Geoscience Canada

History of Geology:
Early Work in Quaternary Botany in Canada

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Volume 13, Number 1, March 1986

URI: https://id.erudit.org/iderudit/geocan13_1fea01

See table of contents

Publisher(s)

The Geological Association of Canada

ISSN

0315-0941 (print)
1911-4850 (digital)

Explore this journal

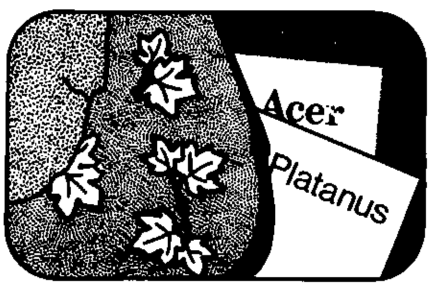
Cite this article

Warner, B. G. (1986). History of Geology:: Early Work in Quaternary Botany in Canada. *Geoscience Canada*, *13*(1), 39–44.

Article abstract

The first collections of Quaternary fossil plants in Canada were made by Sir William Dawson in 1857. His collections were probably the first in North America and among the first in the world. Noteworthy contributions by D.P. Penhallow laid the foundation of Quaternary botany in Canada with his studies on the fossils from the famous Sangamonian Don Formation at Toronto and late Wisconsinan nodules at Green Creek, Ottawa, in addition to numerous miscellaneous collections from across Canada. A re-examination of these early collections and new samples from some of the same localities reveals a high standard of identification and interpretation. Interestingly, current Canadian Quaternary botanists have no links with the early pioneers; they came here during the 1950's from European and American lineages.

Features



History of Geology

Early Work in Quaternary Botany in Canada

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Summary
The first collections of Quaternary fossil plants in Canada were made by Sir William Dawson in 1857. His collections were probably the first in North America and among the first in the world. Noteworthy contributions by D.P. Penhallow laid the foundation of Quaternary botany in Canada with his studies on the fossils from the famous Sangamonian Don Formation at Toronto and late Wisconsinan nodules at Green Creek, Ottawa, in addition to numerous miscellaneous collections from across Canada. A re-examination of these early collections and new samples from some of the same localities reveals a high standard of identification and interpretation. Interestingly, current Canadian Quaternary botanists have no links with the early pioneers; they came here during the 1950's from European and American lineages.

Introduction
As Canadians, most of us must look to Europe or to other lands outside North America to find our genealogical roots. Such is not the case in Canada, however, when one speaks of Quaternary botany, the study of fossilized plant remains in deposits dating within the last two million years.

Studies in Canadian Quaternary botany began with Sir John William Dawson, the son of Scottish immigrants to Pictou, Nova Scotia, where he was born in 1820, and his discovery, as a schoolboy, of a bed of fossil leaves in shale deposits near his home (Clark, 1972). As a consequence, Dawson pursued a career as a geologist, eventually becoming an international authority on Paleozoic plants. Dawson also gave the overlying Quaternary deposits considerable attention. In 1857, he published the first paper on Canadian Quaternary plant fossils, reporting on specimens found near Ottawa and Montreal. The course of history has overlooked two important concepts which Dawson either initiated or strongly promoted (Penhallow, 1901). Fortunately, these concepts have reappeared recently in discussions on Quaternary ecology. The first is that plant fossils should be regarded as products of a vegetation community that developed by succession and competition. As a consequence of this concept, Dawson warned that it is misleading to date deposits or to reconstruct geography or climate on the basis of a single plant taxon. Whether or not he was conscious of the steamy debate in Europe at the time, this view placed Dawson on the side of Gunnar Andersson and his colleagues, scientists who advocated environmental reconstructions based on the ecological demands of individual taxa, as opposed to Axel Blytt and Rudger Sernander who preferred to identify and trace complete plant communities through the fossil record. Today it is accepted that the two concepts are not mutually exclusive, but the debate persists, most actively among peatland paleoecologists.

The second idea was undoubtedly sparked by his belief in the Noachian deluge theory and the purported former presence of icebergs from northern latitudes; Dawson suggested these icebergs could have transported plants as well as erratic boulders. Hence, Dawson cautioned that it is important to consider the stratigraphic context and nature of the enclosing sediments before accepting the plant fossils as evidence for local presence beyond modern distributional boundaries.

Perhaps it is no coincidence that the study of Quaternary plant fossils began with the first geological surveys in Canada. Even the most passive observer cannot help but notice large logs and tree stumps protruding from sea cliffs, peat clasts with leaves washed out along lakeshores and river banks, or plant debris buried deep beneath the present ground surface in hand-dug water wells. Some of the sites which attracted the attention of Dawson and his colleagues are among some of Canada's most prominent fossil localities (Figure 1). These include the Don Valley Brickworks and Scarborough Bluffs at Toronto, Green Creek near Ottawa, and the Point Grey Seacliffs at Vancouver. The purpose of this report is to highlight some of the important contributions of Canada's fathers of Quaternary botany which have been long forgotten, and to put their work in the context of modern research.

The Early Years
The Dawson and Penhallow Period, 1857-1910. Sir William Dawson's discoveries of fossil plants in Quaternary deposits were made at a time when his contemporaries, among whom were Andersson, Lindberg and Nathorst in Scandinavia, Weber in Germany, and Reid in Britain, were engaged in similar botanical surveys in Europe (Dawson, 1857, 1866, 1893). Dawson's early studies lacked stratigraphical precision and did not involve quantitative sampling. His primary purpose for collecting the fossils was to arrive at geological dating and geographical correlations; this dating has since been replaced by direct techniques such as carbon-14.

In 1883 at the age of 29, David Pearce Penhallow joined McGill University as professor of botany (Figure 2; Barlow, 1911). This appointment brought Penhallow in close association with the principal of the university at the time, Sir J.W. Dawson; they formed a team and worked together for 16 years until Dawson's death in 1899 — a team that blazed a path for Quaternary botany in Canada (Dawson and Penhallow, 1890; Dawson *et al.*, 1898; Penhallow, 1894, 1896, 1901, 1904, 1907).

Penhallow's combined interest in botany and paleontology must have had far-reaching impact; it was more usual for botanists

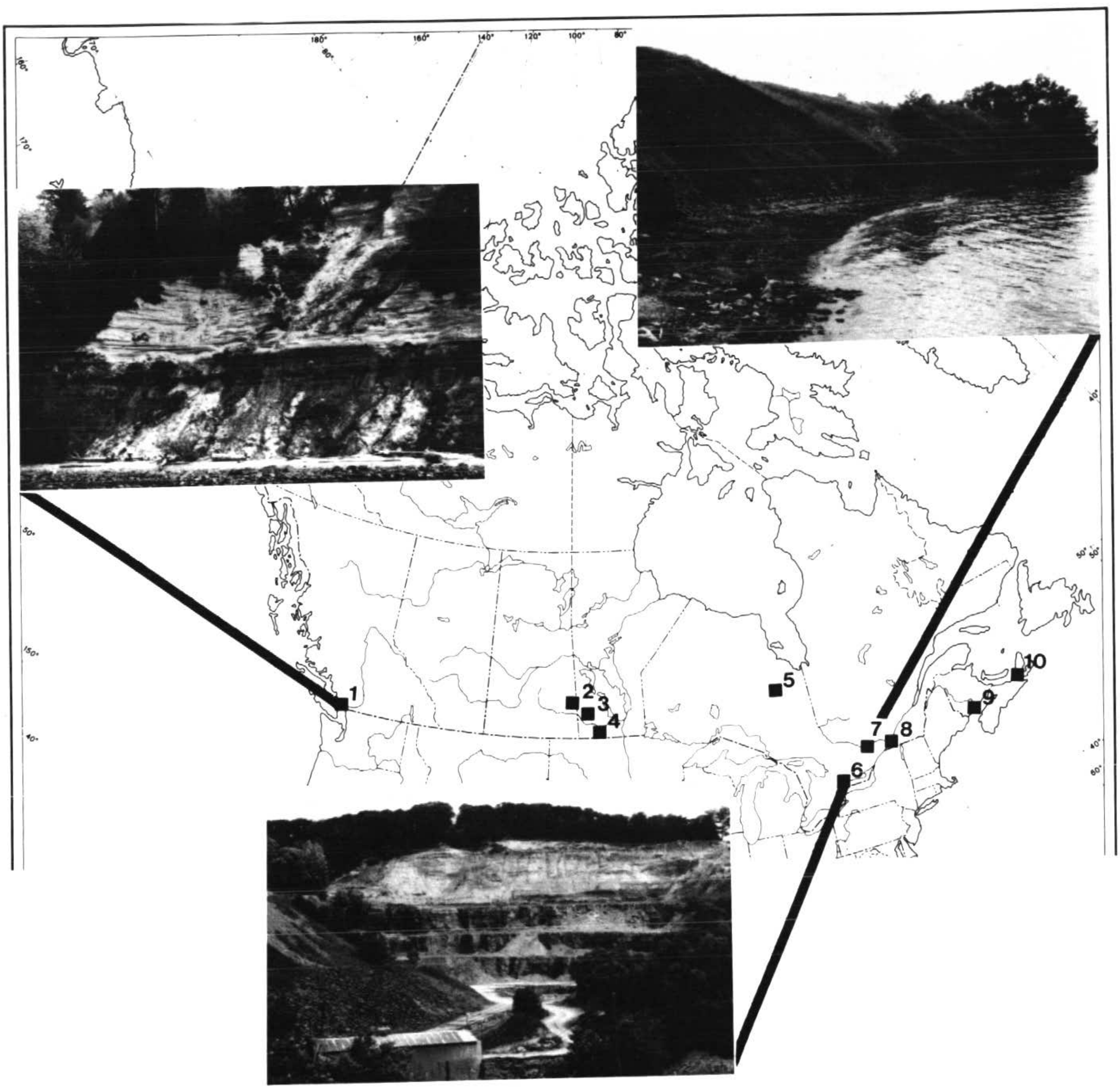

Figure 1 *Location of early fossil collecting localities. Photographs were taken by the author in 1984. Numbered sites are as follows:* **1***-Point Grey, British Columbia;* **2***-Churchbridge, Saskatchewan;* **3***-Solsgirth, Manitoba;* **4***-Pilot Mound, Manitoba;* **5***-Moose and Missinaibi Rivers, Ontario;* **6***-Toronto, Ontario;* **7***-Green Creek, Ontario;* **8***-Montreal, Quebec;* **9***-Mace's Bay, New Brunswick; and* **10***-Inhabitants River, Nova Scotia.*

to study living plants and for geologists to study fossil plants (Penhallow, 1901). Though Penhallow and Dawson had a strong friendship and mutual respect, they held opposing beliefs regarding evolution. This difference stemmed largely from Dawson having been raised in a home with a strict religious commitment. This inclined him to support catastrophism and the deluge theory, and perhaps explains his contradictory views for the existence of separate and successive species in the fossil record. Penhallow's training as a botanist, on the other hand, did not interfere with any religious beliefs he may have held, as indicated by his attempts to fill the evolutionary gaps in plant descent with new and extinct forms.

The last 27 years of Penhallow's career were devoted to the study of fossil plants, both Paleozoic and Cenozoic in age, among which he identified about 50 taxa believed to be from Quaternary deposits. The collections consisted largely of wood specimens and leaf compressions, and most of Penhallow's papers deal simply with identification and description. But at the back of his mind, one clear concept was always present — the southern and northern movement of plant associations with the advancing and retreating glacier icefront during the Quaternary Period. This concept was reinforced by the work of Asa Gray, and a growing knowledge of the modern flora in Canada (Penhallow, 1907).

Post-Penhallow and the Dawning of Pollen Analysis, 1910-Ca. 1930. Just six years after the death of Penhallow in 1910, Lennart von Post delivered his famous lecture in Oslo, Norway, on "Forest tree pollen in south Swedish peat bog deposits" (von Post, 1967).

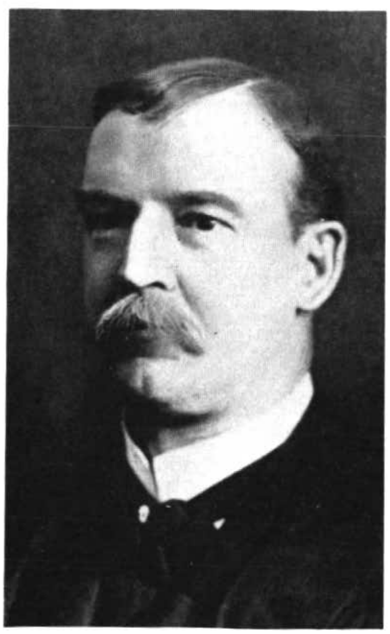

Figure 2 *David Pearce Penhallow. Taken from Barlow (1911).*

Pollen grains were known to exist in geological deposits as early as 1836 (Faegri and Iversen, 1975), but it was von Post who first expressed the results of pollen studies as a stratigraphic sequence of relative frequencies. Quaternary botanists were excited, and favoured the more quantitative and stratigraphically precise technique offered by pollen analysis.

Further interest in the study of the macroscopic plants fell by the wayside. This new interest in fossil pollen grains was carried to Canada in 1927 by a Finnish geologist, Vaino Auer, who published the first pollen diagrams from peatlands in North America. He did not ignore the macroscopic plant fossils, however, as lists of the macrofossils supplemented his pollen analyses of the Holocene peatlands, and of the interglacial Missinaibi and Moose Rivers buried peat beds in northern Ontario (Auer, 1927a, b, 1930).

There are few other reports on Quaternary plant fossils of any kind during this period. One paper by Berry and Johnston (1922), Berry being an American paleobotanist, reported fossils in seacliffs at Vancouver. This constitutes the first study of Quaternary plants from the west coast of Canada. Compared with the time of Dawson and Penhallow, Quaternary botany stagnated for about 25 years until the further development of pollen analysis in the 1950's in Canada. Pollen analysis is still a critical part of paleobotanical studies today, but a renewed interest in plant macrofossils in recent years indicates that the course of Quaternary botany has gone full-circle.

Fossil Localities

Green Creek, Ottawa, Ontario. Generally, the Green Creek site refers to an area along the south bank of the Ottawa River bounded by 75°31'W and 75°36'W Longitude and 45°25'N and 45°30'N Latitude (Figure 1; Harington, 1983). The collections of plant fossils come from calcareous nodules (Figure 3) that are washed out from exposures along the river bank between Hiawatha Park (formerly Besserer's Wharf) and the mouth of Green Creek.

The calcareous nodules are confined to what is thought to be a reworked stratified clay unit laid down in freshwater; this in turn is derived from an underlying older, massive marine clay unit (Gadd, 1963). The origin of the nodules is not known. However, a number of hypotheses have been proposed (Gadd, 1980). Stratigraphical and paleontological evidence suggest that the nodules date to about 10,000 years B.P., near the close of the Champlain Sea episode in the region (Harington, 1983). A radiocarbon date of 9960 ± 820 years B.P. (GSC 2498) on a possible willow twig contained in one nodule, as well as other dates from Champlain Sea deposits elsewhere in the region, establishes a maximum age for the fossils (Gadd, 1980).

The first Quaternary plant fossils collected in Canada, which include leaves of balsam poplar (*Populus balsamifera*) and Norwegian cinquefoil (*Potentilla norvegica*), were from Green Creek nodules (Dawson, 1857). I have re-examined these collections and find it difficult to confirm Dawson's determinations. The leaf compression is most probably poplar, and the more oblate shape and fine dentate margin would favour balsam poplar, but trembling aspen as an alternative cannot be ruled out. The leaf compression originally determined as Norwegian cinquefoil should be regarded as a tentative determination, until a more critical diagnosis can be undertaken. The fossil of *Fucus* figured in Dawson (1866, p. 73) is in fact a marine macrophytic alga, most probably belonging to the genus *Fucus*.

Recent collections have revealed leaves of either balsam poplar or trembling aspen (NMC #34943). In addition, I can confirm Penhallow's report of comb-like pondweed (*Potamogeton pectinatus*). Comb-like pondweed occupies shallow water on mud flats at the edge of freshwater and brackish water bodies. This taxon indicates a nearshore environment, either brackish or freshwater but not marine; this interpretation is compatible with that of Dawson and Penhallow.

Don River Valley and Scarborough Bluffs, Toronto, Ontario. Studies on the Quaternary deposits in the Toronto region have a longstanding history that extends back as far as 1829 (Karrow, 1969). During the latter part of the last century and the early part of this century, the need for building materials in Toronto necessitated the establishment of several brick factories. The valley of the Don River was favoured initially because it contained Quaternary clay deposits, and later,

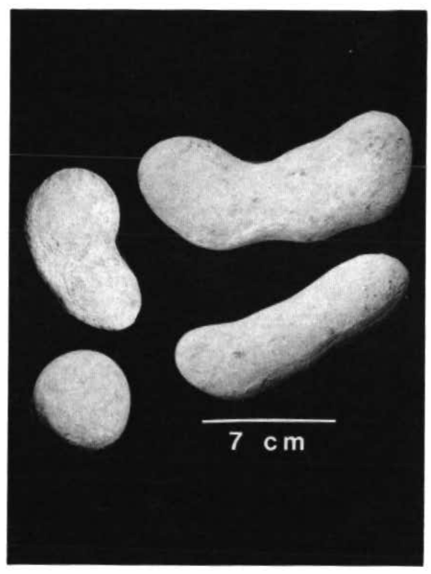

Figure 3 *Calcareous nodules from Green Creek, collected June, 1984. Shapes can range from perfectly round balls to more flattened and longitudinal types. The latter types usually are best for fossils.*

because of its Paleozoic shales of the Georgian Bay Formation. Fortuitously, the brick quarries provided many fine exposures, and an opportunity to study the Quaternary deposits in the region in detail.

In its general stratigraphy, there is a till layer (York Till) immediately covering bedrock; this till is thought to have been deposited during the penultimate (Illinoian) glaciation. Overlying the till are the fossil-bearing stratified sand and clay beds of the Don Formation, attributed to the last interglaciation, the Sangamonian. In turn, the clayey Scarborough Formation represents deltaic deposits that overlie the Don Formation. In contrast to those in the Don beds, the fossils in the Scarborough Formation are more common at higher latitudes today, suggesting a cooler climate (Karrow, 1969). Finally, the remaining deposits in the sequence tell of the gradual onset of full glacial conditions during Wisconsinan time, the ice retreat, and the progression to the present interglacial period. A tripartite climatic sequence of cool temperatures, subsequent amelioration and a return to cool temperatures has been long recognized in the Toronto Region (Penhallow, 1901). Recent studies, however, place the sediments of the Scarborough Formation within Early Wisconsinan time; and these sediments are not interglacial in character and related to the Don Formation as was thought by early geologists. The Don Formation extends northward from the Scarborough Bluffs, and probably underlies much of the region now occupied by Metropolitan Toronto. The sediments comprising the Don Formation are fluvial and alluvial deposits associated with a river system in a large bedrock gorge that flowed southward from the vicinity of present Georgian Bay to a lake in the Ontario basin which stood about 18 m higher than modern levels (Karrow, 1969; Eyles *et al*., 1985).

A.P. Coleman (1894, 1895) was the first geologist to recognize the true interglacial character of the Don Formation. His understanding was aided by Penhallow and J.W. Dawson, who were the first to name many of the fossil broad-leaved thermophilous tree taxa found in these beds (whose modern ranges extend southward from southern Ontario). Many of the finest fossils from this locality, most of which are wood, were collected during these early years by employees working in the brickpits without the aid of machinery, by other amateurs, and by Coleman himself.

Among the most interesting collections are nearly complete leaf compressions of two of Penhallow's extinct maples: *Acer pleistocenicum* and *Acer torontoniensis* (Figure 4). I have located the type specimens and can confirm earlier suspicions (Brown, 1942) that the leaves represent aberrant forms of extinct sycamore (*Platanus occidentalis*; Warner, 1984). One other supposed extinct taxon is a honey-locust tree (*Gleditsia donensis*), but I have been unable to locate a type collection. It is doubtful that an extinct species can be recognized confidently as this identification was probably based on fragmented leaflets. Extinctions in the Quaternary flora are recognized rarely today, because most fossil taxa can be referred to modern ones.

The regional interglacial character of the Don Formation is well established on the basis of the pollen and other fossils (Terasmae, 1960; Karrow, 1969). Sycamore indicates a rich floodplain and valley bottomland, probably along the ancestral Don River. Associated minerotrophic peatlands and seasonally flooded wetlands are indicated by Penhallow's silver maple (*Acer saccharinum*), black ash (*Fraxinus nigra*), white oak (*Quercus alba*), and eastern white cedar (*Thuja occidentalis*). In my samples, I have found a number of shrub and herb species that support these interpretations, along with a variety of aquatic taxa that apparently thrived in open, shallow-water pools and river margins.

Point Grey, Vancouver, British Columbia. The spectacular seacliffs at Point Grey on the University of British Columbia campus (49°15.9'N, 123°15.8'W) expose over 50 m of well-sorted, horizontally and cross-bedded sand and silt (Figure 1). Although the bluffs continually are cut back by the sea, they have not changed markedly since the 1920's when Johnston (see Plate 1 in Berry and Johnston, 1922) conducted his geological study of the area. Today, these deposits are regarded as belonging to the Quadra Sand Formation, comprising fine- to coarse-grained sand with minor gravel and silt beds (Armstrong and Clague, 1977). The Quadra Sand was deposited as a prograding outwash apron during advancing phases of Fraser Ice in the Georgia Depression, at a time when sea levels were much lower than present (Clague, 1981). The Quadra Sand is diachronous unit with the oldest ages exceeding 29,000 years B.P. to the north and northeast, and with progressively younger ages of about 15,000 years B.P. southward. Dates that range from about 26,000 to 24,000 years B.P. have been obtained from the Quadra Sand Formation at Point Grey (Clague, 1980).

Berry and Johnston (1922) found leaf and seed remains of seven shrub taxa that they suggested were characteristic of *Sphagnum* bogs and muskeg in the interior and northern

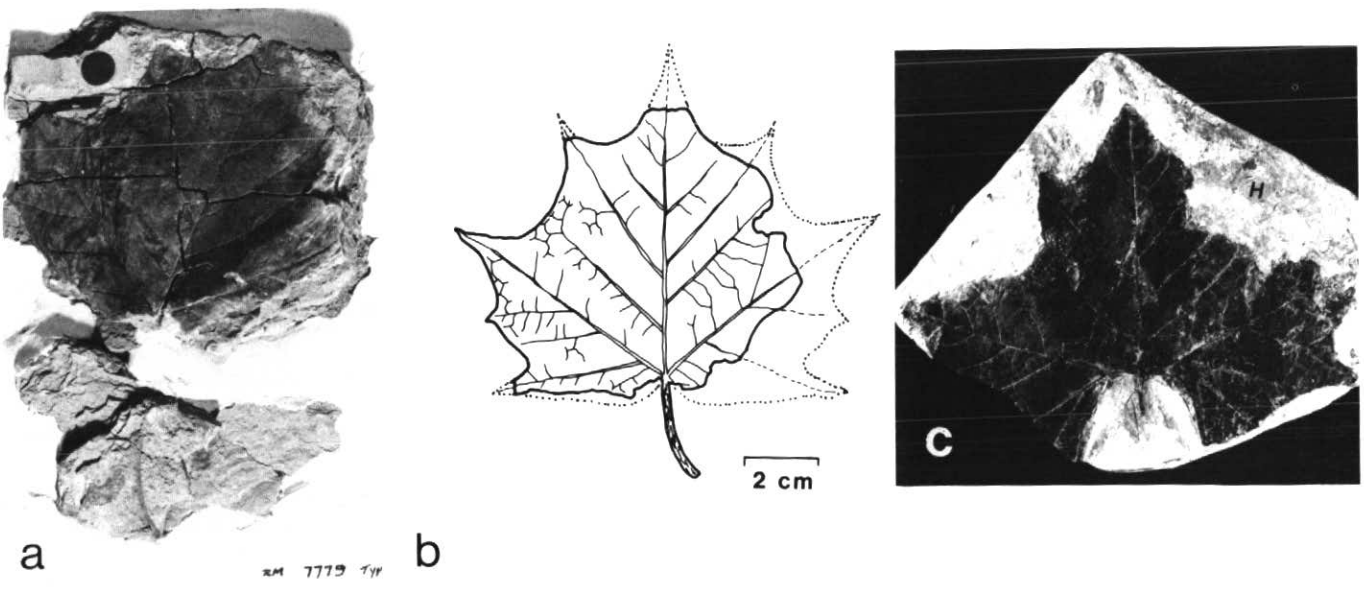

Figure 4 *Fossil leaves of* Platanus occidentalis *from the Don Formation, Toronto.* ***(a)*** *Type specimen of Penhallow's* Acer pleistocenicum, *Redpath Museum 7779.* ***(b)*** *"*Acer pleistocenicum*", redrawn from Figure 1 in Dawson and Penhallow (1890). Compare with* ***(a)***. ***(c)*** *Type specimen of Penhallow's* Acer torontoniensis, *ROM 20211.*

part of the province today. In May 1981, I visited the Point Grey seacliffs and found numerous organic stringers in the silt and clayey-sand beds within the Quadra Sand Formation. These were undoubtedly similar to those Johnston recorded. I recovered a male catkin of what is most likely pedicelled willow (*Salix pedicularis*), a taxon that Berry and Johnston (1922) listed among their leaf remains (Figure 5). This is the only species that our two lists have in common, but perhaps more important, is my discovery of a number of other shrub, herb, and moss fossils whose modern distributions do not extend to the coast today. Indeed, they are characteristic of more interior, continental-type environments!

During the time that these plants were living, the sea was much lower relative to the present land. It remains an open question, however, if the plants represent local communities that lived at Point Grey as was suggested by Berry and Johnston (1922) or are detrital aggregations that were carried downstream in proglacial meltwater channels.

Other Sites. Plant remains commonly were encountered by geologists, H.M. Ami, the Bells, the Dawsons, J.B. Tyrrell and others during their mapping acitivities across Canada. Some of the early collections reported by Dawson and Penhallow come from Holocene peat deposits near Mace's Bay in New Brunswick, sub-till peat deposits on Cape Breton Island, and along the Missinaibi and Moose Rivers in northern Ontario, and from deep pits in Saskatchewan and Manitoba (Figure 1).

The fossils from New Brunswick were collected by Ganong (1897) during his studies of the development of raised bogs along the southeastern coast of the province. The presence of buried tree stumps in these peatlands, some of which Penhallow identified as white pine (*Pinus strobus*) and tamarack (*Larix laricina*), did not help Ganong much in deciding whether these peatlands developed by cyclic regeneration, as purported by Blytt and Sernander, or by some other process as advocated by Andersson. Ganong remained uncommitted.

The organic deposits along the River Inhabitants were rediscovered by D.R. Grant in 1970. Radiocarbon dating, pollen analyses and wood identifications indicate that the deposits represent an Early Wisconsinan Interstade (Mott, 1971). Dawson's collection of yew wood (*Taxus canadensis*) (Penhallow, 1896) is in keeping with modern interpretations of a wetland and floodplain habitat along an ancestral River Inhabitants.

The Sangamonian Interglacial peat beds along the Moose and Missinaibi Rivers are well known. As Skinner (1973) notes, early geologists confused Quaternary peat and Mesozoic lignite and simply described them together as interglacial lignite. With this in mind, the specimens examined by Penhallow are not very useful with the poor collection data that accompany the fossils.

One interesting collection is wood from near Churchbridge, Saskatchewan (originally labelled Manitoba) (Figure 6, Penhallow, 1892). Penhallow regarded this taxon as representing another extinction and named it Churchbridge tamarack (*Larix churchbridgensis*). My preliminary diagnosis indicates that the wood is certainly that of a conifer, and possibly tamarack, however it is not possible to confidently distinguish it from spruce. The precise stratigraphic position of the collection is not clear; nor is the age known. There is a strong likelihood that it is pre-Quaternary in age, and represents reworked wood that was incorporated into Quaternary sediments.

This discussion emphasizes the importance of taxonomy, the necessity of a thorough knowledge of distributions of the modern flora, and illustrates the impact of direct dating techniques in refining our understanding of Quaternary botany in this country. Surely had Penhallow (1896) realized that sitka spruce (*Picea sitchensis*) is an oceanic species confined to the west coast of North America today, he may have reconsidered his determination of sitka spruce fossils from the Don Formation at Toronto.

This brief overview of early studies on Quaternary fossil plants illustrates that Quaternary botany was being practiced at an early stage in Canada. In fact, Dawson's work on Quaternary plants was probably the first in North America, and among the first in the world. The earliest paper on Quaternary plants from the United States seems to be that of Lesquereux (1859).

One more point becomes clear. Current Quaternary botany in Canada was developed and is practiced by investigators with no links, direct or otherwise, with any of the pioneers; current investigators came here from European or American lineages. This is an interesting dichotomy considering Sir Dawson was among the first Quaternary botanists in the world.

Acknowledgements

I am grateful to Ingrid Birker, Redpath Museum, McGill University and Janet Waddington, Royal Ontario Museum for locating and allowing me to examine Dawson's and Penhallow's fossil collections. Dr. C.R. Harington, National Museum of Canada kindly directed me in the field to the Green Creek site. Discussions with L. Kerr-Lawson helped to improve portions of the paper. I appreciate the critical readings of the manuscript by Drs. P.F. Karrow, J.A. Legault and journal review-

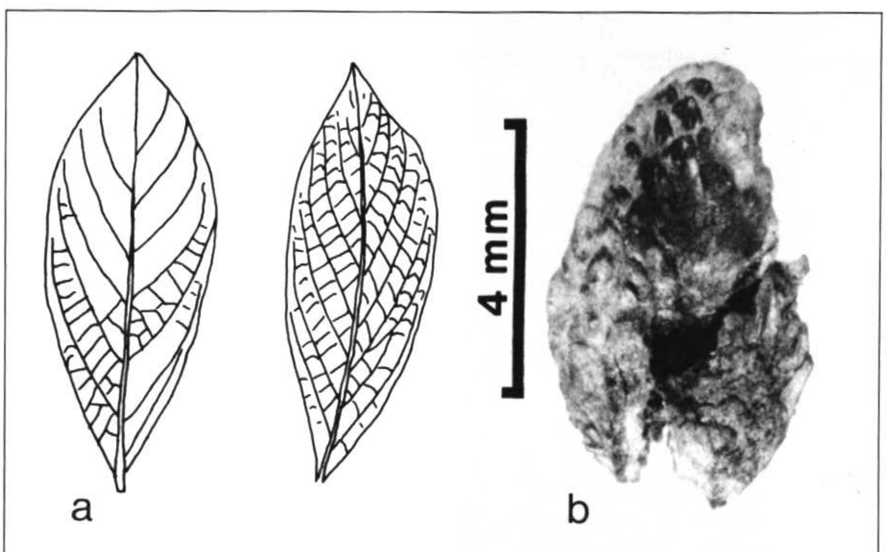

Figure 5 *Fossils of* Salix pedicillaris *from the Quadra Sand Formation at Point Grey, British Columbia. (**a**) Leaves redrawn from Plate 2 in Berry and Johnston (1922). (**b**) Male catkin of* S. pedicillaris*-type collected in May, 1981.*

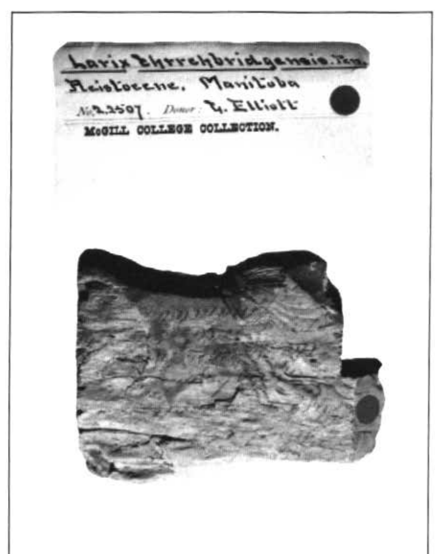

Figure 6 *Holotype of* Larix churchbridgensis, *collected by J.W. Tyrrell from near Churchbridge, Saskatchewan. Redpath Museum 22507.*

ers. Partial support in the form of an Operating Grant from the Natural Sciences and Engineering Research Council of Canada is acknowledged.

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Ms received 29 July 1985;
revision accepted 15 October 1985.