUTEAU 2000). Canada's peat industry had a bumpy start for the first few decades (Fig. 22).

The industry turned around in a major way after World War II when an emphasis in fuel peat shifted to horticultural peat and other peat products. The peat moss industry started in Ontario and Quebec. Today there are no commercial operations in Ontario. Quebec, New Brunswick and Alberta are the leading producers of horticultural peat. Canada is one of the world's largest producers of horticultural peat (LAMARCHE & DAIGLE 1999, BUTEAU & WARNER 2000).

The acidic and peat soils of bogs support commercial production of berry crops such as cranberries (*Vaccinium oxycoccus*), thimbleberry (*Rubus idaeus*), and cloud berries (*Rubus chamaemorus*. The province of British Columbia is one of the largest cranberry growing regions in North America.

Fig. 23: A peatland prepared for harvesting cranberries (*Vaccinium macrocarpon*) in central Ontario.

Hunting for fur-bearing animals, such as beaver which is approaching nuisance status in many parts of its range, is important for livelihoods of many indigenous and local residents. Hunting and fishing is an important part of the ecotourism industry in many remote parts of the country. An example of ecotourism noted for promoting peatlands is the Polar Bear Express which is a popular tourist attraction in Subarctic and Boreal Canada. Its inaugural run was in 1964 and carries thousands of tourists between Cochrane and Moosonee at the mouth of the Moose River on James Bay through the remote wilderness of the second largest peatland area in the world.

Peatlands contribute a large part to Canada's wetland industry (WARNER 2003). We usually think of only the peat moss industry when we think of a peatland industry but it is much more. The existence and economic importance of peatlands has been overlooked because many of the economic activities are small, family-run operations scattered in rural and economically disadvantaged parts of the country. Unfortunately there has not been any attempt to quantify the total economic value of peatlands and peatland businesses, but if estimates could be made, the resulting dollar figures would be surprisingly large.

Conservation and Future of Canada's Peatlands

It has been estimated that about 200,000 km^2 of wetlands, which includes peatlands, have been altered by humans since European settlement about 200 years ago (RUBEC 1996). This is about 16 % of the total extent of wetlands today. This number likely includes mostly non-peatland wetlands because wetlands in the Prairie and Temperate Wetlands Regions are included where peatlands are few or were non-existent historically.

There has been no inventory of protected peatlands under federal, provincial, and municipal legislation. About 17 % of the land in national parks and wildlife protection areas is wetlands (RUBEC 1996), and a large proportion of this is likely peatlands. Canada was the first nation in the world to have a "Federal Policy on Wetland Conservation" (ENVIRONMENT CANADA 1991). It aims to promote the protection and conservation of all wetland resources, including peatlands, through education, research, and public-awareness. At least six of Canada's ten provinces have adopted provincial wetland conservation and management policies (RUBEC 1996), and provinces such as New Brunswick have policies governing peat mining (PROVINCE OF NEW BRUNSWICK 2001). Policies exist at regional and municipal levels, for example, the Grand River Conservation Authority in southern Ontario (GRCA 2003).

The horticultural peat industry, represented by the Canadian Sphagnum Peat Moss Association, promotes a professional code of practice which is sensitive to environmental wise use and management of the peatland resource on which it so depends, and supports research on bog restoration methods for peat mining companies (QUINTY & ROCHEFORT 1997, ROCHEFORT et al. 2003). Peat mining currently uses 0.02 % of the total peatland resource in Canada. Recognition by the industry to adopt sustainable practices will ensure the future viability of the resource and the environmental and economical necessities for safe and sure livelihoods of Canadians (RUBEC 1996).

Maple syrup, hockey and the beaver have become important symbols of Canada. Peatlands should be added to this list of important symbols. Most Canadians probably take peatlands for granted and do not realize how close their health and livelihoods are linked to peatlands.

Zusammenfassung

Moore sind in Kanada weit verbreitet. Die postglaziale Entwicklung der Landschaft, in Verbindung mit dem großen Wasserüberschuss, niedrigen Temperaturen und dem humiden Klima haben dazu beigetragen, dass Torfbildung und Moorentwicklung optimale Bedingungen hatten.Studien zu den kanadischen Mooren begannen im späten 18. Jahrhundert und wurden im frühen 19. Jahrhundert vor allem von europäischen Wissenschaftlern fortgesetzt, die Erfahrung und neue Techniken – wie z.B. die Pollenanalyse – in Kanada einführten. Eingehende Untersuchungen der Moore im ganzen Land begannen allerdings erst in den 50er Jahren des vorigen Jahrhunderts. Alle Torf akkumulierenden Feuchtgebiete mit mindestens 40 cm Torfmächigkeit wurden als Moore definiert, was einen Anteil an der Landesfläche von 1,100.000 km? oder 14 % ergibt.

Moore werden in Kanada in Hochmoore, Niedermoore und Bruchwälder eingeteilt, wobei jede Gruppe noch weiter in Formen und Typen unterteilt wird. Insgesamt gibt es 56 solcher Formen und Typen. Ungefähr zwei Drittel der Moore Kanadas liegen in der borealen Nadelwaldzone und nahezu ein Drittel in der subarktischen Tundra; deutlich seltener sind Moore im Gebirge, in der ozeanischen Region und im Bereich des temperaten Klimas.

Die Moore Kanadas haben eine verhältnismäßig lange Nutzungsgeschichte. Sie wurden für eine Reihe von Bedürfnissen der Gesellschaft und Wirtschaft des Landes genutzt: als intakte, schwach oder auch stark veränderte Moore. Gegenwärtig sorgen politische Konzepte, Managementpläne und Industriecodes dafür, dass Kanadas Moore durch Schutz und nachhaltige Nutzung für künftige Generationen erhalten bleiben.

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