ARCTIC
VOL. 33, NO. 1 (MARCH 1980), P. 50-58

Report on the Distribution of Dwarf Birches and Present Pollen Rain, Baffin Island, N.W.T., Canada

J. T. ANDREWS[1], W. N. MODE[1], P. J. WEBBER[2], G. H. MILLER[1], and J. D. JACOBS[3]

ABSTRACT. A distribution map for the dwarf birches is presented for the region from Frobisher Bay northward to Cumberland Peninsula. These shrubs are restricted to favourable habitats which, at the northern limit of the species (67° 40′ N), are found on south-facing slopes above the immediate local cooling influence of the sea. Pollen studies within the zone of scattered dwarf birch indicate that pollen dispersal from these low, prostrate shrubs is minimal. Samples of moss collected beneath the bushes have 5-36% *Betula* pollen; whereas sites no more than 50 m away from *Betula* shrubs have percentages of <2%. These data will be useful in considering the Holocene and Pleistocene histories of these Low Arctic shrubs in the Eastern Canadian Arctic.

INTRODUCTION

An important element of Low Arctic tundra is the presence of certain shrubs, especially the two dwarf birches, *Betula nana L.* and *Betula glandulosa* Michx. Young (1971) divided the Arctic into four basic zones, each one identified by particular limiting conditions of "summer warmth." In the Eastern Canadian Arctic, the division between Young's floristic zones 2 and 3 cuts across Cumberland Peninsula, Baffin Island, in a position close to the Arctic Circle (Figure 1). *Betula* spp. are part of the diagnostic floras of Young's zone 3. Porsild (1964, p. 176) indicated that the dwarf birch population of the Eastern Canadian Arctic is composed of two species; *B. nana* is shown as occurring in East and West Greenland with an outlier along the southern coast of Cumberland Sound; *B. glandulosa* is restricted to southern Greenland and occurs northward to the head of Cumberland Sound (Figure 1, insert).

The purpose of this note is to: 1) report on the occurrence of dwarf birch on Baffin Island; and 2) comment on the modern pollen fallout of *Betula* pollen at sites close to and far distant from present dwarf shrubs. These data will be useful to Quaternary scientists interested in the relationship between the occurrence of actual dwarf birch shrubs and pollen of the *Betula* genus (*e.g.*, Matthews, 1975; Terasmae *et al.*, 1966). Indeed, the variations of *Betula* pollen, and the interpretation of nearby or distant dwarf birch stands, is a fundamental yardstick in arctic pollen biostratigraphy (Funder, 1978; Short, 1978; Vilks and Mudie, 1978).

1. Institute of Arctic and Alpine Research and Department of Geological Science, University of Colorado, Boulder, Colorado 80309, U.S.A.

2. Institute of Arctic and Alpine Research and Department of Environmental Population and Organismic Biology, University of Colorado, Boulder, Colorado 80309, U.S.A.

3. Department of Geography, University of Windsor, Ontario, Canada N9B 3P4.

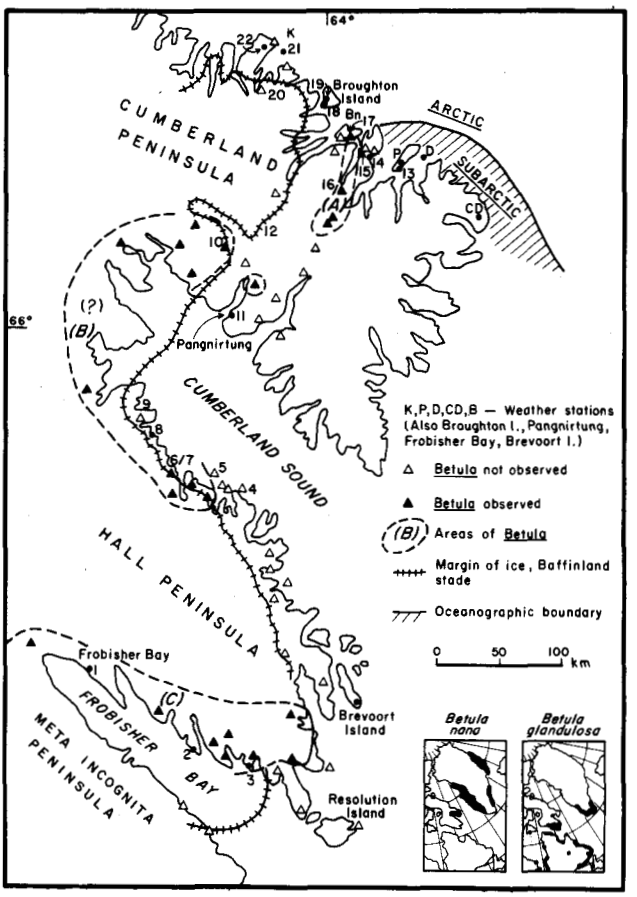

FIG. 1. Location of *Betula* in southeastern Baffin Island. Site numbers are the same as those listed on Table 2. Inserts show distribution of *B. nana* and *B. glandulosa* (after Porsild, 1964). Weather station sites (see Table 1) are shown.

Taxonomy

Our own observations show a deal of complexity in the taxonomy of our collections, which is made even more difficult by disagreements in the literature. No two authors agree on the taxonomy of the dwarf birches. All of our specimens from the southern part of the island fit *B. nana* ssp. *exilis;* but as one progresses northward, the specimens have a greater frequency of the characteristics associated with *Betula nana* ssp. *nana*. Thus, we see the suggestion of a gradient of changing characteristics from the south to the north going from *Betula nana* ssp. *exilis* through to *Betula nana* (Hultén, 1970). For a discussion of the *Betula* problem in the Eastern Canadian Arctic see Terasmae *et al.* (1970). *Betula nana* ssp. *exilis* and *Betula glandulosa* may be regarded as the same taxon. In this paper we refer to dwarf birches on Baffin Island as *Betula nana* in the broad sense or simply *Betula*.

Background

Macrofossils of dwarf birch have been reported from the Isortoq and Flitaway sediments of inferred last interglacial age (Terasmae *et al.*, 1966). These sites lie close to 70° N in central Baffin Island. High pollen counts, both relative and absolute, in sediments of the Cape Christian Member of the Clyde Foreland Formation at about 70° 30′ N near Clyde Inlet, Baffin Island, also conclusively indicate that during the last interglaciation, dwarf birch spread northward at least 3 to 4° latitude further than today (Miller *et al.*, 1977). In addition, buried sediments of interstadial age also have pollen spectra that suggest dwarf birch survived the earliest stadials of the last glaciation (Foxe Glaciation) along the eastern coast of Baffin Island (Miller *et al.*, 1977).

The history of the migration of the dwarf birches into Baffin Island is poorly known. It is not clear whether the shrubs invaded the island from the south/southwest (*i.e.*, the mainland) or whether some plants may have survived on an emerged continental shelf (Andrews, 1979; Ives, 1963, 1974).

Whether or not *Betula* survived on these coastal lowlands during this interval is a matter of speculation, although Vilks and Mudie (1978) interpret the pollen evidence from a deep-sea core in the Cartwright Basin (off the Labrador coast) to favour the presence of *Betula* throughout the period between 22,000 and 10,000 BP. A sharp rise in birch marks the onset of the Holocene warming. Further north along the Labrador Coast, in Okoa Bay, Short and Nichols (1977) and Short (1978) record a similar dramatic rise in birch pollen by about 8,000 years ago.

In Greenland, the present distribution and Holocene history of the dwarf birch species and the nunatak hypothesis has been discussed by Fredskild (1973), Kelly and Funder (1974), and Funder (1978; in press).

The most significant study of dwarf birch distribution on Baffin Island is that of Schwarzenbach (1953, translated 1975) who was a botanist on the 1953 Arctic Institute of North America (AINA) Expedition to the Penny Ice Cap and Cumberland Peninsula. He recognized that dwarf birches formed a distinct vegetational belt which extended to 350 m a.s.l. at the head of Padle Fiord, northern Cumberland Peninsula. Schwarzenbach (1953) remarked that the distribution of this genus, and other species, supported the concept of a glacial refugium in the area during the Last Glaciation. On Figure 1, we show the glacial margin during the Baffinland stade of the Foxe Glaciation. This boundary is diachronous and dates between 11,500 and 8,600 BP (Dyke, 1979; Miller, *in press*).

Regional Climate

The climate of southeastern Baffin Island is characterized by cool, frequently cloudy summers and cold winters (Table 1). At some of the southernmost coastal locations, open water persists throughout the winter, resulting in somewhat milder, wetter winter conditions than are the rule elsewhere. Precipitation is highly variable reflecting substantial gradients in relation to proximity to open water. Winds are generally northwesterly along

TABLE 1. Mean temperature and precipitation at southern Baffin Island stations[1]

Station	Abbreviation (Fig. 1)	Temperature (° C) Summer (JJA)	Winter (DJF)	Annual	Precipitation (cm) Annual
Brevoort I.		2.9	-20.1	-8.8	33.8
Broughton I.		2.7	-23.5	-11.2	38.4
Cape Dyer	CD	3.6	-21.9	-10.0	72.1
Frobisher Bay		6.1	-24.9	-9.0	40.6
Padloping I.	P	3.8	-23.8	-10.2	27.7
Resolution I.		3.0	-18.0	-7.6	38.1

[1]Source: *Canadian Normals – 1941-70,* Canada, Atmospheric Environment Service, Downsview, Ontario, 1975. Note that the period of record for Baffin Island stations is generally less than 30 years.

Davis Strait, but southerly gales are not uncommon, particularly in autumn and early winter.

Conventional climatic data, while adequate to show regional patterns, do not reflect the very significant mesoscale climatic effects of the rugged topography of this region. Such factors as elevation, aspect, slope and nearness to water provide controls on climate that, on the local level, result in differences of the same magnitude as those between distant stations. Although extensive studies of local climates in southern Baffin Island have not yet been undertaken, investigations of summer conditions in coastal areas of archaeological importance by Jacobs and Sabo (1978) have revealed something of local climatic patterns. Some implications of that work for the present study are discussed below.

DISTRIBUTION OF BETULA STANDS

Figure 1 indicates stands of dwarf birch. *Betula* is located at favorable sites in the inner and middle parts of northern Frobisher Bay, in the inner parts of Cumberland Sound, at the head of Padle Fiord and in scattered localities to the north in Kangert Fiord and Canso Channel (Figure 1). No birch has been found north of Canso Channel in ten years of field work.

The northernmost stand of *Betula* occurs within 10 to 20 km of the northernmost limit of the blue mussel, *Mytilus edulis* Linne, a subarctic-boreal species (Lubinsky, 1972). The similarity (Figure 1) between the northern limits of a subarctic bivalve and a subarctic plant probably reflects the impact of oceanographic conditions on adjacent land temperatures. On the large scale, this is clearly seen in the difference between temperatures on West Greenland and eastern Baffin Island — the former reflecting the presence offshore of the "warm" West Greenland Current.

The distribution of dwarf birch suggests a series of three population clusters. Even within the areas outlin Figure 1, *Betula* is restricted to a few favourable habitats below 350 m and usually below 100 m a.s.l. At the northermost site (#11) in Canso Channel, dwarf birch is located on a south-facing slope of a former alluvial fan. The surface is well-drained and the birch is found in association with a variety of dry to mesic plants, notably *Empetrum nigrum, Ledum decumbens, Salix herbacea,* other *Salix* spp., *Arctostaphylos alpina, Saxifraga tricuspidata* (*A. alpina* is also found further north than shown by Porsild (1964, p. 194)). The stand covers about $20m^2$ and is composed of prostrate shrubs no more than 20 cm in height. The maximum elevation was measured at 104 m, but the species does not occur within 20 m of sea level. A large stand of dwarf birch covers several km^2 at the head of Padle Fiord and intermittently continues through the low pass between Padle Fiord and Kangert Fiord to site #8, where *Betula* is found in association with heath plants at the head of the fiord; however, it was not noted further down the fiord. The *Betula* at the head of the Padle Fiord forms thick extensive clumps that approach 1 m in height. They are found on the dry, exposed surfaces of eolian sands that cover most of the valley between the fiord head and the junction with the tributary, June Valley. Schwarzenbach (1953) placed his *Betula* zone as occurring between 0 and 350 m. No *Betula* was observed south of the June River confluence, and, hence, the entire tract of land between Tundra Lake and the mouth of Kinganit Fiord appears to lack a population of *Betula* — this despite favourable topographic and meso-climatic site conditions within this broad, open pass (Bright and Jones, 1977). On present evidence, then, the northern group of locations (A, Figure 1) appear to be disjunct from the central group (B, Figure 1).

A British schoolboys' expedition (Higham, 1975) observed an isolated clump of birch above the head of Pangnirtung Fiord. It occured at 550 m a.s.l. and was restricted to a south-facing slope.

The central group of birch locations (B, Figure 1) occurs south of the Penny Ice Cap and southward to include about one-half the shoreline of northern Hall Peninsula. At site #22, Dyke (pers. comm., 1974) reports thick birch clumps at "Badlands Junction" on the Usualuk River. Jones (1977) studied this site and reported on the productivity of *B. nana,* while Bright and Jones (1977) report it locally abundant with heights up to 80 cm and 30 cm diameter stems.

The southern group (C, Figure 1) is separated from area B by the outer coast sites of Hall Peninsula. Dwarf birch has been noted at sites from the head of Frobisher Bay southward to the limits noted on Figure 1. Isolated stands of dwarf birch have been found on south-facing slopes in the vicinity of the Frobisher Bay settlement. Some 10 km east of Frobisher at the head of Tarr Inlet, *Betula* occurs as numerous small (*ca.* 15 cm) shrubs on tundra hummocks in an area of the valley floor where drifting snow accumulates. Schwarzenbach (1953, p. 143) has described similar formations, which he calls "*Betula* tundra," at low elevations in the Cumberland Peninsula interior.

Microclimate

The sites favored by *Betula* are characterized by a lee slope location which offers protection from winter cold and abrasion through the accumulation of a snow pack. Over most of the region, prevailing winds in winter are northerly and the protected sites are on south-facing slopes or in hollows. The slopes offer the added advantage of high solar radiation due to the near-normal angle of incidence in mid-summer. For the Low and Transitional Arctic, the theoretical clear-sky solar flux on a moderate south-facing slope is about 50% higher than on a north-facing slope at the same location. Frequent cloudiness tends to reduce these differences.

The combined effects of shelter and south-facing slope mean both greater radiant energy input and reduced heat loss through convection than is the case on an exposed, level site. The result is higher air temperatures just above the ground, which has been confirmed by measurements at Broughton Island (67.5° N) in July and August, where daily maximum temperatures on the south sides of this and nearby islands ranged from 1° C to 8° C above those at the village on the northwest side (Jacobs and Sabo, 1978).

A lee-slope location may be of greater benefit to *Betula* than is southerly exposure, when a site does not offer both. Jacobs, who carried out topoclimatic surveys on the Talguak Peninsula (63.7° N, 69.5° W) near Lake Harbour on the south coast of Baffin Island, found that the prevailing summer and autumn winds are southeasterly, off Hudson Strait, and that small stands of *Betula* were growing on northwest-facing slopes and in sheltered, south-trending valleys and ravines, but not on the exposed, south-facing slopes. Mean August (1977) temperatures at 1.5 m above the ground at one such north-slope stand were about 2° C higher than at nearby exposed sites. Windspeed at the base of this slope averaged 66% of that on the exposed ridge 90 m above. As in other places where *Betula* is found, these sites are mesic in terms of summer moisture factor and show evidence of early and persistent winter snowcover.

MODERN POLLEN RAIN OF *BETULA*

The second major aim of our investigation was to determine the variations in the modern rain of *Betula* pollen. Our investigations of the distribution of dwarf birch (above) indicate that on southeastern Baffin Island, they occur in restricted habitats. The pollen, however, can disperse much more widely, and we wished to determine just how far pollen from the genus *Betula* travels throughout the region. Specifically, we queried whether or not there is a statistically significant difference in the modern pollen rain between sites *with* and *without* dwarf birch nearby (within 1 m).

For our investigation, we used living mosses collected at sites shown on Figure 1 (Andrews *et al., in press*). Tree birch pollen from long distance transport is assumed to be present only in small amounts. We recognize the limitations of moss polster samples, especially as they are heavily biased toward local pollen types and give a weak regional vegetation signal (Wright, 1967; Adam and Mehringer, 1974).

Processing of the moss is a standard process at the INSTAAR Palynological Laboratory (Nichols, 1975). The techniques are geared toward the low productivity of tundra regions. A known amount of "exotic" pollen is added during the preparation so that the pollen quantities can be expressed not only as relative data but as "absolute" pollen counts (grains per gram of dry weight = g/gr.dw). Table 2 includes our data on the percentage of *Betula* (expressed as a percent of 19 common taxa, see Table 2), and the absolute amount of this type from sites on southern Baffin Island (Figure 1).

The regional "noise" level of *Betula* pollen is best expressed by sites *not* dominated by the shrub. Data from Frobisher Bay, Pangnirtung Fiord,

TABLE 2. *Betula* percentages and concentrations (grains/gram dry weight) from the sites located on Figure 1. Counts from moss polsters. *Birch shrubs present at the collecting site.

Site # (see Figure 1)	*Betula* % (of 19 common taxa**)	Pollen Concentrations (gr/gdw)
1	0.0,3.0,7.6	0-1384
2	2.7	1575
3*	5.0	2682
4	1.9	116
5	2.2	64
6*	35.7	2163
7*	8.6	4982
8	1.9	72
9	1.0	135
10*	22.0	3336
11	0.8	65
12	6.0,0.9,1.0,2.0	22-65
13	0.0	0
14	0.2	32
15	0.0	0
16*	31.0	7102
17	0.0,0.6	0,48
18	0.0	0
19 (21 polsters from region)	17 to 0	—
20	0.3	80
21	0.0	0
22	1 to 6	62 to 320
Clyde (10 polsters)	0.6	0-200

**19 taxa are: *Alnus, Betula, Picea, Pinus, Salix, Ambrosia, Artemisia,* Caryophyllaceae, Chenopodiaceae, *Epilobium,* Gramineae, *Potentilla,* Rosaceae, Cyperaceae, Ericaceae, Filicales, *Lycopodium clavatum, L. selago, Sphagnum.*

Broughton Island, and Clyde River (*ca.* 70° N) (Table 2) indicate that at such sites *Betula* averages 1.11 ± .89% of the pollen rain and that *Betula* pollen quantities vary most commonly between 10^1 and 10^2 g/gr.dw. At sites within birch stands the average absolute pollen accumulation is 3.7×10^3 g/gr.dw with birch percentages averaging 16.6 ± 15.4%.

SUMMARY

Dwarf birches are found as small isolated groups along the southeastern coast of Baffin Island. They are restricted to favourable micro-topographic and microclimate sites where local summer conditions can be several degrees Celsius above the regional average. Pollen is not widely disseminated from these low prostrate shrubs. At a distance of 50 m from one clump of *Betula* (site 17, Figure 1), the amount of *Betula* pollen is < 1% (Table 2). Discriminant analysis indicates that dwarf birch may be inferred to be close to a site if *Betula* pollen percents are > 6%. Pollen concentrations also indicate a significant difference but, at the moment, we cannot deduce the pollen influx (grains/cm^2/yr) from moss polsters, and, hence, we cannot easily compare these data with pollen concentrations from fossil materials.

ACKNOWLEDGEMENTS

Field work has been supported by grants from the National Science Foundation, National Research Council, and a contract from Parks Canada. This paper is a contribution to NSF grant ATM 77-17549.

REFERENCES

ADAM, D. P. and MEHRINGER, P. J., JR. 1975. Modern pollen surface samples — an analysis of subsamples. Journal Research, U.S.A. Geol. Survey 3: 733-36.

ANDREWS, J. T. In press. 1979. Progress in relative sea level and ice sheet reconstructions, Baffin Island, N.W.T., for the last 125,000 years. In: Mörner, N. A. (ed.) Earth Rheology, Isostasy and Eustasy. London: John Wiley & Sons. pp. 175-200.

———, MODE, W. N., and DAVIS, P. T. In press. Holocene climate based on pollen transfer functions, eastern Canadian Arctic. Arctic and Alpine Research 12.

BRIGHT, P and JONES, G. 1977. Plant collections. In: Baffin 77. Mimeo report, Westminster School and Clifton College, U.K. pp. 94-95.

DYKE, A. S. 1979. Glacial and sea level history of the southwestern Cumberland Peninsula, Baffin Island, N.W.T., Canada. Arctic & Alpine Research 11: 179-202.

FREDSKILD, B. 1973. Studies in the vegetation history of Greenland. Meddelelser om Grønland 198(4): 245 pp.

FUNDER, S. 1978. Holocene stratigraphy and vegetation history in the Scorsby Sund area, East Greenland. Grønlands Geol. Undersøgelse, Bulletin #129. 66 pp.

———. In press. Ice age plant refugia in East Greenland. Palaeogeography, Palaeoclimatology, and Palaeoecology 20.

HIGHAM, J. 1975. A general botanical survey. In: Baffin 75. Mimeo report, Westminster School, U.K. pp. 22-25.

HULTÉN, E. 1970. The Circumpolar Plants II. Dicotyledons. Stockholm: Almqvist & Wiksell. 463 pp.

IVES, J. D. 1963. Field problems in determining the maximum extent of Pleistocene glaciation along the eastern Canadian seaboard. In: Löve, A. & Löve, D. (eds.). North Atlantic Biota and their History. Oxford: Pergamon Press. pp. 337-54.

——— 1974. Biological refugia and the nunatak hypothesis. In: Ives, J. D. & Barry, R. G. (eds.). Arctic and Alpine Environments. London: Methuen. pp. 605-36.

JACOBS, J. D. and SABO, L., III. 1978. Environments and adaptations of the Thule Culture on the Davis Strait coast of Baffin Island. Arctic & Alpine Research 10: 595-615.

JONES, G. 1977. Productivity of *Betula nana* L. and *Salix herbacea* L. in central Baffin Island. In: Baffin 77. Mimeo report, Westminster School and Clifton College, U.K. pp. 77-80.

KELLY, M. and FUNDER, S. 1974. The pollen stratigraphy of late Quaternary lake sediments of South-West Greenland. Grønland Geol. Unders. Rapp. 64: 26 pp.

LUBINSKY, I. 1972. The marine bivalve molluscs of the Canadian Arctic. PhD thesis, McGill University, Montreal. 318 pp.

MATTHEWS, J. V. 1975. Incongruence of macrofossil and pollen evidence: a case from the late Pleistocene of the northern Yukon coast. Geological Survey of Canada, Paper 75-1, Part B: pp. 139-46.

MILLER, G. H. In press. Late Pleistocene glaciation of southern Baffin Island, N.W.T., Canada. Geology.

———, ANDREWS, J. T. and SHORT, S. K. 1977. The last interglacial/glacial cycle, Clyde Foreland, Baffin Island, N.W.T.: Stratigraphy, biostratigraphy, and chronology. Canadian Journal of Earth Sciences 14:2824-57.

NICHOLS, H. 1975. Palynological studies of the Holocene displacement of forest-tundra ecotone in Keewatin and Mackenzie, N.W.T., Canada. INSTAAR Occ. Paper No. 15, University of Colorado, Boulder, Colorado. 87 pp.

PORSILD, A. E. 1964. Illustrated Flora of the Canadian Arctic Archipelago. 2nd Edition. National Museum of Canada, Bulletin No. 146, Biological Series No. 50. 218 pp.

SCHWARZENBACH, F. H. 1953 (translated 1975 from the original German). Botanical observations on the Penny Highlands of Baffin Island. Mimeo, INSTAAR, University of Colorado, Boulder, Colorado. 164 pp.

SHORT, S. K. 1978. Palynology: A Holocene environmental perspective for archeology in Labrador-Ungava. Arctic Anthropology 15: 9-35.

———, and NICHOLS, H. 1977. Holocene pollen diagrams from subarctic Labrador-Ungava: Vegetational history and climatic change. Arctic & Alpine Research 9: 265-90.

TERASMAE, J., WEBBER, P. J., and ANDREWS, J. T. 1966. A study of late-Quaternary plant-bearing beds in north-central Baffin Island, Canada. Arctic 14: 296-318.

VILKS, A. and MUDIE, P. J. 1978. Early deglaciation of the Labrador Shelf. Science 202: 1181-1183.

WRIGHT, H. E., JR. 1967. The use of surface samples in Quaternary pollen analysis. Review Palaeobotany and Palynology 2: 321-330.

YOUNG, S. B. 1971. The vascular flora of St. Lawrence Island with special reference to floristic zonation in the arctic regions. Contrib. Gray Herbarium, Harvard University, 201: 11-115.