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Pollen-based biomes for Beringia 18,000, 6000 and 0 ^{14}C yr BP†

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Abstract

The objective biomization method developed by Prentice *et al*. (1996) for Europe was extended using modern pollen samples from Beringia and then applied to fossil pollen data to reconstruct palaeovegetation patterns at 6000 and 18,000 ^{14}C yr BP.

The predicted modern distribution of tundra, taiga and cool conifer forests in Alaska and north-western Canada generally corresponds well to actual vegetation patterns, although sites in regions characterized today by a mosaic of forest and tundra vegetation tend to be preferentially assigned to tundra. Siberian larch forests are delimited less well, probably due to the extreme under-representation of *Larix* in pollen spectra.

The biome distribution across Beringia at 6000 ^{14}C yr BP was broadly similar to today, with little change in the northern forest limit, except for a possible northward advance in the Mackenzie delta region. The western forest limit in Alaska was probably east of its modern position.

At 18,000 ^{14}C yr BP the whole of Beringia was covered by tundra. However, the importance of the various plant functional types varied from site to site, supporting the idea that the vegetation cover was a mosaic of different tundra types.

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INTRODUCTION

The northern high latitudes play a crucial role in the climate system. High-latitude climates are especially sensitive to major changes in boundary conditions, such as solar radiation and concentrations of greenhouse gases (Bartlein *et al.*, 1992; Watson *et al.*, 1998). This sensitivity is viewed primarily as the result of strong albedo feedback associated with changes in snow and sea-ice cover (Kutzbach & Gallimore, 1988; TEMPO, 1996; Washington & Meehl, 1996). Another potentially powerful climatic feedback is related to changes in the composition and distribution of high-latitude vegetation, particularly the location of the forest–tundra boundary, which acts in synergy with the sea-ice feedback to amplify climatic warming or cooling (Foley *et al.*, 1994; Melillo *et al.*, 1996; TEMPO, 1996; Texier *et al.*, 1997). Records of past large-scale vegetation changes in the Arctic and sub-Arctic are therefore important for testing the performance of: (1) atmospheric general circulation models (AGCMs) in a key region and (2) coupled models that attempt to include physical interactions among the atmosphere, oceans and vegetation (Foley *et al.*, 1998; Kubatzki *et al.*, 1998).

High-quality late-Quaternary palaeovegetation records are relatively scarce in many parts of the far north due to a complex glacial history, the discontinuous nature of non-lacustrine deposits, low lacustrine sedimentation rates, low pollen productivity, and the logistical challenges of working in remote areas (Lamb & Edwards, 1988). However, Beringia (north-western Canada, Alaska and north-eastern Russia) is relatively well studied; for decades there has been broad interdisciplinary interest in the biologically critical 'Bering Land Bridge' that linked Asia and North America (Hopkins, 1967; Hopkins *et al.*, 1982; West, 1997). Furthermore, Beringia was largely unglaciated during the Quaternary and has several continuous records extending to and beyond the last glacial maximum. Thus, palaeoecological records from Beringia can make an important contribution to understanding the dynamics of climate in the Arctic.

The link between vegetation and climate at large spatial scales has encouraged the development of global vegetation models (e.g. Prentice *et al.*, 1992; VEMAP Members, 1995; Haxeltine & Prentice, 1996; Neilson *et al.*, 1998) which can be used to translate the output of AGCMs into maps of present (potential), future, or past vegetation (e.g. Prentice *et al.*, 1992; Harrison *et al.*, 1995; VEMAP Members, 1995; Harrison *et al.*, 1998; Kutzbach *et al.*, 1998; Neilson *et al.*, 1998). The simulated vegetation distribution can be compared with modern vegetation maps (e.g. Prentice *et al.*, 1992) or, in the case of past vegetation, reconstructions based on pollen and plant-macrofossil data (e.g. Harrison *et al.*, 1998; Jolly *et al.*, 1998). For this to be done effectively requires that palaeovegetation data are organized in a way that is compatible with model output. The aim of the BIOME 6000 project (Prentice & Webb, 1998) is to translate fossil pollen assemblages into a form that allows such direct data-model comparison. In the method devised by Prentice *et al.* (1996) pollen taxa are assigned to one or more plant functional types (PFTs), which may then be combined to define biomes according to an explicit algorithm; the resultant biome assignments can be compared with biomes simulated by the vegetation model. The biomization method has been tested and applied in a number of different regions (e.g. Prentice *et al.*, 1996; Jolly *et al.*, 1998; Prentice *et al.*, 1998; Tarasov *et al.*, 1998; Yu *et al.*, 1998; other articles in this issue), and it appears to provide robust results across a wide range of climates and vegetation types.

In this paper we apply the biomization method (Prentice *et al.*, 1996) to reconstruct the biomes across Beringia for 0, 6000, and 18,000 ^{14}C yr BP, and discuss the implications of the results for our understanding of vegetation and climate changes in this region.

STUDY REGION

Beringia (here defined as the area between 130°W and 125°E, and from 53° to 75°N), extends westward from the lower Mackenzie Valley in Canada to the Verkhoyansk Range of eastern Siberia, and from the New Siberian Islands of the Russian Arctic to the Pacific Rim. The topography of eastern Beringia (Alaska and north-western Canada) is dominated by the generally east–west trending Brooks Range in the north and the Alaska, Wrangell-St. Elias, and Coast Ranges in the south. Interior Alaska is a region of large tectonic basins and extensive uplands, with the Yukon-Kuskokwim lowland lying to the south-west. Far northern Alaska is characterized by the Arctic coastal plain. Uplands dominate most of north-western Canada, with the exception of the lower Mackenzie region and the Toktoyuktok Peninsula. Western Beringia (north-east Siberia) is topographically complex. The upper Indigirka and Kolyma drainages, and Kamchatka, are mountainous; the Chukchi and Koryak Uplands dominate the eastern part of the region. However, extensive lowlands occupy the northern coastal plain (Yana-Indigirka-Kolyma lowland) and south-eastern Chukotka (Anadyr Penzhina lowland). Although areas of eastern Beringia bordered the continental and cordilleran ice sheets, much of Beringia remained ice-free during the last glacial maximum (Hamilton & Thorson, 1983; Porter *et al.*, 1983; Ananyeyev *et al.*, 1993). The most extensive glaciation was of the southern mountains and adjacent lowland of south-central

Alaska. Glaciers were restricted to valleys in the mountainous areas of western Beringia and the Brooks Range of northern Alaska.

Modern regional climate

Beringia is not as geographically coherent as its recent common history might imply. Climate (and vegetation) vary considerably across the region today—and presumably have done so in the past. Winter climate is influenced by variations of the East-Asian mid-tropospheric trough-ridge system. A strong upper-level trough is centred south of Beringia off eastern China and traverses through central Canada (Harman, 1991). North of the trough, in western Beringia, the Siberian surface high pressure system is prominent due to intensive radiational cooling (Lydolph, 1977) and creates a cold, north-westerly flow into north-east Asia, thus greatly restricting maritime influence (Mock *et al.*, 1998). January temperatures range from below −40 °C in the interior valleys to around −17 °C along the eastern Siberian coast (WMO, 1979, 1981). Another cold-core high occurs over north-western Canada. January temperatures are *c.* −30 °C in north-eastern Alaska and *c.* −15 °C along the south-west Alaskan coast.

High solar radiation explains much of the summer peak in the annual temperature cycle, although subtropical high pressure systems that dominate the mid-latitudes advect warm air from the south into both eastern and western Beringia during the summer (Mock *et al.*, 1998). Over western Beringia, average July temperatures are somewhat warmer along the eastern coast (*c.* 12 °C) compared with inland and farther north (*c.* 5–10 °C), because the East Asian trough is often centred over eastern Siberia bringing relatively cold air from the north (Moritz, 1979; Mock *et al.*, 1998). Average July temperatures for eastern Beringia generally exhibit a north-south gradient of increasing temperature (5–15 °C; WMO, 1979, 1981), but some west-east gradients exist due to the influence of the Bering Sea. The highest temperatures occur in the eastern interior of Alaska.

Precipitation across Beringia is low during winter; many locations receive < 25 mm on average during January (WMO, 1979, 1981). Higher precipitation in south-eastern Russia results from occasional winter storms that move up the coastline from China (Terada & Hanzawa, 1984). The Aleutian low causes high precipitation in southern coastal Alaska, as moist air masses are uplifted over coastal mountain ranges (Hare & Hay, 1974; Mock, 1996). Over most of Beringia, precipitation exhibits a mid-to-late summer maximum as the East Asian trough steers mid-latitude cyclones through the region. Lydolph (1977) suggested that the onshore flow of moisture into south-eastern Russia resembles a variation of the Asian summer monsoon, although its effects are mostly limited to south of the Okhotsk Sea. Mid-latitude cyclones that originate in the lee of Mongolian mountain ranges occasionally transport monsoonal moisture farther north into Siberia (Chen *et al.*, 1991). Average July precipitation exhibits a general north-south gradient in western Beringia, with values varying from 50 to 100 mm, and in eastern Beringia is generally *c.* 80 mm.

Modern vegetation patterns

The modern Beringian vegetation grades from tundra in the far north and areas bordering the Chukchi and Beaufort Seas, to forest in the continental interiors and the southern coastal regions (Fig. 1b). In eastern Beringia, northern coastal lowlands are characterized by graminoid tundra (*Carex* and *Eriophorum* spp.). Inland, on interfluves and at intermediate elevations, dwarf-birch/heath/willow tundras (*Betula glandulosa*, *B. nana* (*sensu lato*), *Vaccinium* spp., *Ledum* spp., *Salix* spp.) occur, with alder (*Alnus crispa*) locally abundant. The tundra of coastal western Alaska is characterized by grass-herb communities with *Salix*. Alpine tundra of variable composition occurs above 600–800 m. The interior boreal forest of Alaska-Yukon is dominated by spruce (*Picea glauca*, *P. mariana*) and successional hardwoods (*Populus* and *Betula* spp.). The northern forest limit closely follows the southern flanks of the Brooks Range in Alaska and lies just south of the coast in north-western Canada; the forest-tundra margin is relatively abrupt compared with that further east in Canada, but local tree distribution tends to be dependent on substrate and topography. A topographically controlled mosaic of forest and tundra also occurs in the Alaska Range. Westward, spruce becomes progressively more confined to river valleys and occurs predominantly as gallery forest at its western limits. Cool conifer forests, dominated by Sitka spruce (*Picea sitchensis*) and hemlock (*Tsuga heterophylla*, *T. mertensiana*), occur along the coast of south-central and south-eastern Alaska from the Kenai Peninsula eastwards. In the mountainous south-east of the region, subalpine fir (*Abies lasiocarpa*) and lodgepole pine (*Pinus contorta*) are important forest constituents.

Extensive shrub and herb tundra occurs in the northern and eastern parts of western Beringia. On Wrangel Island and the New Siberian Islands, graminoids, mosses and forbs predominate at lower elevations, and fell field occupies mid-elevations and exposed slopes (Yurtsev, 1974; Aleksandrova, 1977). Northern and eastern coastal areas of the mainland are dominated by a graminoid-*Artemisia* tundra with prostrate *Salix* and occasional *Betula exilis*. Lowlands along the Okhotsk Sea coast support wet graminoid-*Salix*-Ericales tundra. A mosaic of tundra types characterize the Chukchi uplands, the Chukchi Peninsula and the Anadyr-Penzhina lowland. *Betula exilis*, *B. middendorfii*, *Alnus fruticosa*, *Salix* spp. and various ericads occur widely, except at high elevations (Kozhevnikov, 1989). *Pinus pumila* is an abundant shrub in southern areas of Chukotka at low- to mid-elevations. An open *Larix dahurica* forest dominates low- to mid-elevation sites over most of the Kolyma and Indigirka drainage basins. The understory contains *P. pumila*, *B. exilis*, *B. middendorfii*, *Salix* spp., ericads and fruticose lichens. *Chosenia arbutifolia* and *Populus suaveolens* grow along floodplains. In the forest, *A. fruticosa* is restricted to stream valleys and mid-elevations with poorly developed soils (Khokhryakov, 1985). *Picea obovata* is restricted to a small disjunct population near Magadan. Areas of steppe are found in the upper Indigirka and upper Yana basins. Small areas of steppe also occur in the Kolyma basin and Chukotka, mostly restricted to warm,

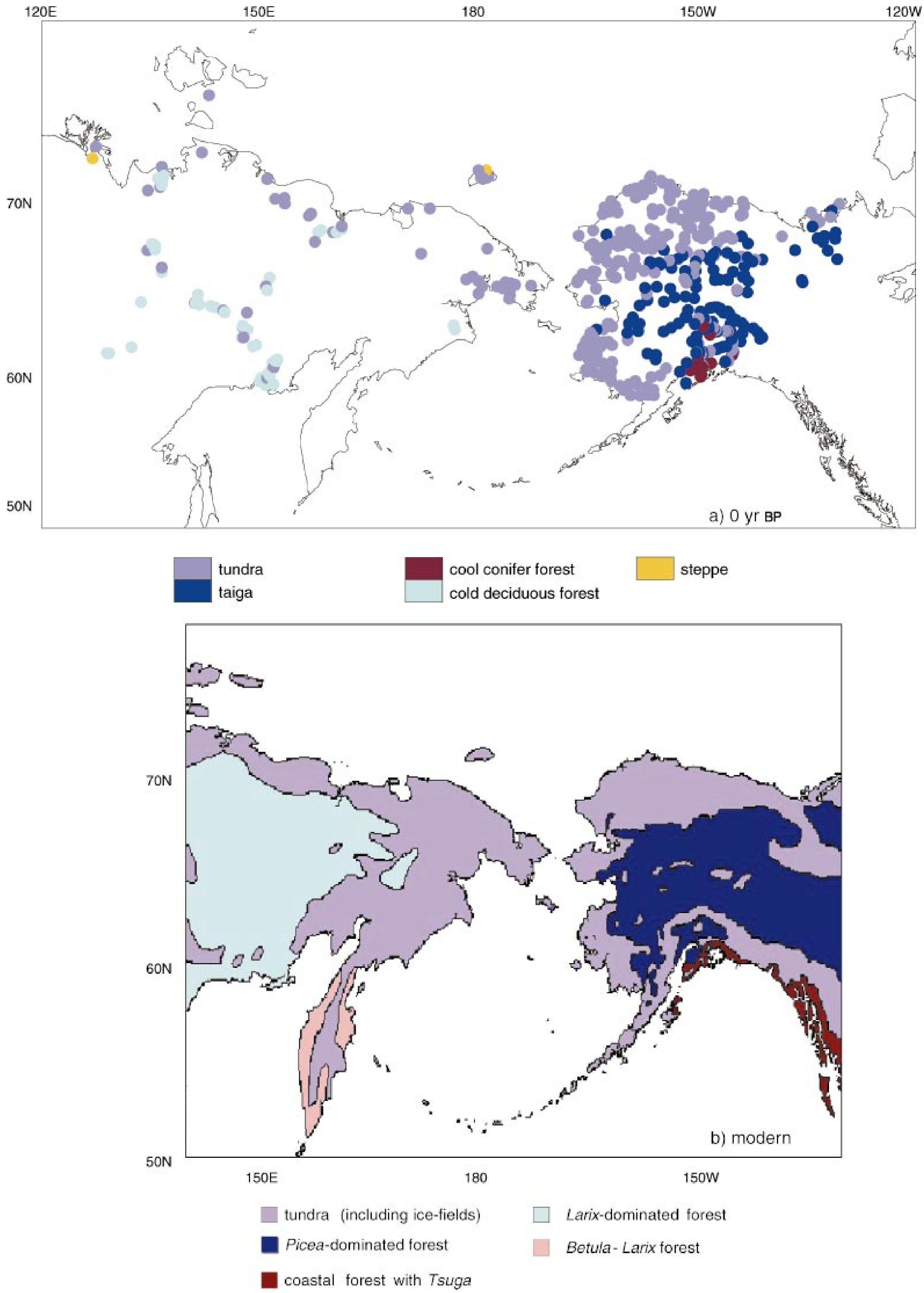

Figure 1 Modern biomes (a) reconstructed from surface pollen data, compared with (b) modern vegetation as reconstructed from data in Viereck *et al*. (1992), Ritchie (1984b), Anonymous (1990) and field descriptions by the investigators. In cases where multiple samples from a site yielded different biome reconstructions, all the alternatives are plotted; otherwise, each site is represented by a single reconstruction.

south-facing slopes (Yurtsev, 1982). Forests dominated by *Betula ermani* and *Larix kurilensis* cover much of Kamchatka at low- and mid-elevations. The vegetation of the northern part of Sakhalin Island is predominantly mixed forest of *Picea jezoensis* and *Abies sachalinensi*. On the mainland coast to the east, the upland forest of the lower Amur region is a mix of *Abies nephrolepsis*, *Picea ajanensis* and broadleaved trees.

Palaeoecological records

Palaeoenvironmental records from Beringia cover the last glacial maximum, the subsequent deglaciation, and the Holocene. In eastern Beringia there is a relatively good coverage of modern and fossil pollen sites (see reviews in Ager, 1983; Ritchie, 1984a, 1987; Ager & Brubaker, 1985; Barnosky *et al.*, 1987; Lamb & Edwards, 1988; Anderson & Brubaker, 1993, 1994; Edwards & Barker, 1994). Western Beringa is less extensively covered, but recent work (e.g. Lozhkin *et al.*, 1993; Anderson & Lozhkin, 1995; Lozhkin & Anderson, 1995) has added considerably to the vegetation records of this region.

DATA AND METHODS

Modern pollen and vegetation data

We assembled the raw pollen counts from 445 modern pollen samples from 411 sites in eastern Beringia (Table 1). Most samples (90%) were derived from surficial lake sediments or lacustrine sediment core tops; the rest were from peat, moss polsters or alluvium. For western Beringia (Table 2) we obtained a total of 238 samples from 92 different localities; 55 samples are from unpublished original pollen counts, the others are digitized from percentage data published in the literature. Most of the western Beringian samples were from moss polsters, peat, alluvium or soil; the others (17%) were surficial lake sediments. In Russia, the nature of the pollen sum varies among authors (e.g. arboreal sum, non-arboreal sum, sum of pollen and spores). We only used data from those publications in which the nature of the pollen sum was described, so it was possible to back-calculate pollen counts using an arbitrary sum.

A map of modern vegetation (Fig. 1b) was made using the maps and descriptions in Viereck *et al.* (1992), Ritchie (1984b), Anonymous (1990) and from the personal knowledge of the investigators.

Pollen data for 6000 and 18,000 ^{14}C yr BP

The fossil pollen data were derived from both published and unpublished sources. Most of the data were obtained as raw counts via the North American Pollen Database (NAPD) and the PALE Pollen Database (PPD). Some published pollen diagrams were digitized and are represented by percentage data only. Most of the records come from lake-sediment sections, the rest from peat sections or other deposits. For 6000 ^{14}C yr BP we used 92 pollen spectra from 79 sites in eastern Beringia (Table 3) and 24 spectra from 22 sites in western Beringia (Table 4). Data for 18,000 ^{14}C yr BP were available for 11 dated Beringian sites, 3 of which are from western Beringia (see Tables 3 and 4).

For each site, we used the pollen spectrum nearest to 6000 or 18,000 ^{14}C yr BP, within a $\pm$500-year window. In one western Beringian site (Elikchan: Lozhkin & Anderson, 1995), a sample just outside the 6000 $\pm$ 500 yr BP time window was selected because the site was considered too important geographically to omit. All sites are radiocarbon-dated, and virtually all the samples were defined by interpolation from an age model (in a few cases the sample was derived by a short extrapolation). In cases when multiple age models would have resulted in the selection of different samples, we biomised all the samples. This exercise showed that the choice of different age models had no effect on the reconstructed biome, except in a very few cases. In cases where the choice of age model resulted in the reconstruction of different biomes, all of the alternative reconstructions are plotted on the final maps.

Biomization procedure

The biomization procedure has been described in detail by Prentice *et al.* (1996). Pollen taxa are assigned to one or more plant functional types (PFTs), according to the structural and functional features of the constituent species, e.g. stature, phenology, leaf type, and bioclimatic tolerances. Each biome is defined by a set of characteristic PFTs that is based on both bioclimatic considerations and observed ranges of the PFTs. Combining the taxa to PFT, and the PFT to biome, allocations allows a biome-taxon matrix to be constructed. Using a fuzzy logic approach, each individual pollen spectrum is assumed to have a degree of affinity with each biome, which can be expressed numerically. The biome with the highest affinity score is then selected as the one corresponding to the pollen spectrum. In cases where the highest affinity score for two or more biomes is equal, a tie-breaking rule is applied to determine which biome is attributed to the sample, following Prentice *et al.* (1996).

Following Tarasov *et al.* (1998), we included all terrestrial pollen taxa, except those that are obvious exotics to the region and a few minor taxa with obscure biologies. The motivation for doing this is that treeless biomes such as tundra may be better identified palynologically if a suite of minor taxa are included; otherwise relatively high levels of pollen of forest taxa may distort the tundra signal and resultant assignments in the biomization procedure. Spores of the lower vascular plants and mosses were excluded because their abundances can fluctuate dramatically as a result of changing sediment influx due to changes in subaerial erosion even when their representation in the catchment vegetation is unchanged. Aquatic taxa were also excluded as they do not reflect terrestrial vegetation. The cold deciduous forest of north-east Siberia is dominated by *Larix*, which is very poorly represented in both modern and fossil pollen assemblages; *Larix* may not be represented in a modern pollen sample even when locally present. We applied a weighting ($\times$20) to occurrences of *Larix* in individual pollen spectra, in order to maximize the chance of reconstructing cold deciduous forest when it

Table 1 Characteristics of the surface pollen sample sites from Alaska and north-western Canada. Longitude is expressed by the standard convention, with + for °E and – for °W. For mapping purposes, some sites (indicated by ‡) which are very close to one another have been displaced slightly.

Site	Site name	Lat. (°N)	Long. (°)	Elev. (m)	Sample type	Modern vegetation type	References
1	none	67.37	−147.70	n/a	lake	closed forest	Anderson & Brubaker, unpublished
2	none	67.55	−145.90	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
3	none	68.33	−146.43	n/a	lake	tundra	Anderson & Brubaker, unpublished
4	none	68.33	−146.42	n/a	lake	tundra	Anderson & Brubaker, unpublished
5	none	68.40	−145.80	n/a	lake	closed forest	Anderson & Brubaker, unpublished
6	none	68.25	−145.20	n/a	lake	closed forest	Anderson & Brubaker, unpublished
7	none	67.27	−144.83	n/a	lake	open forest	Anderson & Brubaker, unpublished
8	none	68.38	−143.92	n/a	lake	closed forest	Anderson & Brubaker, unpublished
9	none	68.02	−143.05	n/a	lake	closed forest	Anderson & Brubaker, unpublished
10	none	67.30	−143.12	n/a	lake	open forest	Anderson & Brubaker, unpublished
11	none	67.08	−142.43	n/a	lake	closed forest	Anderson & Brubaker, unpublished
12	none	67.18	−142.07	n/a	lake	closed forest	Anderson & Brubaker, unpublished
13	none	67.18	−141.08	n/a	lake	closed forest	Anderson & Brubaker, unpublished
14	none‡	66.83	−143.48	n/a	lake	closed forest	Anderson & Brubaker, unpublished
15	none‡	66.83	−143.48	n/a	lake	open forest	Anderson & Brubaker, unpublished
16	none	66.35	−143.53	n/a	lake	open forest	Anderson & Brubaker, unpublished
17	none	66.25	−143.75	n/a	lake	open forest	Anderson & Brubaker, unpublished
18	none	66.00	−142.97	n/a	lake	closed forest	Anderson & Brubaker, unpublished
19	none	65.38	−143.12	n/a	lake	closed forest	Anderson & Brubaker, unpublished
20	none	65.52	−144.53	n/a	lake	open forest	Anderson & Brubaker, unpublished
21	none	65.47	−144.48	n/a	lake	open forest	Anderson & Brubaker, unpublished
22	none	66.52	−145.05	n/a	lake	closed forest	Anderson & Brubaker, unpublished
23	none	66.10	−145.87	n/a	lake	closed forest	Anderson & Brubaker, unpublished
24	none	66.08	−146.93	n/a	lake	open forest	Anderson & Brubaker, unpublished
25	none	66.20	−147.48	n/a	lake	closed forest	Anderson & Brubaker, unpublished
26	none	66.63	−147.77	n/a	lake	open forest	Anderson & Brubaker, unpublished
27	none	67.17	−148.22	n/a	lake	closed forest	Anderson & Brubaker, unpublished
28	none	67.57	−147.45	n/a	lake	closed forest	Anderson & Brubaker, unpublished
29	none	68.07	−147.20	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
30	none	67.92	−156.82	n/a	lake	tundra	Anderson & Brubaker, unpublished
31	none	67.85	−158.40	n/a	lake	tundra	Anderson & Brubaker, unpublished
32	none	67.93	−160.42	n/a	lake	tundra	Anderson & Brubaker, unpublished
33	none	67.90	−162.60	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
34	none	67.08	−162.38	n/a	lake	closed forest	Anderson & Brubaker, unpublished
35	none	67.22	−163.70	n/a	lake	tundra	Anderson & Brubaker, unpublished
36	none	67.90	−164.73	n/a	lake	tundra	Anderson & Brubaker, unpublished
37	none	68.43	−166.25	n/a	lake	tundra	Anderson & Brubaker, unpublished
38	none	68.68	−164.27	n/a	lake	tundra	Anderson & Brubaker, unpublished
39	none	68.00	−164.27	n/a	lake	tundra	Anderson & Brubaker, unpublished
40	none	67.90	−164.00	n/a	lake	tundra	Anderson & Brubaker, unpublished
41	none	66.87	−161.38	n/a	lake	tundra	Anderson & Brubaker, unpublished
42	none	67.12	−160.82	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
43	none	66.75	−159.35	n/a	lake	tundra	Anderson & Brubaker, unpublished

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Table 1 *continued*

Site	Site name	Lat. (°N)	Long. (°)	Elev. (m)	Sample type	Modern vegetation type	References
44	none	66.80	−158.35	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
45	none	67.22	−158.60	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
46	none	67.05	−156.45	n/a	lake	closed forest	Anderson & Brubaker, unpublished
47	none	67.77	−157.23	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
48	none	66.48	−155.85	n/a	lake	closed forest	Anderson & Brubaker, unpublished
49	none	65.67	−155.57	n/a	lake	closed forest	Anderson & Brubaker, unpublished
50	none	64.83	−154.57	n/a	lake	closed forest	Anderson & Brubaker, unpublished
51	none	65.58	−153.70	n/a	lake	closed forest	Anderson & Brubaker, unpublished
52	none	65.07	−153.12	n/a	lake	closed forest	Anderson & Brubaker, unpublished
53	none	65.12	−151.60	n/a	lake	closed forest	Anderson & Brubaker, unpublished
54	none	65.03	−150.38	n/a	lake	open forest	Anderson & Brubaker, unpublished
55	none	65.65	−150.15	n/a	lake	closed forest	Anderson & Brubaker, unpublished
56	none	66.05	−150.28	n/a	lake	open forest	Anderson & Brubaker, unpublished
57	none	66.12	−151.45	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
58	none	66.13	−151.80	n/a	lake	closed forest	Anderson & Brubaker, unpublished
59	none	66.58	−151.67	n/a	lake	closed forest	Anderson & Brubaker, unpublished
60	none	66.42	−150.50	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
61	none	69.37	−150.23	n/a	lake	tundra	Anderson & Brubaker, unpublished
62	none	69.73	−149.50	n/a	lake	tundra	Anderson & Brubaker, unpublished
63	none	70.33	−149.23	n/a	lake	tundra	Anderson & Brubaker, unpublished
64	none	70.40	−150.45	n/a	lake	tundra	Anderson & Brubaker, unpublished
65	none	69.98	−150.97	n/a	lake	tundra	Anderson & Brubaker, unpublished
66	none	69.92	−150.77	n/a	lake	tundra	Anderson & Brubaker, unpublished
67	none	69.55	−150.88	n/a	lake	tundra	Anderson & Brubaker, unpublished
68	none	69.23	−151.15	n/a	lake	tundra	Anderson & Brubaker, unpublished
69	none	68.92	−151.32	n/a	lake	tundra	Anderson & Brubaker, unpublished
70	none	68.15	−151.70	n/a	lake	tundra	Anderson & Brubaker, unpublished
71	none	67.78	−152.22	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
72	none	67.40	−152.03	n/a	lake	closed forest	Anderson & Brubaker, unpublished
73	none	67.40	−149.78	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
74	none	67.40	−149.78	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
75	none	67.23	−152.58	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
76	none	67.58	−151.42	n/a	lake	open forest	Anderson & Brubaker, unpublished
77	none	67.13	−153.88	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
79	none	67.97	−155.03	n/a	lake	tundra	Anderson & Brubaker, unpublished
80	none	67.57	−151.38	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
81	none	67.13	−153.65	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
82	none	65.92	−151.47	n/a	lake	closed forest	Anderson & Brubaker, unpublished
83	none	66.07	−147.53	n/a	lake	closed forest	Anderson & Brubaker, unpublished
84	none	67.70	−154.55	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
85	none	66.72	−153.50	n/a	lake	closed forest	Anderson & Brubaker, unpublished
87	none	66.05	−145.78	n/a	lake	closed forest	Anderson & Brubaker, unpublished
88	none	71.12	−156.52	n/a	lake	tundra	Anderson & Brubaker, unpublished
89	none	70.43	−157.40	n/a	lake	tundra	Anderson & Brubaker, unpublished
90	none	70.55	−153.77	n/a	lake	tundra	Anderson & Brubaker, unpublished

Table 1 *continued*

Site	Site name	Lat. (°N)	Long. (°)	Elev. (m)	Sample type	Modern vegetation type	References
91	none	70.15	−153.77	n/a	lake	tundra	Anderson & Brubaker, unpublished
92	none	70.70	−158.4	n/a	lake	tundra	Anderson & Brubaker, unpublished
93	none	71.23	−156.37	n/a	lake	tundra	Anderson & Brubaker, unpublished
94	none	68.60	−160.53	n/a	lake	tundra	Anderson & Brubaker, unpublished
95	none	70.93	−154.67	n/a	lake	tundra	Anderson & Brubaker, unpublished
96	none	69.48	−156.05	n/a	lake	tundra	Anderson & Brubaker, unpublished
97	none	71.13	−156.52	n/a	lake	tundra	Anderson & Brubaker, unpublished
98	none	68.12	−161.42	n/a	lake	tundra	Anderson & Brubaker, unpublished
99	none	67.10	−160.38	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
100	none	66.58	−157.25	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
101	none	69.58	−153.25	n/a	lake	shrub tundra	Anderson & Brubaker, unpublished
102	none	67.43	−147.85	n/a	lake	forest tundra	Anderson & Brubaker, unpublished
103	none	66.80	−150.35	n/a	lake	forest tundra	Anderson & Brubaker, unpublished
104	none	68.13	−156.03	n/a	lake	shrub tundra	Anderson & Brubaker, unpublished
105	none	66.83	−155.73	n/a	lake	spruce forest	Anderson & Brubaker, unpublished
106	none	66.86	−155.71	n/a	lake	spruce forest	Anderson & Brubaker, unpublished
107	none	66.91	−155.03	n/a	lake	spruce forest	Anderson & Brubaker, unpublished
108	none	66.96	−156.45	n/a	lake	spruce forest	Anderson & Brubaker, unpublished
109	none	68.41	−149.92	n/a	lake	shrub tundra	Anderson & Brubaker, unpublished
110	none	65.94	−166.47	n/a	lake	low shrub/tussock tundra	Anderson & Brubaker, unpublished
111	none	66.09	−166.28	n/a	lake	low shrub/tussock tundra	Anderson & Brubaker, unpublished
112	none	66.36	−165.50	n/a	lake	tussock/grass tundra	Anderson & Brubaker, unpublished
113	none	66.13	−164.41	n/a	lake	shrub/tussock tundra	Anderson & Brubaker, unpublished
114	none	66.55	−164.27	n/a	lake	sedge/tussock tundra	Anderson & Brubaker, unpublished
115	none	66.52	−163.95	n/a	lake	tussock tundra	Anderson & Brubaker, unpublished
116	none	66.33	−159.13	n/a	lake	tall shrub/sedge tundra with open forest	Anderson & Brubaker, unpublished
117	none	64.60	−157.93	n/a	lake	shrub and open forest	Anderson & Brubaker, unpublished
118	none	64.92	−156.84	n/a	lake	shrub/tussock tundra	Anderson & Brubaker, unpublished
119	none	65.28	−156.91	n/a	lake	open forest	Anderson & Brubaker, unpublished
120	none	65.64	−157.16	n/a	lake	open forest	Anderson & Brubaker, unpublished
121	none	65.58	−163.90	n/a	lake	tussock tundra	Anderson & Brubaker, unpublished
122	none	66.19	−161.17	n/a	lake	shrub/tussock tundra	Anderson & Brubaker, unpublished
123	none	66.40	−161.79	n/a	lake	shrub/tussock tundra	Anderson & Brubaker, unpublished
124	none	67.74	−156.19	n/a	lake	tundra	Anderson & Brubaker, unpublished
125	none	68.33	−158.72	n/a	lake	tundra	Anderson & Brubaker, unpublished
126	none	68.25	−159.86	n/a	lake	shrub tundra	Anderson & Brubaker, unpublished
127	none	67.66	−162.55	n/a	lake	forest tundra	Anderson & Brubaker, unpublished
128	none	67.38	−162.82	n/a	lake	forest tundra	Anderson & Brubaker, unpublished
129	none	67.64	−164.07	n/a	lake	shrub tundra	Anderson & Brubaker, unpublished
130	none	64.43	−146.85	n/a	lake	boreal forest	Anderson & Brubaker, unpublished
131	none	64.31	−146.67	n/a	lake	boreal forest	Anderson & Brubaker, unpublished
132	none	64.21	−145.82	n/a	lake	boreal forest	Anderson & Brubaker, unpublished
133	none	64.09	−145.60	n/a	lake	black spruce muskeg, shrub/sedge	Anderson & Brubaker, unpublished
134	none	63.19	−145.65	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
135	none	63.12	−145.50	n/a	lake	high shrub tundra	Anderson & Brubaker, unpublished

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Table 1 *continued*

Site	Site name	Lat. (°N)	Long. (°)	Elev. (m)	Sample type	Modern vegetation type	References
136	none	63.05	−145.94	n/a	lake	high shrub tundra	Anderson & Brubaker, unpublished
137	none	62.95	−145.51	n/a	lake	boreal forest	Anderson & Brubaker, unpublished
138	none	62.71	−144.19	n/a	lake	boreal forest	Anderson & Brubaker, unpublished
139	none	62.91	−143.80	n/a	lake	boreal forest	Anderson & Brubaker, unpublished
140	none	63.23	−142.29	n/a	lake	boreal forest	Anderson & Brubaker, unpublished
141	none	62.98	−141.64	n/a	lake	boreal forest	Anderson & Brubaker, unpublished
142	none	62.89	−141.55	n/a	lake	boreal forest	Anderson & Brubaker, unpublished
143	none	62.65	−141.07	n/a	lake	black spruce muskeg-sedge meadows	Anderson & Brubaker, unpublished
144	none	63.36	−143.54	n/a	lake	black spruce muskeg	Anderson & Brubaker, unpublished
145	none	63.74	−144.71	n/a	lake	boreal forest	Anderson & Brubaker, unpublished
147	none	69.46	−143.74	n/a	lake	shrub tundra	Anderson & Brubaker, unpublished
148	none	69.41	−144.05	n/a	lake	shrub tundra	Anderson & Brubaker, unpublished
149	none	69.44	−144.03	n/a	lake	shrub tundra	Anderson & Brubaker, unpublished
151	none	63.92	−151.58	n/a	lake	boreal forest	Anderson & Brubaker, unpublished
152	none	67.00	−155.28	n/a	lake	spruce muskeg	Anderson & Brubaker, unpublished
153	none	66.38	−165.75	n/a	lake	spruce muskeg	Anderson & Brubaker, unpublished
154	none	63.02	−154.62	n/a	lake	boreal forest	Anderson & Brubaker, unpublished
155	none	61.63	−156.83	n/a	lake	boreal forest	Anderson & Brubaker, unpublished
156	none	61.56	−155.65	n/a	lake	boreal forest-lichen woodland	Anderson & Brubaker, unpublished
157	none	61.24	−155.74	n/a	lake	boreal forest-muskeg	Anderson & Brubaker, unpublished
158	none	60.64	−154.29	n/a	lake	boreal forest (near treeline)	Anderson & Brubaker, unpublished
159	none	60.16	−155.05	n/a	lake	boreal forest-lichen woodland	Anderson & Brubaker, unpublished
160	none	60.05	−156.28	n/a	lake	boreal forest	Anderson & Brubaker, unpublished
161	none	59.38	−156.89	n/a	lake	shrub tundra (some trees)	Anderson & Brubaker, unpublished
162	none	59.18	−156.03	n/a	lake	shrub tundra	Anderson & Brubaker, unpublished
163	none	58.77	−155.95	n/a	lake	shrub tundra	Anderson & Brubaker, unpublished
164	none	58.81	−156.73	n/a	lake	shrub tundra	Anderson & Brubaker, unpublished
165	none	58.74	−157.78	n/a	lake	shrub tundra (few trees)	Anderson & Brubaker, unpublished
166	none	58.79	−159.15	n/a	lake	shrub tundra (few trees)	Anderson & Brubaker, unpublished
167	none	59.53	−158.27	n/a	lake	open boreal forest	Anderson & Brubaker, unpublished
168	none	59.80	−158.52	n/a	lake	open boreal forest	Anderson & Brubaker, unpublished
169	none	59.57	−159.37	n/a	lake	lichen woodland	Anderson & Brubaker, unpublished
170	none	59.13	−160.08	n/a	lake	shrub tundra	Anderson & Brubaker, unpublished
171	none	59.43	−160.58	n/a	lake	shrub tundra	Anderson & Brubaker, unpublished
172	none	59.75	−161.78	n/a	lake	shrub tundra	Anderson & Brubaker, unpublished
173	none	60.03	−161.90	n/a	lake	shrub tundra	Anderson & Brubaker, unpublished
174	none	60.12	−163.08	n/a	lake	shrub/tussock tundra	Anderson & Brubaker, unpublished
175	none	60.33	−164.07	n/a	lake	wet tussock tundra	Anderson & Brubaker, unpublished
176	none	60.58	−162.63	n/a	lake	wet tundra/grassy	Anderson & Brubaker, unpublished
177	none	60.46	−161.77	n/a	lake	wet tundra/grassy	Anderson & Brubaker, unpublished
178	none	61.08	−161.68	n/a	lake	tussock tundra	Anderson & Brubaker, unpublished
179	none	60.98	−162.93	n/a	lake	shrub/tussock tundra	Anderson & Brubaker, unpublished
180	none	60.93	−164.33	n/a	lake	tussock tundra	Anderson & Brubaker, unpublished
181	none	61.43	−164.20	n/a	lake	tussock tundra	Anderson & Brubaker, unpublished
182	none	61.53	−165.10	n/a	lake	wet tussock tundra	Anderson & Brubaker, unpublished

Table 1 *continued*

Site	Site name	Lat. (°N)	Long. (°)	Elev. (m)	Sample type	Modern vegetation type	References
183	none	62.08	−165.53	n/a	lake	tussock tundra	Anderson & Brubaker, unpublished
184	none	62.10	−164.63	n/a	lake	tussock tundra	Anderson & Brubaker, unpublished
185	none	62.55	−164.50	n/a	lake	shrub/tussock tundra	Anderson & Brubaker, unpublished
186	none	62.37	−163.60	n/a	lake	shrub tundra/alder	Anderson & Brubaker, unpublished
187	none	62.02	−163.62	n/a	lake	shrub tundra	Anderson & Brubaker, unpublished
188	none	62.38	−162.17	n/a	lake	tussock tundra (few trees)	Anderson & Brubaker, unpublished
189	none	62.17	−161.67	n/a	lake	boreal forest transition	Anderson & Brubaker, unpublished
190	none	62.49	−159.55	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
191	none	62.94	−159.57	n/a	lake	boreal forest-muskeg	Anderson & Brubaker, unpublished
192	none	63.05	−158.08	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
193	none	63.52	−157.92	n/a	lake	boreal forest-muskeg	Anderson & Brubaker, unpublished
194	none	63.51	−159.38	n/a	lake	boreal forest	Anderson & Brubaker, unpublished
195	none	63.91	−158.85	n/a	lake	boreal forest-muskeg	Anderson & Brubaker, unpublished
196	none	63.85	−149.03	n/a	lake	forest-tundra	Anderson & Brubaker, unpublished
197	none	63.72	−148.85	n/a	lake	forest-tundra	Anderson & Brubaker, unpublished
198	none	63.38	−148.67	n/a	lake	spruce forest	Anderson & Brubaker, unpublished
199	none	63.29	−147.90	n/a	lake	boreal forest-tundra	Anderson & Brubaker, unpublished
200	none	63.20	−147.65	n/a	lake	boreal forest-tundra	Anderson & Brubaker, unpublished
201	none	63.35	−149.10	n/a	lake	boreal forest	Anderson & Brubaker, unpublished
202	none	62.73	−150.12	n/a	lake	spruce-hardwood deciduous forest	Anderson & Brubaker, unpublished
203	none	61.80	−148.20	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
204	none	61.95	−147.17	n/a	lake	mix of forest & tundra	Anderson & Brubaker, unpublished
205	none	62.03	−146.65	n/a	lake	black spruce muskeg	Anderson & Brubaker, unpublished
206	none	62.10	−146.30	n/a	lake	black spruce muskeg	Anderson & Brubaker, unpublished
207	none	61.08	−146.15	n/a	lake	coastal forest	Anderson & Brubaker, unpublished
208	none	61.12	−145.73	n/a	lake	shrub tundra	Anderson & Brubaker, unpublished
209	none	61.72	−145.20	n/a	lake	boreal forest	Anderson & Brubaker, unpublished
210	none	62.10	−146.02	n/a	lake	black spruce muskeg	Anderson & Brubaker, unpublished
211	none	61.80	−148.20	n/a	lake	hardwood deciduous forest	Anderson & Brubaker, unpublished
212	none	64.33	−151.27	n/a	lake	black spruce muskeg	Anderson & Brubaker, unpublished
213	none	63.90	−151.50	n/a	lake	spruce-hardwood deciduous forest	Anderson & Brubaker, unpublished
214	none	63.54	−152.52	n/a	lake	black spruce muskeg	Anderson & Brubaker, unpublished
215	none	63.25	−153.56	n/a	lake	black spruce muskeg	Anderson & Brubaker, unpublished
220	none	68.48	−154.06	n/a	lake	low shrub tundra/alder	Anderson & Brubaker, unpublished
221	none	68.36	−154.64	n/a	lake	low shrub tundra	Anderson & Brubaker, unpublished
222	none	68.66	−155.86	n/a	lake	low shrub tundra	Anderson & Brubaker, unpublished
223	none	68.75	−156.42	n/a	lake	low shrub/tussock tundra	Anderson & Brubaker, unpublished
226	none	68.14	−158.13	n/a	lake	sedge/tussock tundra	Anderson & Brubaker, unpublished
227	none	69.70	−155.05	n/a	lake	sedge/tussock tundra	Anderson & Brubaker, unpublished
230	none	70.70	−156.27	n/a	lake	sedge/grass tundra	Anderson & Brubaker, unpublished
231	none	71.04	−154.98	n/a	lake	sedge/grass tundra	Anderson & Brubaker, unpublished
233	none	70.83	−157.41	n/a	lake	sedge/grass tundra	Anderson & Brubaker, unpublished
234	none	70.69	−158.49	n/a	lake	sedge/grass tundra	Anderson & Brubaker, unpublished
235	none	70.58	−159.55	n/a	lake	sedge/grass tundra	Anderson & Brubaker, unpublished
236	none	70.26	−158.43	n/a	lake	sedge/grass tundra	Anderson & Brubaker, unpublished

Table 1 *continued*

Site	Site name	Lat. (°N)	Long. (°)	Elev. (m)	Sample type	Modern vegetation type	References
238	none	70.11	−161.80	n/a	lake	sedge/tussock tundra	Anderson & Brubaker, unpublished
239	none	69.88	−161.27	n/a	lake	sedge/tussock tundra	Anderson & Brubaker, unpublished
240	none	69.81	−162.72	n/a	lake	sedge/grass tundra	Anderson & Brubaker, unpublished
241	none	69.48	−162.96	n/a	lake	sedge/grass tundra	Anderson & Brubaker, unpublished
242	none	69.62	−162.03	n/a	lake	sedge/grass tundra	Anderson & Brubaker, unpublished
243	none	69.56	−160.91	n/a	lake	sedge/tussock tundra	Anderson & Brubaker, unpublished
244	none	69.74	−156.11	n/a	lake	sedge/tussock tundra	Anderson & Brubaker, unpublished
248	none	69.31	−153.45	n/a	lake	low shrub tundra/alder	Anderson & Brubaker, unpublished
250	none	68.66	−148.52	n/a	lake	low shrub tundra	Anderson & Brubaker, unpublished
251	none	68.82	−149.06	n/a	lake	low shrub tundra	Anderson & Brubaker, unpublished
252	none	69.24	−148.95	n/a	lake	low shrub tussock tundra	Anderson & Brubaker, unpublished
254	none	70.02	−149.26	n/a	lake	sedge patterned ground	Anderson & Brubaker, unpublished
255	none	70.08	−147.40	n/a	lake	sedge patterned ground	Anderson & Brubaker, unpublished
256	none	70.09	−145.77	n/a	lake	sedge/grass patterned ground	Anderson & Brubaker, unpublished
257	none	70.06	−143.75	n/a	lake	sedge/grass tundra	Anderson & Brubaker, unpublished
258	none	69.86	−143.55	n/a	lake	sedge/tussock tundra	Anderson & Brubaker, unpublished
259	none	69.84	−146.61	n/a	lake	sedge/tussock tundra	Anderson & Brubaker, unpublished
260	none	69.97	−147.59	n/a	lake	sedge/tussock tundra	Anderson & Brubaker, unpublished
261	none	69.55	−150.33	n/a	lake	shrub/tussock tundra	Anderson & Brubaker, unpublished
262	none	69.60	−151.16	n/a	lake	shrub/sedge tussock tundra	Anderson & Brubaker, unpublished
263	none	69.92	−151.89	n/a	lake	sedge/shrub tussock tundra	Anderson & Brubaker, unpublished
264	none	69.58	−153.26	n/a	lake	shrub/sedge tussock tundra	Anderson & Brubaker, unpublished
265	none	69.23	−152.27	n/a	lake	shrub/sedge tundra	Anderson & Brubaker, unpublished
266	none	70.44	−149.11	n/a	lake	grass/sedge tundra	Anderson & Brubaker, unpublished
267	none	70.30	−150.51	n/a	lake	sedge/grass tundra	Anderson & Brubaker, unpublished
269	none	70.51	−153.00	n/a	lake	sedge/grass tundra	Anderson & Brubaker, unpublished
270	none	70.87	−153.72	n/a	lake	sedge/grass tundra	Anderson & Brubaker, unpublished
271	none	70.29	−153.87	n/a	lake	grass/sedge tundra	Anderson & Brubaker, unpublished
272	none	68.80	−150.79	n/a	lake	shrub/tussock tundra	Anderson & Brubaker, unpublished
273	none	68.91	−151.32	n/a	lake	shrub/tussock tundra	Anderson & Brubaker, unpublished
274	none	68.36	−151.71	n/a	lake	shrub/tussock tundra	Anderson & Brubaker, unpublished
277	none	63.71	−144.65	n/a	lake	closed boreal forest	Anderson & Brubaker, unpublished
278	none	63.57	−143.93	n/a	lake	closed boreal forest	Anderson & Brubaker, unpublished
279	Karoleva	67.39	−149.44	n/a	lake	alpine open forest/tundra transition	Edwards & Krumhardt, unpublished
280	Grayling	66.58	−150.23	n/a	lake	alpine open forest/tundra transition	Edwards & Krumhardt, unpublished
281	Frightened Duck	63.19	−149.10	n/a	lake	alpine open forest/tundra transition	Edwards & Krumhardt, unpublished
282	Pagan's Puddle	68.48	−148.50	n/a	lake	arctic tundra	Edwards & Krumhardt, unpublished
283	Bog Walk	69.35	−148.38	n/a	lake	arctic tundra	Edwards & Krumhardt, unpublished
284	East Cobb	62.42	−144.02	n/a	lake	boreal forest	Edwards & Krumhardt, unpublished
285	Kent	68.40	−149.15	n/a	lake	arctic tundra	Edwards & Krumhardt, unpublished
286	Big Sky	69.35	−148.38	n/a	lake	arctic tundra	Edwards & Krumhardt, unpublished
287	Ozera	67.40	−149.43	n/a	lake	alpine open forest/tundra transition	Edwards & Krumhardt, unpublished
288	Stinky‡	63.13	−147.41	n/a	lake	alpine tundra	Edwards & Krumhardt, unpublished
289	Downwind	63.04	−146.12	n/a	lake	alpine tundra	Edwards & Krumhardt, unpublished
290	Parallel Pipeline	67.08	−150.21	n/a	lake	alpine open forest/tundra transition	Edwards & Krumhardt, unpublished

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Table 1 *continued*

Site	Site name	Lat. (°N)	Long. (°)	Elev. (m)	Sample type	Modern vegetation type	References
291	Lost Quartz	64.12	−145.50	n/a	lake	boreal forest	Edwards & Krumhardt, unpublished
292	Yarger	62.58	−141.38	n/a	lake	boreal forest	Edwards & Krumhardt, unpublished
293	Tern	63.24	−148.40	n/a	lake	alpine open forest/tundra transition	Edwards & Krumhardt, unpublished
294	Smith	64.52	−147.52	n/a	lake	boreal forest	Edwards & Krumhardt, unpublished
295	Windmill	63.39	−148.49	n/a	lake	alpine open forest/tundra transition	Edwards & Krumhardt, unpublished
296	Swampbuggy	63.03	−147.25	n/a	lake	alpine open forest/tundra transition	Edwards & Krumhardt, unpublished
297	Marina	63.46	−145.48	n/a	lake	alpine open forest/tundra transition	Edwards & Krumhardt, unpublished
298	Stormy Bathtub	68.27	−149.22	n/a	lake	arctic tundra	Edwards & Krumhardt, unpublished
299	Little Harding	64.25	−146.54	n/a	lake	boreal forest	Edwards & Krumhardt, unpublished
300	Float Plane	63.24	−148.40	n/a	lake	alpine open forest/tundra transition	Edwards & Krumhardt, unpublished
301	Bonanza Creek Lake	64.45	−148.18	n/a	lake	boreal forest	Edwards & Krumhardt, unpublished
302	10 Mile	63.05	−145.42	n/a	lake	alpine tundra	Edwards & Krumhardt, unpublished
303	Ace	64.52	−147.56	n/a	lake	boreal forest	Edwards & Krumhardt, unpublished
304	Last Tundra	68.28	−149.23	n/a	lake	arctic tundra	Edwards & Krumhardt, unpublished
305	Dune	64.25	−149.54	n/a	lake	boreal forest	Edwards & Krumhardt, unpublished
306	Nutella‡	63.13	−147.41	n/a	lake	alpine tundra	Edwards & Krumhardt, unpublished
307	Quartz	64.12	−145.50	n/a	lake	boreal forest	Edwards & Krumhardt, unpublished
308	Lost Birch	64.18	−146.41	n/a	lake	boreal forest	Edwards & Krumhardt, unpublished
309	Jaeger	68.39	−149.28	n/a	lake	arctic tundra	Edwards & Krumhardt, unpublished
310	Birch	64.18	−146.38	n/a	lake	boreal forest	Edwards & Krumhardt, unpublished
311	Jan	63.34	−143.54	n/a	lake	boreal forest	Edwards & Krumhardt, unpublished
312	Meli	68.41	−149.05	n/a	lake	arctic tundra	Edwards & Krumhardt, unpublished
313	Harding	64.25	−146.54	n/a	lake	boreal forest	Edwards & Krumhardt, unpublished
314	Toolik, Site 1	68.38	−149.36	n/a	lake	arctic tundra	Edwards & Krumhardt, unpublished
315	Round Tangle	63.03	−146.00	n/a	lake	alpine tundra	Edwards & Krumhardt, unpublished
316	Paxson	62.56	−145.31	n/a	lake	boreal forest	Edwards & Krumhardt, unpublished
317	Robe Lake	61.09	−146.17	12	lake	Pacific coastal forest	Ager, unpublished
318	Sagwon Bluffs, N slope (R3310)	69.25	−148.67	< 1000	peat	arctic mesic tundra	Ager, unpublished
319	Summit Lake‡	61.77	−149.32	1158	lake	alpine tundra	Ager, unpublished
320	Stop 2, N slope (R3309)	69.25	−148.67	< 1000	peat	arctic tundra	Ager, unpublished
321	Worthington Glacier	61.17	−145.71	661	lake	alpine tundra with alder/willow shrubs	Ager, unpublished
322	Pond #2, Worthington Glacier	61.17	−145.71	661	lake	alpine tundra with alder/willow shrubs	Ager, unpublished
323	Kepler Lake, Palmer	61.55	−149.21	27	lake	boreal forest	Ager, unpublished
324	Robe Lake, Valdez	61.09	−146.17	12	lake	Pacific coastal forest	Ager, unpublished
325	Summit L./Hatcher Pass‡	61.77	−149.32	1149	lake	alpine tundra	Ager, unpublished
326	Willow Creek	61.77	−149.71	454	lake	boreal forest	Ager, unpublished
327	S. Rolly Lake	61.67	−150.13	58	lake	boreal forest	Ager, unpublished
328	Toklat River Lake (R2151)	63.50	−150.33	n/a	lake	boreal forest	Ager, unpublished
329	Austin's Cabin, St. Michael Village	63.47	−162.09	9	surface sample	peat bog	Ager, unpublished
330	St. Michael Village	63.48	−162.10	9	shallow pond	mesic coastal tundra	Ager, unpublished
331	St. Michael Village	63.47	−162.07	9	shallow pond	mesic coastal tundra	Ager, unpublished

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Table 1 *continued*

Site	Site name	Lat. (°N)	Long. (°)	Elev. (m)	Sample type	Modern vegetation type	References
333	St. Michael Village, peat section	63.48	−162.08	12	shallow pond	mesic coastal tundra	Ager, unpublished
334	Lucille Lake, Wasilla	61.58	−149.45	99	lake	disturbed boreal forest	Ager, unpublished
335	Loon Lake	61.60	−149.75	76	lake	boreal forest	Ager, unpublished
336	70 Mile Lake, Richardson Hwy	61.52	−145.23	564	lake	boreal forest	Ager, unpublished
337	Grouse Lake	60.20	−149.38	76	lake	Pacific coastal forest	Ager, unpublished
338	Denali Hwy, mile 8	63.08	−145.65	1097	pond sediment	shrub tundra with some spruce	Ager, unpublished
339	Denali Hwy, mile 15	63.05	−145.83	1036	pond sediment	shrub tundra	Ager, unpublished
340	Theneta Lake (Leila Lake)	61.90	−147.31	893	lake	boreal forest	Ager, unpublished
341	Richardson Hwy	61.86	−145.23	443	pond sediment	boreal forest	Ager, unpublished
342	Copper River Basin	62.37	−145.15	552	peat	boreal forest	Ager, unpublished
343	Long Lake	61.80	−148.22	453	lake	boreal forest	Ager, unpublished
344	Kenny Lake	61.73	−144.94	383	lake	boreal forest	Ager, unpublished
345	Silvertip Creek‡	60.73	−149.30	198	moss polster	boreal forest/Pacific coastal forest	Ager, unpublished
346	Sterling Hwy	60.78	−149.21	290	beaver pond	boreal forest/Pacific coastal forest	Ager, unpublished
347	Beluga Lake	59.64	−151.53	3	lake	salt marsh/Pacific coastal forest	Ager, unpublished
348	Crow Creek Mine	61.00	−148.08	244	moss polster	Pacific coastal forest	Ager, unpublished
349	Christiansen Lake, Talkeetna area	62.32	−150.06	107	lake	boreal forest	Ager, unpublished
350	Longmere Lake‡	60.51	−150.91	78	lake	boreal forest	Ager, unpublished
351	Portage Lakes area	60.73	−150.55	76	moss, lake edge	disturbed boreal forest	Ager, unpublished
352	Knik salt marsh	61.47	−149.73	3	shallow pond	salt marsh nr boreal forest	Ager, unpublished
353	Parks Hwy	63.33	−149.17	869	peat + moss	boreal forest	Ager, unpublished
354	Nancy Lakes	61.68	−150.08	59	lake	boreal forest	Ager, unpublished
355	Wasilla Lake	61.58	−149.41	98	lake	disturbed boreal forest	Ager, unpublished
356	Little Susitna River	61.76	−149.23	457	surface mud	boreal forest	Ager, unpublished
357	Willow Creek	61.76	−149.57	549	shallow pond	boreal forest	Ager, unpublished
358	Kepler Lake, Wasilla	61.55	−149.21	27	lake	boreal forest	Ager, unpublished
359	Mile 99 Parks Hwy	62.14	−150.05	101	lake	boreal forest	Ager, unpublished
360	Matanuska Lake	61.55	−149.23	24	lake	boreal forest	Ager, unpublished
361	Junction Lake	61.56	−149.26	24	lake	boreal forest	Ager, unpublished
362	Junction Lake	61.56	−149.26	24	lake	disturbed boreal forest	Ager, unpublished
363	Echo Lake	61.55	−149.22	24	lake	boreal forest	Ager, unpublished
364	Denali Hwy, M 95	63.26	−147.78	899	pond sediment	tundra	Ager, unpublished
365	Winchester Lagoon	61.21	−149.90	2	shallow pond	salt marsh nr boreal forest	Ager, unpublished
366	Christiansen Lake (R3096)	62.42	−150.67	< 1000	lake	n/a	Ager, unpublished
367	Ptarmigan Pond, St. Michael (R2101)	63.50	−162.05	0	lake	mesic coastal tundra	Ager, unpublished
368	N. Yukon Delta, Jones' site‡	63.17	−163.80	3	pond sediment	mesic coastal tundra	Ager, unpublished
369	Stebbins, St. Michael	63.53	−162.28	5	shallow pond	mesic coastal tundra	Ager, unpublished
370	Pond, St. Marys (R1643)	62.08	−163.25	< 1000	lake	boreal forest	Ager, unpublished
371	Yukon Delta	62.08	−164.93	9	shallow pond	mesic to wet coastal tundra	Ager, unpublished
372	Yukon Delta	62.08	−164.93	9	shallow pond	mesic to wet coastal tundra	Ager, unpublished

Table 1 *continued*

Site	Site name	Lat. (°N)	Long. (°)	Elev. (m)	Sample type	Modern vegetation type	References
373	Yukon Delta	62.73	−164.33	3	shallow pond	mesic to wet coastal tundra	Ager, unpublished
374	NW Yukon Delta	62.53	−165.10	2	shallow pond	mesic to wet coastal tundra	Ager, unpublished
375	Yukon Delta	62.95	−164.63	3	shallow pond	mesic to wet coastal tundra	Ager, unpublished
376	Kgun Lake, Yukon Delta	61.58	−163.75	6	tundra pond	shrub tundra	Ager, unpublished
377	Coastal station 24, Yukon Delta	62.00	−165.75	3	shallow pond	mesic to wet coastal tundra	Ager, unpublished
378	Scammon Bay	61.83	−165.58	3	shallow pond	mesic to wet coastal tundra	Ager, unpublished
379	The Sisters volcanic flows	63.33	−161.68	305	shallow pond	mesic tundra with local bog	Ager, unpublished
380	Yukon Delta	62.08	−164.93	9	shallow pond	mesic to wet coastal tundra	Ager, unpublished
381	Yukon Delta (R1936)	62.08	−164.93	9	pond sediment	n/a	Ager, unpublished
382	Yukon Delta (R1906)	62.08	−164.93	9	pond sediment	n/a	Ager, unpublished
383	Yukon Delta	62.08	−164.93	9	pond sediment	coastal tundra	Ager, unpublished
384	Tungak Lake area	61.17	−164.20	46	peat	xeric tundra	Ager, unpublished
385	Tungak Lake	61.19	−164.17	46	peat	shrub tundra	Ager, unpublished
386	Tungak Lake	61.19	−164.17	43	peat	mesic to wet tundra	Ager, unpublished
387	Puyuk Lake, St. Michael Island	63.50	−162.21	12	lake	mesic shrub tundra	Ager, unpublished
388	Puyuk Lake area, St. Michael Island	63.50	−162.22	15	pond sediment	mesic shrub tundra	Ager, unpublished
389	Yukon Delta	62.63	−164.20	15	peat	mesic to wet tundra	Ager, unpublished
390	Tungak Lake	61.19	−164.22	27	lake	mesic tundra	Ager, unpublished
391	St. Michael Island	63.51	−162.10	15	surface	mesic shrub tundra	Ager, unpublished
392	Yukon Delta	62.67	−164.86	2	pond sediment	mesic to wet tundra	Ager, unpublished
393	Ingakslugwat Lake	61.18	−164.13	76	peat	mesic tundra with shrubs	Ager, unpublished
394	Yukon Delta	62.37	−162.83	6	moss, pon, edge	shrub mesic tundra	Ager, unpublished
395	Yukon Delta	62.80	−164.43	3	peat	mesic tundra	Ager, unpublished
396	Point Romanof	63.19	−162.83	3	peat	mesic tundra	Ager, unpublished
397	Longmere Lake‡	60.51	−150.91	78	lake sediment	boreal forest	Ager, unpublished
398	Yukon Delta (R1353)	62.38	−163.80	n/a	n/a	n/a	Ager, unpublished
399	Yukon Delta (R1352)	62.07	−163.53	n/a	peat	n/a	Ager, unpublished
403	Denali Hwy, 2 Mile W of Cantwell (R1689)	63.33	−148.92	< 1000	surface	boreal forest	Ager, unpublished
404	Drashner Lake, M 131, Denali Hwy (R1687)	63.00	−145.83	> 1000	surface mud	boreal forest	Ager, unpublished
406	Usibelli Mine, Nenana Valley (R1456)	63.83	−149.83	< 1000	lake	boreal forest	Ager, unpublished
407	Bison Gulch (R1450)	63.83	−149.00	< 1000	surface sample	boreal forest	Ager, unpublished
408	Lake George	63.75	−144.75	< 1000	lake	boreal forest	Ager, unpublished
409	Blair Lake (R1458)	64.50	−147.33	n/a	lake	boreal forest	Ager, unpublished
412	Bear Lake	60.42	−152.37	110	lake	boreal forest/Pacific coastal forest	Ager, unpublished
413	Watana Triangle Pond (R3365A)‡	62.84	−148.24	n/a	lake	boreal forest/shrub tundra	Ager, unpublished
414	Watana Triangle Pond (R3347)‡	62.84	−148.24	n/a	lake	boreal forest/shrub tundra	Ager, unpublished

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Table 1 *continued*

Site	Site name	Lat. (°N)	Long. (°)	Elev. (m)	Sample type	Modern vegetation type	References
415	Watana Triangle Pond (R3348)	62.84	−148.24	n/a	lake	boreal forest/shrub tundra	Ager, unpublished
416	Watana Triangle Pond (R3345)	62.84	−148.24	n/a	lake	boreal forest/shrub tundra	Ager, unpublished
417	Watana Triangle Pond (R3346)	62.84	−148.24	n/a	lake	boreal forest/shrub tundra	Ager, unpublished
418	Johnson R bog‡	63.17	−163.80	440	peat	boreal forest	Ager, unpublished
419	Tungak Lake (R1977)	61.17	−164.20	46	n/a	n/a	Ager, unpublished
421	Silvertip Creek area‡	60.73	−149.30	198	shallow pond	open boreal forest/Pacific coastal forest	Ager, unpublished
422	Beaverpond	60.78	−149.21	290	pond sediment	boreal forest/Pacific coastal forest	Ager, unpublished
423	Grouse Lake nr Seward	60.08	−149.50	76	lake	Pacific coastal forest	Ager, unpublished
424	Longmere Lake	60.51	−150.91	78	lake	boreal forest	Ager, unpublished
425	Yukon Delta	62.42	−165.25	2	shallow pond	wet to mesic tundra	Ager, unpublished
426	Yukon Delta N of Scammon Bay	62.10	−165.42	3	shallow pond	wet to mesic tundra	Ager, unpublished
427	Delta, south end of Nelson Island	60.42	−165.13	2	shallow pond	mesic to wet coastal tundra	Ager, unpublished
428	Nelson Island, Lowland near Tununak	60.57	−165.25	8	shallow pond	mesic to wet coastal tundra	Ager, unpublished
429	Nelson Island, Lowlands	60.58	−165.27	9	shallow pond	mesic shrub tundra	Ager, unpublished
430	Yukon Delta, W of Newtok	61.20	−164.75	6	shallow pond	mesic shrub tundra	Ager, unpublished
431	Yukon Delta, E of Newtok (R1227)	60.92	−164.50	n/a	shallow pond	mesic shrub tundra	Ager, unpublished
432	Yukon Delta, NW Hooper Bay	61.53	−166.17	9	shallow pond	mesic shrub tundra	Ager, unpublished
433	Shaw Site, Yukon Delta (no code)	61.53	−166.17	n/a	tundra pond	mesic shrub tundra	Ager, unpublished
434	Tungak Lake, Yukon Delta	61.18	−164.17	38	peat	mesic shrub tundra	Ager, unpublished
435	Tungak Lake, Yukon Delta	61.18	−164.17	61	surface mud	mesic shrub tundra	Ager, unpublished
436	Quartz Lake	64.25	−145.83	290	lake	boreal forest	Ager, unpublished
437	NOATAK1	68.07	−159.26	230	moss polster	tundra	Elias *et al.*, 1999
438	NOATAK2	68.07	−159.26	230	moss polster	tundra	Elias *et al.*, 1999
439	NOATAK3	68.07	−159.26	230	moss polster	tundra	Elias *et al.*, 1999
440	NOATAK4	68.07	−159.26	230	moss polster	tundra	Elias *et al.*, 1999
441	NOATAK5	68.07	−159.26	230	moss polster	tundra	Elias *et al.*, 1999
442	NOATAK6	68.07	−159.26	230	moss polster	tundra	Elias *et al.*, 1999
443	NOATAK7	68.70	−159.26	230	moss polster	tundra	Elias *et al.*, 1999
444	NOATAK8	68.12	−159.77	200	moss polster	tundra	Elias *et al.*, 1999
445	NOATAK9	68.15	−160.36	160	moss polster	tundra	Elias *et al.*, 1999
446	NOATAK10	68.15	−160.36	160	moss polster	tundra	Elias *et al.*, 1999
447	NOATAK11	67.90	−160.87	140	moss polster	tundra	Elias *et al.*, 1999
448	NOATAK12	67.90	−160.87	140	moss polster	tundra	Elias *et al.*, 1999

Table 1 *continued*

Site	Site name	Lat. (°N)	Long. (°)	Elev. (m)	Sample type	Modern vegetation type	References
449	NOATAK13	67.90	−160.87	140	moss polster	tundra	Elias *et al*., 1999
450	NOATAK14	67.90	−160.87	140	moss polster	tundra	Elias *et al*., 1999
451	NOATAK15‡	67.97	−161.925	85	moss polster	gallery forest	Elias *et al*., 1999
452	NOATAK16‡	67.97	−161.925	85	moss polster	gallery forest	Elias *et al*., 1999
453	S72094A	64.90	−162.67	100	moss polster	gallery forest	Elias *et al*., 1999
454	S72194B	64.75	−165.20	200	moss polster	tundra	Elias *et al*., 1999
455	S72194D	64.90	−165.00	300	moss polster	tundra	Elias *et al*., 1999
456	S5002	69.25	−133.67	30	lake	tundra	Anderson *et al*., 1989
457	S5007	68.38	−138.38	500	lake	tundra	Anderson *et al*., 1989
458	S5008	68.27	−133.47	75	lake	forest/tundra	Anderson *et al*., 1989
459	S5010	65.95	−135.52	610	lake	forest/tundra	Anderson *et al*., 1989
460	S5011	67.20	−130.77	300	lake	forest/tundra	Anderson *et al*., 1989
461	S5014	68.30	−133.42	85	lake	forest/tundra	Anderson *et al*., 1989
462	S5015	68.25	−131.07	210	lake	forest/tundra	Anderson *et al*., 1989
463	S5020	67.68	−136.55	275	lake	forest/tundra	Anderson *et al*., 1989
464	S5021	66.05	−135.63	760	lake	forest/tundra	Anderson *et al*., 1989
465	S5022	69.05	−133.45	70	lake	tundra	Anderson *et al*., 1989
466	S5023	67.65	−132.02	300	lake	forest/tundra	Anderson *et al*., 1989
467	S5137	69.65	−131.50	30	lake	tundra	Anderson *et al*., 1989
468	S5138	69.97	−130.47	20	lake	tundra	Anderson *et al*., 1989
469	S5139	69.35	−131.70	25	lake	tundra	Anderson *et al*., 1989
470	S5140	69.12	−133.18	30	lake	tundra	Anderson *et al*., 1989
471	S5152	69.57	−134.38	20	lake	tundra	Anderson *et al*., 1989
472	S5163	68.10	−132.75	260	lake	forest/tundra	Anderson *et al*., 1989
473	S5167	68.40	−132.50	190	lake	forest/tundra	Anderson *et al*., 1989
474	S5169	68.57	−131.00	170	lake	forest/tundra	Anderson *et al*., 1989
475	S5160	68.88	−134.20	100	lake	tundra	Anderson *et al*., 1989

Table 2 Characteristics of the surface pollen samples sites from Siberia. Longitude is expressed by the standard convention, with + for °E and – for °W. For mapping purposes, some sites (indicated by ‡) which are very close to one another have been displaced slightly.

Site	Lat. (°N)	Long. (°)	Elev. (m)	Sample type	Modern vegetation type	References
R050‡	70.75	136.27	10	terrestrial surface	*Larix* forest	Klimanov & Andreev, 1992
R051‡	70.75	136.27	10	terrestrial surface	*Larix* forest	Klimanov & Andreev, 1992
R052‡	70.75	136.27	10	terrestrial surface	*Larix* forest	Klimanov & Andreev, 1992
R053‡	70.75	136.27	10	terrestrial surface	*Larix* forest	Klimanov & Andreev, 1992
R054‡	70.75	136.27	10	terrestrial surface	*Larix* forest	Klimanov & Andreev, 1992
R055‡	70.75	136.27	10	terrestrial surface	*Larix* forest	Klimanov & Andreev, 1992
R056	70.97	136.53	5	terrestrial surface	*Larix* forest-tundra	Klimanov & Andreev, 1992
R057	70.84	136.53	5	terrestrial surface	*Larix* forest-tundra	Klimanov & Andreev, 1992
R058‡	71.15	136.00	5	terrestrial surface	*Larix* forest-tundra	Klimanov & Andreev, 1992
R059‡	71.15	136.00	5	terrestrial surface	*Larix* forest-tundra	Klimanov & Andreev, 1992
R060‡	71.15	136.00	5	terrestrial surface	*Larix* forest-tundra	Klimanov & Andreev, 1992
R061‡	71.15	136.00	5	terrestrial surface	*Larix* forest-tundra	Klimanov & Andreev, 1992
R072	67.92	135.58	200	terrestrial surface	*Larix* forest	Evteeva, pers. comm.
R073	66.75	136.50	250	terrestrial surface	*Larix* forest	Evteeva, pers. comm.
R079	67.99	135.17	200	terrestrial surface	*Larix* forest	Evteeva, pers. comm.
R081	67.72	135.58	200	terrestrial surface	*Larix* forest	Evteeva, pers. comm.
R082	67.92	135.42	220	terrestrial surface	*Larix* forest	Evteeva, pers. comm.
R083	66.50	136.50	250	terrestrial surface	*Larix* forest	Evteeva, pers. comm.
R090	64.67	141.67	600	terrestrial surface	*Larix* forest	Evteeva, pers. comm.
R101	62.67	147.50	500	terrestrial surface	*Larix* forest	Evteeva, pers. comm.
R102‡	60.17	151.33	1060	terrestrial surface	*Larix* forest-tundra	Vas'kovskiy, 1957
R103‡	60.17	151.33	1000	terrestrial surface	*Larix* forest-tundra	Vas'kovskiy, 1957
R105	65.50	151.00	100	terrestrial surface	*Larix* forest	Vas'kovskiy, 1957
R109	59.50	150.75	200	terrestrial surface	*Larix* forest	Vas'kovskiy, 1957
R110	60.00	150.17	300	terrestrial surface	*Larix* forest	Vas'kovskiy, 1957
R111	62.67	147.50	600	terrestrial surface	*Larix* forest	Evteeva, pers. comm.
R112	60.00	150.17	300	terrestrial surface	*Larix* forest	Vas'kovskiy, 1957
R117	62.67	147.50	500	terrestrial surface	*Larix* forest	Evteeva, pers. comm.
R118	62.67	147.50	400	terrestrial surface	*Larix* forest	Evteeva, pers. comm.
R119	69.50	173.00	70	terrestrial surface	shrub tundra	Vas'kovskiy, 1957
R120	69.50	173.00	70	terrestrial surface	shrub tundra	Vas'kovskiy, 1957
R121	69.75	173.33	50	terrestrial surface	shrub tundra	Vas'kovskiy, 1957
R122	69.75	173.33	50	terrestrial surface	shrub tundra	Vas'kovskiy, 1957
R123	66.00	180.00	100	terrestrial surface	herb tundra	Vas'kovskiy, 1957
R124	66.00	180.00	100	terrestrial surface	herb tundra	Vas'kovskiy, 1957
KHO-CHO	71.13	136.25	10	terrestrial surface	*Larix* forest-tundra	Andreev, unpublished
R42	71.17	–179.65	204	lake	high arctic herb tundra	Anderson & Lozhkin, unpublished
R43	71.17	–179.00	7	lake	high arctic herb tundra	Anderson & Lozhkin, unpublished
R44	71.17	–179.00	7	lake	high arctic herb tundra	Anderson & Lozhkin, unpublished
R45	71.17	–179.42	8	lake	high arctic herb tundra	Anderson & Lozhkin, unpublished
R46	71.17	–179.42	7	lake	high arctic herb tundra	Anderson & Lozhkin, unpublished
R47	71.17	–179.42	7	lake	high arctic herb tundra	Anderson & Lozhkin, unpublished
R48	71.17	–179.17	55	lake	high arctic herb tundra	Anderson & Lozhkin, unpublished
R49	71.20	–178.75	120	lake	fellfield	Anderson & Lozhkin, unpublished
R50	71.20	–178.70	215	lake	fellfield	Anderson & Lozhkin, unpublished
R51	67.75	–178.83	280	lake	shrub tundra	Anderson & Lozhkin, unpublished
R52	63.42	176.55	103	lake	shrub tundra	Anderson & Lozhkin, unpublished
R53	63.17	176.75	121	lake	shrub tundra	Anderson & Lozhkin, unpublished
R54	62.17	149.50	822	lake	*Larix* forest	Anderson & Lozhkin, unpublished
R55	62.17	149.50	870	lake	*Larix* forest	Anderson & Lozhkin, unpublished

Table 2 *continued*

Site	Lat. (°N)	Long. (°)	Elev. (m)	Sample type	Modern vegetation type	References
R56	62.08	149.00	1040	lake	*Larix* forest-tundra	Anderson & Lozhkin, unpublished
R57	62.10	149.00	1053	lake	*Larix* forest-tundra	Anderson & Lozhkin, unpublished
R58‡	60.75	151.88	810	lake	*Larix* forest	Anderson & Lozhkin, unpublished
R59	59.85	150.62	115	lake	*Larix* forest	Anderson & Lozhkin, unpublished
R60	59.55	151.83	95	lake	*Larix* forest	Anderson & Lozhkin, unpublished
R61	59.75	149.92	3	lake	*Larix* forest	Anderson & Lozhkin, unpublished
R62	62.17	149.50	800	lake	*Larix* forest	Anderson & Lozhkin, unpublished
R63	62.17	149.50	870	lake	*Larix* forest	Anderson & Lozhkin, unpublished
R64‡	60.75	151.88	810	lake	*Larix* forest	Anderson & Lozhkin, unpublished
R65	60.75	151.88	810	lake	*Larix* forest	Anderson & Lozhkin, unpublished
R66	60.75	151.88	810	lake	*Larix* forest	Anderson & Lozhkin, unpublished
R67	60.12	151.00	400	lake	*Larix* forest	Anderson & Lozhkin, unpublished
R68	60.32	151.15	850	lake	*Larix* forest	Anderson & Lozhkin, unpublished
R69	61.02	151.72	980	lake	*Larix* forest	Anderson & Lozhkin, unpublished
R70	61.17	152.08	870	lake	*Larix* forest-tundra	Anderson & Lozhkin, unpublished
R71	61.12	152.27	810	lake	*Larix* forest	Anderson & Lozhkin, unpublished
R72	61.13	152.33	750	lake	*Larix* forest	Anderson & Lozhkin, unpublished
R73	63.38	147.65	969	lake	*Larix* forest	Anderson & Lozhkin, unpublished
R74	63.32	147.63	850	lake	*Larix* forest-tundra	Anderson & Lozhkin, unpublished
R75	64.18	148.20	850	lake	*Larix* forest-tundra	Anderson & Lozhkin, unpublished
R76	64.30	144.93	700	lake	*Larix* forest	Anderson & Lozhkin, unpublished
R77	64.30	144.90	700	lake	*Larix* forest	Anderson & Lozhkin, unpublished
R78	64.50	143.78	550	lake	*Larix* forest-tundra	Anderson & Lozhkin, unpublished
R79	64.75	141.12	800	lake	*Larix* forest	Anderson & Lozhkin, unpublished
R80	64.22	145.16	800	lake	*Larix* forest	Anderson & Lozhkin, unpublished
R81	67.50	172.08	490	lake	shrub tundra	Anderson & Lozhkin, unpublished
R82	67.50	172.08	490	lake	shrub tundra	Anderson & Lozhkin, unpublished
R83	67.50	172.08	490	lake	shrub tundra	Anderson & Lozhkin, unpublished
S1	68.75	161.25	n/a	terrestrial surface	*Sphagnum*, sedges	Vas'kovskiy, 1957
S2‡	65.70	150.82	n/a	terrestrial surface	*Sphagnum*, sedges	Vas'kovskiy, 1957
S3	64.75	141.56	n/a	terrestrial surface	steppe	Vas'kovskiy, 1957
S4	67.67	134.53	n/a	terrestrial surface	steppe	Vas'kovskiy, 1957
S5‡	62.67	147.75	n/a	terrestrial surface	steppe	Vas'kovskiy, 1957
S6‡	62.67	147.75	n/a	terrestrial surface	steppe	Vas'kovskiy, 1957
S7	69.75	170.31	n/a	terrestrial surface	moss-lichen tundra	Vas'kovskiy, 1957
S8	69.75	170.31	n/a	terrestrial surface	shrub tundra	Vas'kovskiy, 1957
S9	66.26	179.16	n/a	terrestrial surface	dry tundra	Vas'kovskiy, 1957
S10	66.26	179.16	n/a	terrestrial surface	boggy tundra	Vas'kovskiy, 1957
S11	67.67	134.53	n/a	terrestrial surface	*Pinus pumula* dominant	Vas'kovskiy, 1957
S13‡	64.75	141.00	n/a	terrestrial surface	*Pinus pumula* dominant	Vas'kovskiy, 1957
S14	64.58	143.23	n/a	terrestrial surface	*Pinus pumula* dominant	Vas'kovskiy, 1957
S15‡	65.70	150.82	n/a	terrestrial surface	*Larix* forest	Vas'kovskiy, 1957
S16	68.75	161.25	n/a	terrestrial surface	*Larix* forest	Vas'kovskiy, 1957
S17‡	64.75	141.00	n/a	terrestrial surface	sedges, grass	Vas'kovskiy, 1957
S18	64.75	141.00	n/a	terrestrial surface	grass	Vas'kovskiy, 1957
S19	70.00	153.40	n/a	terrestrial surface	tundra with *Salix*, cottongrass	Lozhkin & Prokhorova, 1971 (unpublished)
S20	70.00	153.40	n/a	terrestrial surface	tundra with *Carex* communities	Lozhkin & Prokhorova, 1971 (unpublished)
S21	70.00	153.40	n/a	terrestrial surface	boggy tundra with *Salix*	Lozhkin & Prokhorova, 1971 (unpublished)
S22	70.00	153.40	n/a	terrestrial surface	shrub tundra, *Betula*, *Salix*, Gramineae	Lozhkin & Prokhorova, 1971 (unpublished)
S23	70.00	153.40	n/a	terrestrial surface	shrub tundra, *Betula*, *Salix*, Gramineae, *Dryas*, *Ledum*	Lozhkin & Prokhorova, 1971 (unpublished)

Table 2 *continued*

Site	Lat. (°N)	Long. (°)	Elev. (m)	Sample type	Modern vegetation type	References
S24	70.25	153.35	n/a	terrestrial surface	shrub tundra, *Salix*, *Artemisia*, *Betula exilis*	Lozhkin & Prokhorova, 1971 (unpublished)
S25	70.25	153.35	n/a	terrestrial surface	shrub tundra	Lozhkin & Prokhorova, 1971 (unpublished)
S26	70.25	153.35	n/a	terrestrial surface	shrub tundra	Lozhkin & Prokhorova, 1971 (unpublished)
S27	70.25	153.35	n/a	terrestrial surface	shrub tundra	Lozhkin & Prokhorova, 1971 (unpublished)
S28	70.25	153.35	n/a	terrestrial surface	grass tundra	Lozhkin & Prokhorova, 1971 (unpublished)
S29	70.25	153.35	n/a	terrestrial surface	grass tundra	Lozhkin & Prokhorova, 1971 (unpublished)
S30	70.20	152.10	n/a	terrestrial surface	shrub tundra	Lozhkin & Prokhorova, 1971 (unpublished)
S31	70.20	152.10	n/a	terrestrial surface	tundra with *Dryas*	Lozhkin & Prokhorova, 1971 (unpublished)
S32	70.20	152.10	n/a	terrestrial surface	shrub tundra with *Alnaster fruticosa*	Lozhkin & Prokhorova, 1971 (unpublished)
S33	70.20	152.10	n/a	terrestrial surface	tundra, *Salix* dominant	Lozhkin & Prokhorova, 1971 (unpublished)
S34	70.20	152.10	n/a	terrestrial surface	tundra, *Salix* dominant	Lozhkin & Prokhorova, 1971 (unpublished)
S35‡	60.00	151.00	n/a	terrestrial surface	mixed *Larix* forest	Kartashova, 1971
S36‡	60.00	151.00	n/a	terrestrial surface	mixed *Larix* forest	Kartashova, 1971
S37‡	60.00	151.00	n/a	terrestrial surface	mixed *Larix* forest	Kartashova, 1971
S38‡	60.00	151.00	n/a	terrestrial surface	mixed *Larix* forest	Kartashova, 1971
S39‡	60.00	151.00	n/a	terrestrial surface	mixed *Larix* forest	Kartashova, 1971
S40‡	60.00	151.00	n/a	terrestrial surface	mixed *Larix* forest	Kartashova, 1971
S41‡	60.00	151.00	n/a	terrestrial surface	mixed *Larix* forest	Kartashova, 1971
S42‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest with willows & aspen	Kartashova, 1971
S43‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest with willows & aspen	Kartashova, 1971
S44‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest with willows & aspen	Kartashova, 1971
S45‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest with willows & aspen	Kartashova, 1971
S46‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest with willows & aspen	Kartashova, 1971
S47‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest, meadow	Kartashova, 1971
S48‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest, meadow	Kartashova, 1971
S49‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest, meadow	Kartashova, 1971
S50‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest, meadow	Kartashova, 1971
S51‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest, meadow	Kartashova, 1971
S52‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest	Kartashova, 1971
S53‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest	Kartashova, 1971
S54‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest	Kartashova, 1971
S55‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest	Kartashova, 1971
S56‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest	Kartashova, 1971
S57‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest	Kartashova, 1971
S58‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest	Kartashova, 1971
S59‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest	Kartashova, 1971
S60‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest	Kartashova, 1971
S61‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest	Kartashova, 1971
S62‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest	Kartashova, 1971
S63‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest	Kartashova, 1971
S64‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest	Kartashova, 1971
S65‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest	Kartashova, 1971
S66‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest	Kartashova, 1971
S67‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest	Kartashova, 1971
S68‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest	Kartashova, 1971
S69‡	60.00	151.00	n/a	terrestrial surface	*Larix* forest	Kartashova, 1971
S70‡	72.00	127.00	n/a	terrestrial surface	moss-lichen tundra, cottongrass	Savvinova, 1975a
S71‡	72.00	127.00	n/a	terrestrial surface	alpine tundra	Savvinova, 1975a
S72‡	72.00	127.00	n/a	terrestrial surface	alpine tundra	Savvinova, 1975a
S73‡	72.00	127.00	n/a	terrestrial surface	alpine tundra	Savvinova, 1975a
S74‡	72.00	127.00	n/a	terrestrial surface	dry tundra	Savvinova, 1975a

Table 2 *continued*

Site	Lat. (°N)	Long. (°)	Elev. (m)	Sample type	Modern vegetation type	References
S75‡	72.00	127.00	n/a	terrestrial surface	*Carex*, cottongrass tundra	Savvinova, 1975a
S76‡	72.00	127.00	n/a	terrestrial surface	moss-lichen tundra, cottongrass	Savvinova, 1975a
S77	70.60	134.60	n/a	terrestrial surface	tundra	Savvinova, 1975a
S78	70.60	134.60	n/a	terrestrial surface	tundra	Savvinova, 1975a
S79	70.60	134.60	n/a	terrestrial surface	tundra	Savvinova, 1975b
S80	62.05	132.33	n/a	terrestrial surface	steppe with *Carex*, *Artemisia*, forest *c*. 200 m	Savvinova, 1975b
S81	62.05	132.33	n/a	terrestrial surface	steppe with *Carex*, *Artemisia*, forest *c*. 200 m	Savvinova, 1975b
S82	62.05	132.33	n/a	terrestrial surface	steppe with *Carex*, *Artemisia*	Savvinova, 1975b
S83	62.05	132.33	n/a	terrestrial surface	steppe & meadow vegetation, grass	Savvinova, 1975b
S84	62.05	132.33	n/a	terrestrial surface	steppe & meadow vegetation, forest close	Savvinova, 1975b
S85	64.80	133.67	n/a	terrestrial surface	grass	Savvinova, 1975b
S86	64.80	133.67	n/a	terrestrial surface	grass	Savvinova, 1975b
S87	61.67	129.25	n/a	terrestrial surface	*alas* (depression); forest *c*. 100 m distant	Savvinova, 1975b
S88	61.67	129.25	n/a	terrestrial surface	*alas* (depression); forest *c*. 100 m distant	Savvinova, 1975b
S89	61.67	129.25	n/a	terrestrial surface	*Larix* forest, pine *c*. 6 km distant	Savvinova, 1975b
S90	61.67	129.25	n/a	terrestrial surface	*Larix* forest, pine *c*. 6 km distant	Savvinova, 1975b
S91	61.67	129.25	n/a	terrestrial surface	muskeg, forest close by	Savvinova, 1975b
S92	61.67	129.00	n/a	terrestrial surface	*Larix* forest	Savvinova, 1975b
S93	61.67	129.00	n/a	terrestrial surface	wet meadow, grass, birch forest *c*. 100 m	Savvinova, 1975a
S94	71.10	151.00	n/a	terrestrial surface	steppe	Savvinova, 1975a
S95	71.10	151.00	n/a	terrestrial surface	arctic tundra	Savvinova, 1975a
S96	71.10	151.00	n/a	terrestrial surface	arctic tundra	Savvinova, 1975a
S97	71.10	151.00	n/a	terrestrial surface	arctic tundra	Savvinova, 1975a
S98	71.10	151.00	n/a	terrestrial surface	arctic tundra	Savvinova, 1975a
S99	68.90	161.25	n/a	terrestrial surface	arctic tundra	Savvinova, 1975a
S100	68.90	161.25	n/a	terrestrial surface	arctic tundra	Savvinova, 1975a
S101	68.90	161.25	n/a	terrestrial surface	arctic tundra	Savvinova, 1975a
S102	68.90	161.25	n/a	terrestrial surface	arctic tundra	Savvinova, 1975a
S103	68.90	161.25	n/a	terrestrial surface	arctic tundra	Savvinova, 1975a
S104	68.90	161.25	n/a	terrestrial surface	arctic tundra	Savvinova, 1975a
S107	69.50	157.00	n/a	terrestrial surface	arctic tundra	Sher, unpublished
S108	69.50	157.00	n/a	terrestrial surface	arctic tundra	Sher, unpublished
S109	69.50	157.00	n/a	terrestrial surface	arctic tundra	Sher, unpublished
S110	68.70	158.40	n/a	terrestrial surface	arctic tundra	Sher, unpublished
S111	68.70	158.40	n/a	terrestrial surface	arctic tundra	Sher, unpublished
S112	68.70	158.40	n/a	terrestrial surface	arctic tundra	Sher, unpublished
S113‡	68.10	157.50	n/a	terrestrial surface	arctic tundra	Sher, unpublished
S114‡	68.10	157.50	n/a	terrestrial surface	arctic tundra	Sher, unpublished
S115	69.30	177.50	n/a	terrestrial surface	arctic tundra	Tergrigoryan, 1978
S116	69.30	177.50	n/a	terrestrial surface	arctic tundra	Tergrigoryan, 1978
S117	69.30	177.50	n/a	terrestrial surface	arctic tundra	Tergrigoryan, 1978
S118	69.30	177.50	n/a	sediment	arctic tundra	Tergrigoryan, 1978
S119	69.30	177.50	n/a	sediment	arctic tundra	Tergrigoryan, 1978
S120	69.30	177.50	n/a	sediment	arctic tundra	Tergrigoryan, 1978
S121	69.30	177.50	n/a	sediment	arctic tundra	Tergrigoryan, 1978
S122	69.30	177.50	n/a	sediment	arctic tundra	Tergrigoryan, 1978
S123	69.30	177.50	n/a	sediment	arctic tundra	Tergrigoryan, 1978

Table 2 *continued*

Site	Lat. (°N)	Long. (°)	Elev. (m)	Sample type	Modern vegetation type	References
S124	65.75	−172.80	n/a	terrestrial surface	arctic tundra	Davidovich, 1978
S125	65.75	−172.80	n/a	terrestrial surface	arctic tundra	Davidovich, 1978
S128	65.00	−175.80	n/a	terrestrial surface	arctic tundra	Davidovich, 1978
S129	65.20	−175.70	n/a	terrestrial surface	arctic tundra	Davidovich, 1978
S130	65.80	−175.00	n/a	terrestrial surface	arctic tundra	Davidovich, 1978
S131	65.95	−176.30	n/a	terrestrial surface	arctic tundra	Davidovich, 1978
S132	65.90	−175.60	n/a	terrestrial surface	arctic tundra	Davidovich, 1978
S133	65.50	−175.70	n/a	terrestrial surface	arctic tundra	Davidovich, 1978
S134	65.70	−177.50	n/a	terrestrial surface	arctic tundra	Davidovich, 1978
S135	65.70	−179.50	n/a	terrestrial surface	arctic tundra	Davidovich, 1978
S136	65.30	180.00	n/a	terrestrial surface	arctic tundra	Davidovich, 1978
S137	65.30	180.00	n/a	terrestrial surface	arctic tundra	Davidovich, 1978
S139	65.30	180.00	n/a	terrestrial surface	arctic tundra	Davidovich, 1978
S141	66.10	178.30	n/a	terrestrial surface	arctic tundra	Davidovich, 1978
S142	65.60	−176.70	n/a	terrestrial surface	arctic tundra	Davidovich, 1978
S143	68.60	160.50	n/a	terrestrial surface	arctic tundra	Giterman, 1979 (unpublished)
S144	68.60	160.00	n/a	terrestrial surface	*Larix* forest	Giterman, 1979 (unpublished)
S145	71.50	−179.00	n/a	terrestrial surface	*Larix* forest	Giterman, 1979 (unpublished)
S146	71.50	180.00	n/a	terrestrial surface	arctic tundra	Giterman, 1979 (unpublished)
S147	69.40	156.70	n/a	terrestrial surface	arctic tundra	Lozhkin & Prohorova, 1982
S148	69.40	156.70	n/a	terrestrial surface	no plant cover	Lozhkin & Prohorova, 1982
S149	69.40	156.70	n/a	terrestrial surface	no plant cover	Lozhkin & Prohorova, 1982
S150	69.40	156.70	n/a	terrestrial surface	tundra, moss-grass cover	Lozhkin & Prohorova, 1982
S151	69.40	156.70	n/a	terrestrial surface	tundra, moss grass, willow	Lozhkin & Prohorova, 1982
S152	69.40	156.70	n/a	terrestrial surface	tundra, sedges, moss, grass	Lozhkin & Prohorova, 1982
S153	69.40	156.70	n/a	terrestrial surface	tundra, moss, cottongrass, grass	Lozhkin & Prohorova, 1982
S154	69.40	156.70	n/a	terrestrial surface	tundra, moss grass, willow	Lozhkin & Prohorova, 1982
S155	69.40	156.70	n/a	terrestrial surface	tundra, willow, moss, grass	Lozhkin & Prohorova, 1982
S156	69.40	156.70	n/a	terrestrial surface	tundra, moss, cottongrass, grass	Lozhkin & Prohorova, 1982
S157	69.40	156.70	n/a	terrestrial surface	tundra, willow, moss, grass	Lozhkin & Prohorova, 1982
S158	69.40	156.70	n/a	terrestrial surface	tundra, moss, cottongrass, grass	Lozhkin & Prohorova, 1982
S159	69.40	156.70	n/a	terrestrial surface	tundra, moss, cottongrass, grass	Lozhkin & Prohorova, 1982
S160	69.40	156.70	n/a	terrestrial surface	tundra, willow, moss, *Dryas*	Lozhkin & Prohorova, 1982
S161	72.25	142.00	n/a	terrestrial surface	tundra, willow, moss, grass	Lozhkin, unpublished
S162	72.25	142.00	n/a	terrestrial surface	tundra, yedoma	Lozhkin, unpublished
S163	72.25	142.00	n/a	terrestrial surface	tundra, yedoma	Lozhkin, unpublished
S164	72.25	142.00	n/a	terrestrial surface	tundra, yedoma	Lozhkin, unpublished
S165	72.25	142.00	n/a	terrestrial surface	tundra, yedoma	Lozhkin, unpublished
S166	72.25	142.00	n/a	sediment	tundra, yedoma	Lozhkin, unpublished
S167	74.50	143.00	n/a	sediment	tundra	Lozhkin, unpublished

Table 3 Characteristics of the 6000 and 18,000 ^{14}C yr BP pollen sites from Alaska and north-western Canada. Longitude is expressed by the standard convention, with + for °E and – for °W. Dating control (DC) codes are based on the COHMAP dating control scheme (Webb, 1985; Yu & Harrison, 1995). For sites with continuous sedimentation (indicated by a C after the numeric code), the dating control is based on bracketing dates where 1 indicates that both dates are within 2000 years of the selected interval, 2 indicates one date within 2000 years and the other within 4000 years, 3 indicates both within 4000 years, 4 indicates one date within 4000 years and the other within 6000 years, 5 indicates both dates within 6000 years, 6 indicates one date within 6000 years and the other within 8000 years, and 7 indicates bracketing dates more than 8000 years from the selected interval. For sites with discontinuous sedimentation (indicated by D after the numeric code), 1 indicates a date within 250 years of the selected interval, 2 a date within 500 years, 3 a date within 750 years, 4 a date within 1000 years, 5 a date within 1500 years, 6 a date within 2000 years, and 7 a date more than 2000 years from the selected interval. For mapping purposes, some sites (indicated by ‡) which are very close to one another have been displaced slightly.

Site name or CODE	Lat. (°N)	Long. (°)	Elev. (m)	Sample type	Record length (yr)	No. of ^{14}C dates	DC at 6000 ^{14}C yr BP	DC at 18,000 ^{14}C yr BP	References
Antifreeze Pond	62.35	−140.83	706	lake	0–29,700	7 + top	4C	7C	Rampton, 1971
Bells Lake	65.02	−127.48	n/a	lake	0–10,230	5	1C	n/a	Szeicz *et al.*, 1995
Bluffers Pingo	69.65	−132.22	0	lake	n/a	3	2C	n/a	Spear, 1993
Candelabra Lake	61.68	−130.65	n/a	lake	0–10,000	11 + top	1C	n/a	Cwynar & Spear, 1995
Chapman	64.87	−138.25	n/a	peat	0–13,870	1 + top	5C	n/a	Terasmae & Hughes, 1966
Clam Gulch	60.24	−151.15	30	peat	0–7900	2 + top	1C	n/a	Ager, unpublished
Colville Lake	67.10	−125.78	n/a	peat	n/a	7	1C	n/a	Nichols, 1974
Crowsnest Lake	68.33	−146.48	881	lake	0–10,600	4 + top	2D	n/a	Anderson, unpublished
Dune Lake	64.42	−149.90	134	lake	0–9800	5 + # + §	1D	n/a	Bigelow, 1997
Eightmile Lake	63.89	−149.25	648	peat	0–14,100	4 + top	1C	n/a	Ager, 1983
Eisenmenger Forest	64.33	−143.80	900	peat	0–15,300	2 + top	4C	n/a	Ager, unpublished
Etivlik Lake	68.13	−156.03	631	lake	0–13,750	3† + top	2C	n/a	Anderson, unpublished
Farewell Lake	62.55	−153.63	320	lake	0–11,000	5 + top	1C	n/a	Hu *et al.*, 1996
Grandfather Lake	59.80	−158.52	n/a	lake	0–13,000	6 + top	1C	n/a	Hu *et al.*, 1995
Gill	65.61	−139.75	n/a	peat	0–12,600	1 + top	5C	n/a	Terasmae & Hughes, 1966
Glacial Lake	64.87	−166.27	120	lake	0–15,000	top + poll.	7	n/a	Lozhkin *et al.*, 1996b
Grizzly Lake	62.71	−144.20	n/a	peat	0–5100	1 + top	1D	n/a	Ager, unpublished
Grosvenor Lake	58.66	−155.17	110	peat	0–10,000	2 + top	4C	n/a	Ager, unpublished
Hail Lake	60.03	−129.02	n/a	lake	0–9500	11 + top	1D	n/a	Cwynar & Spear, 1995
Hanging Lake	68.38	−138.38	500	lake	0–41,100	20 + top	1C	1C	Cwynar, 1982
Harding Lake	64.44	−146.91	n/a	lake	0–16,000	4 + top	4C	n/a	Nakao *et al.*, 1980
Headwaters Lake	67.93	−155.05	820	lake	0–11,750	3 + top	2C	n/a	Brubaker *et al.*, 1983
Healy Lake (2)‡	64.00	−144.08	343	lake	0–7700	1 + top + poll.	4C	n/a	Ager, 1975
Hidden Lake	60.48	−150.29	n/a	lake	0–15,300	4 + top	1D	n/a	Ager & Brubaker, 1985
Homer Peat	59.63	−151.55	10	peat	0–12,400	2 + top	4C	n/a	Ager, unpublished
Idavain Lake	58.77	−155.95	223	lake	0–14,000	10 + top	2C	n/a	Brubaker *et al.*, in press
Joe Lake	66.77	−157.22	183	lake	0–36,970	8† + top	1C	6C	Anderson, 1988; Anderson *et al.*, 1994
Johnson River Bog (2)‡	63.70	−144.15	442	peat	0–8000	1 + top	4C	n/a	Ager, 1975
4th of July Creek (2)	63.20	−148.67	n/a	peat	0–7100	2 + top	1C	n/a	Ager, unpublished
Kaiyak Lake	68.15	−161.42	190	lake	0–37,000	6† + top	2C	3C	Anderson, 1985
Kalifonsky Beach	60.48	−151.25	n/a	peat	0–10,600	1 + top	5C	n/a	Ager, unpublished
Keele Lake	64.17	−127.62	1150	lake	0–11,900	6	2C	n/a	Szeicz *et al.*, 1995
Kolioksok Lake (2)‡	66.97	−156.45	213	lake	0–15,100	4 + top	2C	n/a	Anderson, unpublished
Lake M (2) (Maria Lake)	68.10	−133.47	105	lake	n/a	5	2C	n/a	Ritchie, 1977
Longmere Lake (2)	60.65	−151.30	n/a	lake	0–11,300	2 + top	4C	n/a	Ager, unpublished
Louise Pond	53.42	−131.75	650	lake	0–10,100	5 + top	2C	n/a	Pellatt & Mathewes, 1994
Lac Meleze (2)	65.22	−126.12	650	lake	0–11,000	6	1D	n/a	MacDonald, 1987
Minakokosa Lake (2)	66.92	−155.03	122	lake	0–16,000	4† + top	2C	n/a	Anderson, 1993 (unpublished)
Lake Minchumina	63.90	−152.23	196	lake	0–8400	1 + top	4C	n/a	Ager, unpublished
NATL2_3	63.02	−128.80	1380	peat	0–8700	6†	1C	n/a	MacDonald, 1983
NATLA1	63.02	−128.80	1380	peat	0–8700	6†	1C	n/a	MacDonald, 1983
NATLA4	63.02	−128.80	1380	peat	0–8700	6†	1C	n/a	MacDonald, 1983

Table 3 *continued*

Site name or CODE	Lat. (°N)	Long. (°)	Elev. (m)	Sample type	Record length (yr)	No. of ^{14}C dates	DC at 6000 ^{14}C yr BP	DC at 18,000 ^{14}C yr BP	References
Niliq Lake	67.87	−160.45	274	lake	0–13,880	5 + top	2C	n/a	Anderson, 1988
North Killeak Lake	66.33	−164.17	16	lake	0–14,100	2 + top	2C	n/a	Anderson, unpublished
Ongivinuk Lake	59.57	−159.37	163	lake	0–12,500	top + strat.	1C	n/a	Hu *et al*., 1995
Otto Lake	63.83	−149.03	546	lake	0–5700	2 + top	2D	n/a	Ager, unpublished
Ped Pond	67.20	−142.07	211	lake	0–12,530	6 + top	1C	n/a	Edwards & Brubaker, 1986
PolyBog	67.80	−139.80	n/a	peat	0–11,600	11	1C	n/a	Ovenden, 1982
Puyuk Lake	63.50	−162.03	15	lake	0–16,000	2 + top	4C	n/a	Ager, 1982
Quartz Lake	64.20	−145.80	290	lake	0–10,600	1 + top	5C	n/a	Ager, 1975
Ra Lake	65.23	−126.42	330	lake	n/a	2	2D	n/a	MacDonald, 1984
Ranger Lake	67.15	−153.65	820	lake	0–20,900	8 + top	1C	6C	Brubaker *et al*., 1983
Rebel Lake	67.42	−149.80	914	lake	0–14,430	2† + top	4C	n/a	Edwards *et al*., 1985
Redondo Lake	67.68	−155.03	460	lake	0–5800	2 + top	6D	n/a	Brubaker *et al*., 1983
Redstone Lake	67.25	−152.60	914	lake	0–14,100	3† + top	2D	n/a	Edwards *et al*., 1985
Ruppert Lake	67.07	−154.23	210	lake	0–13,000	8† + top	1C	n/a	Brubaker *et al*., 1983
Sakana Lake	67.43	−147.85	640	lake	0–13,000	4† + top	1C	n/a	Brubaker, 1993 (unpublished)
Sands of Time Lake	66.30	−147.55	230	lake	0–22,700	10 + top	1C	2C	Lamb & Edwards, 1988
SC1POND	54.42	−131.90	550	lake	0–7100	3 + top	2C	n/a	Pellatt & Mathewes, 1997
Screaming Yellowlegs Pond	67.58	−151.42	650	lake	0–13,300	8† + top	1C	n/a	Edwards *et al*., 1985
Seagull Lake	68.27	−145.22	637	lake	0–13,800	3† + top	2C	n/a	Brubaker, unpublished
Shangri-La Bog	53.27	−132.40	595	peat	0–7200	1 + top	4C	n/a	Pellatt & Mathewes, 1997
Sithylemenkat Lake	66.07	−151.27	213	lake	0–14,000	5 + top	2C	n/a	Anderson *et al*., 1990
Sleet Lake	69.25	−133.67	n/a	lake	n/a	5	1C	n/a	Spear, 1983
Snipe Lake	60.64	−154.28	579	lake	0–13,600	7 + top	1C	n/a	Anderson, unpublished
Squirrel Lake	67.10	−160.38	91	lake	0–140,000	3 + top + strat.	2C	6C	Anderson, 1985
St Lawrence Island	63.75	−171.50	n/a	peat	0–29,000	7 + top	2C	n/a	Lozhkin, unpublished
St Lawrence Section	63.75	−171.00	0	peat	0–5600	6 + top	2D	n/a	Lozhkin, unpublished
Sweet Little Lake	67.65	−132.02	0	lake	0–10,300	4 + top	2C	n/a	Ritchie, 1984b
Ten Mile Lake	63.10	−145.70	1000	lake	0–11,880	4 + top	2C	n/a	Anderson *et al*., 1994
Tiinkdhul Lake	66.58	−143.15	189	lake	0–17,280	6† + top	2C	3D	Anderson *et al*., 1988
Tuktoyaktuk	69.05	−133.45	60	n/a	0–13,900	5 + top	2C	n/a	Ritchie & Hare, 1971
Twin Lakes	68.30	−133.42	0	peat	0–8200	1 + top	4C	n/a	MacKay & Terasmae, 1963
Watana Triangle	62.84	−148.24	n/a	lake	0–13,700	4 + top	1C	n/a	Ager, unpublished
Wiener Lake	61.81	−148.16	n/a	lake	0–12,600	1 + top	5C	n/a	Ager, unpublished
Wein Lake	64.33	−151.27	305	lake	0–12,200	8† + top	1C	n/a	Hu *et al*., 1993
Windmill Lake (2)	63.65	−148.13	640	lake	0–14,100	9 + top	1D	n/a	Bigelow, 1997
Wonder Lake	63.48	−151.08	610	lake	0–10,270	8 + top	2C	n/a	Anderson *et al*., 1994
Point Woronzof	61.12	−149.13	n/a	peat	0–11,600	1 + top + strat.	5C	n/a	Ager & Brubaker, 1985

(2) = number of samples biomised.
† = some dates rejected and not used to erect chronology.
top = top of core/section assumed modern.
# = additional tephra dates used to erect chronology.
§ = additional ^{210}Pb dates used to erect chronology.
poll. = additional pollen stratigraphic dates used to erect chronology.
strat. = additional regional stratigraphic dates used to erect chronology.

Table 4 Characteristics of the 6000 and 18,000 ^{14}C yr BP pollen sites from Siberia. Longitude is expressed by the standard convention, with + for °E and – for °W. Site names with asterisks indicate digitized data, those without an asterisk were taken from the Noth American Pollen Database or the PALE Pollen Database. Dating control (DC) codes follow the scheme described in Table 3.

Site name or CODE	Lat. (°N)	Long. (°)	Elev. (m)	Sample type	Record length (yr)	No. of ^{14}C dates	DC at 6000 ^{14}C yr BP	DC at 18,000 ^{14}C yr BP	References
Elikchan	60.75	151.88	810	lake	0–47,000	4** +top	3C	6C	Lozhkin *et al.*, 1995
Gytgykai	63.42	176.55	102	lake	0–27,000	5**	4C	4C	Anderson & Lozhkin, unpublished
Jack London (Magadan Oblast′)	62.10	149.30	820	lake	0–26,000	7**	4C	2C	Lozhkin *et al.*, 1993
Jack London, Wrangel Is.	70.83	–179.00	7	lake	1000–12,000	5 +top	2C	n/a	Lozhkin *et al.*, in press
ADYCHA	67.57	134.42	130	peat horizon & palaeosol	1000–8800	5 +top	2C	n/a	Lozhkin, unpublished
ALAZEYA	68.50	154.00	40	peat exposure	4000–10,000	5	2C	n/a	Kaplina & Lozhkin, 1982
Camping exposure	59.55	151.83	91	peat	0–7000	5	1D	n/a	Anderson *et al.*, 1997a
DIMA4	62.67	146.02	700	palaeosols	1000–6000	4	1C	n/a	Shilo *et al.*, 1983
Elgennya	62.08	149.00	1040	lake	0–15,000	6 +top	4C	n/a	Lozhkin *et al.*, 1996a; Anderson *et al.*, 1997b
Kazachie	70.77	136.25	15	peat exposure	0–7000	11**	1C	n/a	Andreev *et al.*, 2000
KUOBAKH	64.98	142.63	500	alluvium	1000–6000	5 +top	2D	n/a	Lozhkin, unpublished
LORINO	65.50	171.03	12	peat exposure	4300–8500	3	2D	n/a	Ivanov, 1986
MALTAN	60.93	150.38	800	peat & alluvium	1000–18,600	10***	4C	n/a	Lozhkin & Glushkova, 1997
Uandi*	51.40	142.08	229	peat exposure	> 9000	4	4C	n/a	Khotinskiy, 1977; Peterson, 1993
Cherni Iar*	52.33	140.45	77	n/a	< 9000	2	7	n/a	Korotkiy *et al.*, 1976; Peterson, 1993
Kirganskaiya Tundra*	54.80	158.80	150	peat	> 9000	0****	7	n/a	Khotinskiy, 1977; Peterson, 1993
Icha*	55.57	155.98	77	peat exposure	> 9000	3	2C	n/a	Khotinskiy, 1977; Peterson, 1993
Ushkovskiy*	56.22	159.97	150	n/a	> 9000	1	7	n/a	Kuprina, 1970; Peterson, 1993
Ust-Khairiuzovo*	57.13	156.78	77	peat exposure	> 9000	4	1C	n/a	Khotinskiy, 1977; Peterson, 1993
Selerikan*	64.30	141.87	458	peat exposure	> 9000	2	2C	n/a	Belorusova *et al.*, 1977; Peterson, 1993
Sort*	68.83	148.00	20	peat exposure	> 6000	2	2C	n/a	Boyarskaya & Kaplina, 1979; Peterson, 1993
Penzhinskaya Gulf	62.42	162.08	32	peat	2800–6000	2	2C	n/a	Ivanov *et al.*, 1984
ULAKHAN	67.83	134.42	130	peat	4000–8700	3 +top	1C	n/a	Lozhkin, unpublished
Old Camp	62.17	149.35	870	lake	0–5600	2***	7	n/a	Anderson & Lozhkin, unpublished
Rock Island	62.17	149.35	870	lake	0–5800	2	1D	n/a	Lozhkin *et al.*, 1993

** age reversals, not all dates used for chronology.
*** basal date rejected, site not used for 18,000 ^{14}C yr BP.
**** dates rejected, age model based on regional stratigraphy.
top = top of core/section assumed modern.

Table 5 Assignments of pollen taxa from Beringia to the plant functional types (PFTs) used in the biomization procedure.

Abbr.	Plant functional type	Pollen taxa
aa	arctic/alpine dwarf shrub	*Alnus viridis*, *Alnus*, *Alnus fructicosa*-type, *Alnaster*, Betulaceae, *Betula*, *Betula exilis*, *Betula* sect. Nanae, *Betula nana*, *Betula nana*-type, *Betula* shrub, *Dryas*, *Rhododendron*, Rosaceae, *Salix*, *Spiraea*
ab	arctic/boreal dwarf shrub	*Rubus arcticus*, *Rubus chamaemorus*
af	arctic/alpine forb	*Aconitum*, *Allium*, Alliaceae, *Ambrosia*-type, Apiaceae, Asteraceae undiff., Asteraceae subf. Cichorioideae, Asteroideae, Brassicaceae, *Bupleurum*, Campanulaceae, *Cardamine*, Cichoroideae, *Circea alpina*, Compositae, Crassulaceae, cf. Crassulaceae, Cruciferae, Caryophyllaceae, *Dodecatheon*-type, *Epilobium*, *Epilobium angustifolium*, Fabaceae, *Filipendula*, *Galium*, Gentianaceae, *Gentiana*, *Hedysarum*-type, *Koenigia*, *Koenigia islandica*, *Lagotis*, Leguminosae, Liguliflorae, Liliaceae, cf. Liliaceae, *Lupinus*, Onagraceae, *Pedicularis*, *Pedicularis langsdorfii*, *Pedicularis verticilliata*, *Plantago maritima*, Polygonaceae, Polemoniaceae, *Polemonium*, *Polygonum bistorta*-type, *Polygonum viviparum*, *Polygonum* sect. *bistorta*, *Potentilla*, Primulaceae, Ranunculaceae, *Ranuculus*, Rosaceae, Rubiaceae, *Rubus*, *Rumex*, *Rumex arcticus*, *Rumex/Oxyria*, *Rumex/Oxyria digyna*, *Sanguisorba*, *Saussurea*, Saxifragaceae undiff., *Saxifraga*, *Saxifraga cernua*-type, *Saxifraga foliosa*-type, *Saxifraga hieracifolia*-type, *Saxifraga tricuspidata*, *Saxifraga tricuspidata*-type, Scrophulariaceae, *Senecio*, *Sedum*, *Stellaria*, *Taraxacum*, *Thalictrum*, Tubuliflorae, Umbelliferae, Valerianaceae, *Valeriana*, *Valeriana egnifata*
ah	arctic heath	*Cassiope*, *Diapensia*
bec	boreal evergreen conifer	*Abies*, *Picea*, *Picea* sect. *eupicea*, *Picea glauca*, *Picea mariana*
bf	boreal forb	*Aconitum*, Alliaceae, *Allium*, *Ambrosia*-type, Asteraceae undiff., Asteraceae subf. Cichorioideae, Asteroideae, Boraginaceae, *Cardamine*, Cichorioideae, Compositae, *Coptis*, *Epilobium*, *Epilobium angustifolium*, Fabaceae, *Filipendula*, *Fragaria*, *Galium*, Geraniaceae, *Geranium erianthum*, *Hedysarum*-type, Labiatae undiff., Lamiaceae, Leguminosae, Liguliflorae, Liliaceae, cf. Liliaceae, *Linnaea*, *Mentha*-type, *Mertensia*, Onagraceae, *Parnassia*, *Plantago maritima*, Polemoniaceae, *Polemonium*, Ranunculaceae, *Ranunculus*, Rosaceae, Rubiaceae, *Rubus*, *Rumex*, *Rumex arcticus*, *Rumex/Oxyria*, *Rumex/Oxyria digyna*, *Sanguisorba*, *Senecio*, Tubuliflorae, Valerianaceae, *Valeriana*, *Valeriana egnifata*, *Viola*
bs	boreal summergreen	*Alnus* undiff., *Alnus glutinosa*, *Alnus incana*, *Alnus viridis*, *Alnus fruticosa*-type, *Alnaster*, Betulaceae, *Betula* undiff., *Betula* arbor s. *Albae*, *Betula* a., *Betula albae*, *Betula* arbor., *Betula fruticosa*, *Betula platyphylla*, *Chosenia*, Cornaceae, *Cornus*, *Cornus canadensis*, *Cornus sericea*, *Myrica*, cf. *Myrica*, *Populus*, *Populus balsamifera*, *Populus tremuloides*, *Salix*
bsc	boreal summergreen conifer	*Larix*, *Larix gmelinii*
bts	boreal-temperate summergreen shrub	Caprifoliaceae, *Lonicera*, *Ribes*, Rosaceae, *Sambucus*, *Shepherdia*, *Shepherdia canadensis*, *Spiraea*, *Viburnum*, cf. *Viburnum*, *Viburnum opulus*
cbc	cool-boreal conifer shrub	*Pinus pumila*; in Siberia *Pinus*, *Pinus* (Haploxylon) also included
ctc	cool-temperate conifer	*Abies*, *Tsuga*, *Tsuga heterophylla*, *Tsuga mertensiana*
dtf	dry tundra forb	*Androsace*, *Anemone*-type, *Arnica*, *Astragalus*-type, *Draba*, *Oxyria digyna*, *Oxytropis*, Papaveraceae, *Papaver*, *Phlox*, *Plantago* undiff., *Plantago canescens*-type, *Plantago major*-type, Plantaginaceae, *Saxifraga oppositifolia*, *Selaginella siberica*
ec	eurythermic conifer	Cupressaceae, *Juniperus*, Pinaceae, *Pinus* (Haploxylon), *Pinus contorta*, *Pinus* subg. *Pinus*, *Pinus* sect., *Pinus sylvestris*, *Pinus* subg. *Strobus*; in Alaska *Pinus*, *Pinus* (Diploxylon) also included
g	grass	Gramineae, Poaceae
h	heath	*Arctostaphylos*, *Empetrum*, Ericaceae undiff., Ericales, *Ledum*-type, Pyrolaceae, *Pyrola*, *Vaccinium*-type
s	sedge	Cyperaceae
sf	steppe forb	*Allium*, Alliaceae, *Amarantha*, *Ambrosia*-type, *Anemone*-type, Apiaceae, *Artemisia*, Asteraceae subf. Cichorioideae, Asteraceae undiff., Asteroideae, Boraginaceae, Brassicaceae, *Bupleurum*, Campanulaceae, Cichorioideae, Compositae, Crassulaceae, cf. Crassulaceae, Cruciferae, Caryophyllaceae, *Dodecatheon*-type, *Epilobium*, Fabaceae, *Galium*, Geraniaceae, Labiatae undiff., Lamiaceae, Leguminosae, Liguliflorae, Liliaceae, cf. Liliaceae, *Mentha*-type, Onagraceae, *Oxytropis*, *Plantago* undiff., *Plantago major*-type, Plantaginaceae, Plumbaginaceae, Polygonaceae, *Potentilla*, Primulaceae, Ranunculaceae, *Ranunculus*, Rosaceae, Rubiaceae, *Rumex*, *Rumex/Oxyria digyna*, *Rumex/Oxyria*, Saxifragaceae undiff., *Saxifraga*, *Saxifraga hierac*-type, *Saxifraga tricuspidata*, *Saxifraga tricuspidata*-type, Scrophulariaceae, *Senecio*, *Sedum*, *Stellaria*, *Taraxacum*, Tubuliflorae, Umbelliferae, Valerianaceae, *Valeriana*, *Valariana egnifata*
tf	temperate forb	*Allium*, Alliaceae, *Cardamine*, *Coptis*, *Epilobium angustifolium*, Fabaceae, *Fragaria*, *Geranium erianthum*, Labiatae undiff., Lamiaceae, Leguminosae, Liliaceae, cf. Liliaceae, *Mertensia*, *Parnassia*, *Ranunculus*, *Rubus*, *Spiraea*, *Stellaria*, *Taraxacum*, Valerianaceae, *Valeriana*, *Valeriana egnifata*, *Viola*
xf	xeric forb	*Amarantha*, Chenopodiaceae, Chenopod/Amaranth, *Ephedra*, Polygonaceae

was probably present. The value of × 20 was selected after consideration of several biomizations of both the modern surface samples and the fossil pollen samples using different weighting factors (× 1, × 10, × 20).

We initially adopted the pollen-to-PFT assignment defined for Europe by Prentice *et al.* (1996) and subsequently modified for Mongolia and the Former Soviet Union west of ≈ 130°E by Tarasov *et al.* (1998). We defined six new PFTs: arctic/alpine forb (af: e.g. *Circea alpina*), arctic heath (ah: e.g. *Cassiope*), boreal forb (bf: e.g. *Linnaea*), boreal summergreen conifer (bsc: e.g. *Larix*), dry tundra forb (dtf: e.g. *Androsace*) and xeric forb (xf: e.g. Chenopodiaceae, Polygonaceae). The boreal forbs are too widely distributed to have diagnostic value; this PFT is therefore not assigned to biomes and is excluded from subsequent steps in the biomization procedure. The 'cold desert' biome to which xeric forbs contributed was not intended to be comparable to 'desert' as defined by Tarasov *et al.* (2000). It is rather a possible biome within the 'no-analogue' tundra vegetation of Beringia at the last glacial maximum (Hopkins, 1967; Cwynar & Ritchie, 1980; Anderson *et al.*, 1989).

Pollen taxa were assigned to one or more of the defined PFTs based on our knowledge of the modern ecology and biology of individual species. Arboreal and shrub forms of *Betula* and *Alnus* are placed in the appropriate PFTs if they were distinguished palynologically. *Pinus* and *Pinus* (Haploxylon) in samples from Alaska were classified as eurythermic conifers (ec). However, in Siberia, these taxa were classified as cool-boreal conifer shrubs (cbc) because *Pinus pumila* is the only representative of the genus present in this region. Table 5 shows the assignment of pollen taxa to the PFTs used in the Beringian biomization.

The steppe forb PFT includes taxa that are known from azonal grasslands in Beringia today (Yurtsev, 1981). Several of these taxa (e.g. *Anemone*, *Galium*) are also assigned to the tundra forb PFT. Although *Artemisia* occurs today in tundra regions, it was classified as a steppe forb in this biomization for consistency with the treatment of *Artemisia* in the biomizations of Europe (Prentice *et al.*, 1996), other regions of North America (Thompson & Anderson, 2000; Williams *et al.*, 2000) and China (Yu *et al.*, 2000). An experiment in which *Artemisia* was classified as both a steppe forb and an arctic/alpine forb showed that this decision did not adversely affect the modern biomization of Beringia.

Seven biomes could potentially occur in Beringia: tundra, steppe, cold desert (characterized by xeric forbs), cold deciduous forest (*Larix* and hardwoods), cold mixed forest (hardwoods, *Abies*, *Tsuga* and *Pinus*), taiga (characterized by *Picea*), and cool conifer forest (characterized by *Tsuga*). Table 6 shows the defined composition of each biome in terms of PFTs. In the case of tie-breaks, biomes were assigned in the order they appear in Table 6. The PFT definitions, the assignments of individual pollen taxa to PFTs, and the assignments of PFTs to biomes are broadly consistent with the definitions used in adjacent regions of North America by Williams *et al.* (2000) and Thompson & Anderson (2000).

Table 6 Assignment of plant functional types (PFTs) to biomes in Beringia.

Biome	Code	Plant functional types
tundra	TUND	aa, ab, af, ah, cbc, dtf, g, h, s
cold deciduous forest	CLDE	ab, bs, bsc, bts, cbc, ec, h
taiga	TAIG	ab, bec, bs, bsc, bts, ec, h
cold mixed forest	CLMX	ab, bs, ctc, ec, h
cool conifer forest	COCO	ab, bec, bs, ctc, ec, h
cold desert	DESE	xf
steppe	STEP	g, sf

RESULTS

Predicted vs. observed modern biomes

The pollen-derived biome map (Fig. 1a) shows patterns which correspond well to observed patterns in vegetation distribution (Fig. 1b) in eastern Beringia. In particular, the map accurately captures the modern position of both the northern and western boundary of the taiga, and the occurrence of cool conifer forest along the coast of south-central Alaska. Two sites in North America (S338, S353) beyond the observed northern limit of the coastal cool conifer forest are misclassified. This apparently reflects the presence of low percentages of *Tsuga* pollen, probably derived by long-distance transport from the south. Sites in regions of eastern Beringia characterized today by a mosaic of tundra and taiga vegetation tend to be preferentially assigned to tundra. However, moss-polster samples from this zone are more likely to correctly reflect the local presence of gallery forest (e.g. two samples from gallery forest, from the Noatak River and Seward Peninsula, are classified as taiga).

Vegetation patterns in western Beringia are captured less well in the biome maps, but there is a broad-scale agreement. The Chukotkan tundra is well delimited, but the extent of cold deciduous forest in north-east Siberia is underestimated. This probably reflects the fact that *Larix*, one of the dominant tree species in this type of forest, is systematically under-represented in the pollen spectra. As in eastern Beringia, open forest areas are often classified as tundra.

Mid-Holocene biomes

The reconstructed distribution of biomes across Beringia at 6000 ^{14}C yr BP (Fig. 2a) is similar to the modern distribution. There is almost no change in the northern position of the tundra/taiga boundary in Alaska, although taiga is indicated north of its modern limit in the Mackenzie Delta region. There are insufficient data to delimit accurately the western limit of taiga in Alaska. However, the reconstruction of tundra vegetation at a number of sites within the modern taiga zone suggests the forest cover in the western interior was more discontinuous than it is today. Tundra characterizes the southern coastal region of Alaska rather than cool conifer forest, which is shown only in the far south-east of Alaska. The extent of tundra in Chukotka and coastal Kamchatka at

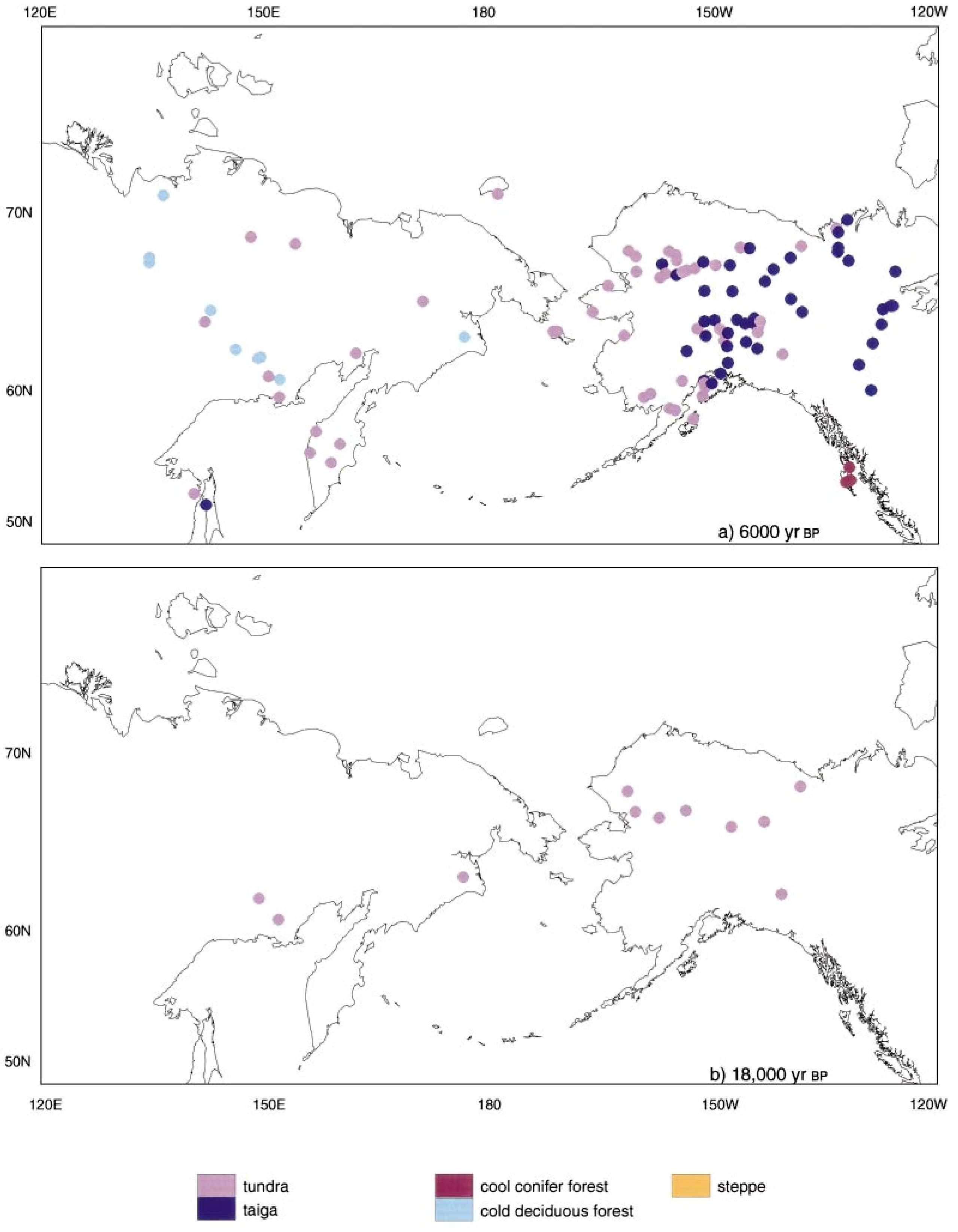

Figure 2 Biomes reconstructed from fossil pollen data at (a) 6000 ^{14}C yr BP and (b) 18,000 ^{14}C yr BP.

Table 7 Percentage contribution of different plant functional types (PFTs), derived from the biomization procedure, in LGM pollen samples from Beringia. The PFT codes are defined in Table 5. PFTs contributing to the tundra biome are listed first.

	Tundra PFTs						Other forb PFTs				Other tree/shrub PFTs				
Site	aa	af	dtf	g	s	h	bf	sf	tf	xf	bec	bs	bsc	bts	ec
Antifreeze Pond	26.2	7.7	0.0	11.5	12.6	0.0	5.0	9.2	0.0	0.0	2.8	25.1	0.0	0.0	0.0
Hanging Lake	20.9	9.9	2.0	10.5	4.8	0.0	6.4	18.4	2.0	2.0	3.4	21.7	0.0	0.8	0.0
Ranger Lake	15.7	4.8	0.0	15.9	17.3	0.0	2.4	19.9	0.0	3.4	0.0	20.5	0.0	0.0	0.0
Rebel Lake	13.7	11.5	0.0	14.2	9.2	0.0	6.6	28.7	0.0	4.7	0.0	11.4	0.0	2.3	0.0
Joe Lake	16.8	9.4	0.0	16.8	17.9	0.0	6.1	16.2	0.0	0.0	0.0	16.8	0.0	0.0	0.0
Kaiyak Lake	6.2	21.7	0.0	15.8	5.9	0.0	9.1	27.8	0.0	0.0	0.0	4.5	9.0	1.8	0.0
Tiinkdhul Lake	8.0	6.6	0.0	13.1	40.1	0.0	6.6	9.8	0.0	6.1	1.8	8.0	0.0	0.0	0.0
Sands of Time Lake	14.0	6.4	0.0	11.0	15.3	0.0	6.4	11.8	0.0	12.5	6.5	16.0	0.0	0.0	0.0
Elikchan	9.0	27.0	0.0	9.3	5.5	1.1	8.2	28.2	1.1	0.0	0.0	7.9	0.0	1.1	3.9
Gytgykai	8.5	4.3	0.0	23.2	28.6	0.0	0.0	20.5	0.0	4.3	2.1	8.5	0.0	0.0	0.0
Jack London (M)	32.9	1.5	0.0	7.9	0.0	4.1	1.5	17.6	0.0	0.0	0.0	32.9	0.0	0.0	1.5

6000 ^{14}C yr BP is similar to today. Given the problem of *Larix* representation in the pollen record, the reconstruction of tundra in areas of the Yana-Indigirka-Kolyma lowland cannot be interpreted as reliably indicating a southward shift in the northern limit of cold deciduous forest in western Siberia at 6000 ^{14}C yr BP. In accord with other interpretations of the data, our reconstructions provide no evidence of an expansion of other biomes (e.g. taiga or cold mixed forest) into the region occupied today by cold deciduous forest.

Last glacial maximum biomes

In contrast to the situation at 6000 ^{14}C yr BP, the predicted distribution of biomes at 18,000 ^{14}C yr BP was very different from today. The biome map for 18,000 ^{14}C yr BP (Fig. 2b) shows tundra across the whole of Beringia. However, the importance of component tundra PFTs differs from region to region (Table 7). For example, at Kaiyak Lake (Anderson, 1985) steppe forbs (sf) are strongly represented, whereas at Sands of Time Lake (Lamb & Edwards, 1988) the xeric forb (xf) PFT is quite prominent, and at Jack London, Magadan (Lozhkin *et al.*, 1993) shrub and heath PFTs (aa, h, bs) are important.

DISCUSSION AND CONCLUSIONS

The biomization method

The biomization method appears to capture the broad-scale features of the modern vegetation patterns across Beringia reasonably well, except that it fails to predict the observed extent of the *Larix*-dominated cold deciduous forest in western Beringia. Correctly defining the limits of *Larix*-dominated forest from pollen data is difficult because of the poor representation of *Larix* in the pollen record. Although our use of a weighting factor for *Larix* increases the number of sites correctly assigned to cold deciduous forest, weighting is only effective when *Larix* pollen is actually present in a sample. One possible solution to this problem would be to average the pollen spectra of several samples within a specified window (e.g. 6000 ± 500 yr) and use this composite spectrum for biomization. Such an approach would enhance the representation of *Larix* because, although not present in every sample, *Larix* pollen tends to be present in some samples within a broader time series. An alternative approach might be to use macrofossil records in conjunction with the pollen data from a given site.

Vegetation and climate of Beringia at 6000 ^{14}C yr BP

The biome map (Fig. 2a) shows that northern treeline in western Beringia and Alaska was similar to present at 6000 ^{14}C yr BP. In northern Alaska, there is no macrofossil evidence that *Picea* occurred further north than today at any stage during the Holocene (Hopkins *et al.*, 1981) and the pollen record has consistently been interpreted as showing that the position of northern treeline in this region was similar to today (e.g. Brubaker *et al.*, 1983; Anderson, 1985, 1988). The biomised data, although somewhat noisy, indicate that treeline was further north than today in the lower Mackenzie-Tuktoyaktuk region. There was a treeline advance in north-western Canada in the early Holocene, and dated macrofossils show that *Picea* grew north of its modern limit as late as 6000 ^{14}C yr BP (Ritchie & Hare, 1971; Ritchie *et al.*, 1983; Spear, 1983; Ritchie, 1984a). Our data appear to reflect the waning stages of this early Holocene treeline advance, and underscore differences in treeline response between Alaska and the easternmost part of the Beringian region. Macrofossil evidence also suggests that treeline was further north in western Beringia during the early Holocene (Khotinskiy, 1984), but it is not possible to detect any residual treeline extension from the biome map for 6000 ^{14}C yr BP. Biome reconstructions for other regions of the Arctic (e.g. Prentice *et al.*, 1996; Texier *et al.*, 1997; Tarasov *et al.*, 1998) indicate that treeline was considerably further north than today, with the greatest northward shift (of up to 200–300 km) in central Siberia. Arctic tree line extensions during the mid-Holocene have been interpreted as indicating increased growing-season warmth as a result of orbitally induced insolation changes (e.g. TEMPO, 1996; Prentice *et al.*, 2000). Our reconstructions demonstrate that there was a strong regionalization to this circum-polar warming. They suggest that other, indirect responses to orbital forcing (e.g. variations in the East Asian trough-ridge system or changes in circulation in the Arctic Ocean) may have played an important role in determining Arctic regional climates during the mid-Holocene (see Ritchie & Hare, 1971). MacDonald *et al.* (1993) also noted the apparent asymmetry of Holocene treeline extensions. This asymmetry has not been seen in climate model simulations to date (e.g. TEMPO, 1996; Harrison *et al.*, 1998; Joussaume *et al.*, 1998).

There are insufficient data to delimit accurately the western limit of taiga in Alaska at 6000 ^{14}C yr BP. However, the mixture of tundra and taiga in the central and western interior of Alaska, which we interpret as indicating that the forest cover was less complete than today, is consistent with data that indicate that the westward spread of *Picea* was not completed until after 6000 ^{14}C yr BP (Anderson & Brubaker, 1994; Edwards & Barker, 1994; Hu *et al.*, 1996).

The presence of tundra in southern coastal Alaska, in contrast to today's cool conifer forest, may indicate that winters were colder than present and exceeded the tolerances of *Tsuga* and *Picea sitchensis*, although some factor other than winter cold must also have limited the spread of *P. glauca* and *P. mariana* to the coast (Lozhkin *et al.*, 1993). The westward limitation of *Picea* in Alaska may reflect an enhanced east–west summer temperature gradient, with advection due to a strong Pacific subtropical high causing a relative cooling of the Alaskan coast and adjacent regions (see e.g. Ritchie & Hare, 1971; Mock *et al.*, 1998).

There is no evidence that the cold deciduous forests of western Beringia were less extensive at 6000 ^{14}C yr BP than they are today. Cold deciduous forests are confined to regions where the winter temperatures exceed the limits for the growth of boreal evergreen conifers (Prentice *et al.*, 1992). Thus, the fact that biomes such as taiga, cool conifer, or cold mixed forests do not encroach on the cold deciduous forest zone in western Beringia indicates that winters were not significantly warmer than today. This climatic interpretation is consistent with evidence from Japan (Takahara *et al.*, 2000).

Vegetation and climate of Beringia at the last glacial maximum

Our reconstructions show that Beringia was covered by tundra vegetation at the last glacial maximum. The occurrence of tundra across Beringia at the LGM is consistent with a significant, and most likely year-round, cooling. A large cooling is also implied by the biome reconstructions in adjacent regions of western Siberia (Tarasov *et al.*, 2000), northern China (Yu *et al.*, 2000) and Japan (Takahara *et al.*, 2000). Such a cooling suggests that the southerly flow along the western edge of the North American ice sheet that is observed in many palaeoclimatic simulations (e.g. Broccoli & Manabe, 1987; Kutzbach *et al.*, 1993; Kutzbach *et al.*, 1998) did not result in significant warming in Beringia, nor did it lead to significantly warmer conditions in Beringia than in adjacent regions. Differences in the relative abundance of PFTs from site to site support the widely accepted idea that the vegetation of Beringia was a mosaic of different tundra types (Ritchie & Cwynar, 1982; Schweger, 1982). A more detailed subdivision of tundra, based on an analysis of the modern physiologic and bioclimatic limits of Arctic PFTs, would be helpful in order to analyse the climatic implications of variation in tundra vegetation types across Beringia.

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BIOSKETCH

The Paleoclimates from Arctic Lakes and Estuaries (PALE) initiative, which is now part of the Paleoenvironmental Arctic Sciences (PARCS) initiative, was established in 1992 and is supported by the US National Science Foundation (PARCS, 1999). The initiative has as a goal the collection of arctic and subarctic palaeoenvironmental datasets for data-model comparison. Pollen and macrofossil data, and biome reconstructions made using these data, are one component of the PALE data base. The PARCS steering committee is co-chaired by Mary Edwards (Department of Geography, NTNU, Trondheim) and Michael Retelle (Department of Geology, Bates College, Lewiston). Matt Duvall (Quaternary Research Center, University of Washington, Seattle) is the PARCS Data Coordinator. More information about the PARCS initiative can be accessed via http://www.ngdc.noaa.gov/paleo/parcs/.