10. PRELIMINARY RESULTS FROM POLLEN ANALYSES OF SELECTED SAMPLES FROM LEG 145[1]

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ABSTRACT

The results from preliminary analyses of 50 samples from Sites 881, 883, and 887 show variations in pollen assemblages that appear to reflect vegetational and climatic changes in northeast Asian and northwest North American subarctic environments. Reliable interpretation of these pollen data, however, is precluded by the minimal amount of pollen in all the samples, and by the presence of large amounts of reworked material, particularly in samples from Site 887.

INTRODUCTION

Although the value of marine pollen in providing terrestrial late Neogene paleoclimatic data has been demonstrated in lower latitudes (Dupont and Agwu, 1992; Heusser, 1992a), the limited use of pollen from high-latitude marine sediments in paleoenvironmental reconstructions is a result, at least in part, of the numerous environmental limitations of the arctic environment (e.g., the relatively restricted amount of continuous vegetation). Nevertheless, investigations of arctic marine pollen have expanded since 1985, particularly in the Northwest Atlantic region (de Vernal et al., 1987; Aksu et al., 1992). Previous studies of pollen in North Pacific, Bering Sea, and Arctic Ocean sediments indicated that pollen concentrations in Leg 145 sediments would be marginal (P. Colinvaux, pers. comm., 1973; Heusser and Balsam, 1977; Nelson, unpubl. data, 1978; Sancetta et al., 1985). The obvious problems associated with a study of this type were offset, however, by the potential value of obtaining Neogene paleoclimatic data from subarctic Siberia and Alaska.

Initially, one site in the Gulf of Alaska, Ocean Drilling Program (ODP) Site 887 (54°22′N, 148°27′W, 3643 mbsf), was selected for pollen analyses because of its comparatve proximity to land, as well as its relation to aeolian and marine pollen transport vectors (Fig. 1). Pollen data were expected to complement the anticipated high-resolution marine and continental (e.g., ice-rafted debris) proxy paleoclimate data by providing a reconstruction of the response of vegetation and implied terrestrial climatic change to Neogene glaciation and global climate change. The poor quality of the pollen recovered in the first set of samples processed from Site 887 prompted us to examine selected Neogene samples from Holes 883B (51°11′N, 167°46′W, 2396 mbsf), 881C (47°6′N, 161°29′W, 5541 mbsf), and 881D (47°6′N, 161°29′W, 5542 mbsf) (Fig. 1). Biostratigraphy used in this paper is based on Morley et al. (this volume), and Morley and Nigrini (this volume).

METHODS AND RESULTS

Approximately 50 samples, subsets of 5 cm increments analyzed for radiolaria (Morley et al., this volume; Morley and Nigrini, this volume), were processed using standard palynological techniques (Heusser and Stock, 1984). Sample size ranged from 1 to 16 g dry weight. The prepared samples were stained with Safranin-O to aid in identifying reworked pollen (Stanley, 1966). Processing the siliceous silty clays from Site 887 was particularly time-consuming and not altogether satisfactory as the residues contained large amounts of undigested siliceous material, even after extended treatment with hydrofluoric acid. As expected, pollen recovery from all samples, even samples as large as 16 g, was minimal, yielding less than a drop of residue. Pollen recovery in samples <4 g was possible in only a few instances. Even though pollen sums were low, concentration (grains/g dry weight sediment) and percentages of pollen (the total of apparently autochthonous pollen) and percentages of spores (based on the sum of total pollen and spores) were calculated so that we could have a standard means of comparing samples (Tables 1–3).

Preservation of pollen was highly variable, with most pollen grains showing some evidence of diagenetic alteration (e.g., differential stain acceptance and corrosion). This presented a major problem in differentiating autochthonous and allochthonous (reworked) pollen and spores because all of the pollen and spores examined were morphologically similar to contemporaneous pollen types. In samples from Hole 887A, separation of pollen (presumably derived from glaciogenic erosion of polliniferous Neogene deposits in the Alaska Range (Hamilton et al., 1986) was essentially a subjective judgment based on differential stain acceptance, "flattening," and corrosion observed in each grain. Conservative estimates of pollen grains from older Neogene sediments were usually >50% in Quaternary samples from Site 887. Reworked pollen and spores were generally less abundant in sediments from northwest Pacific Sites 881 and 883, with reworked pollen grain percentages <10% in Pliocene samples from Site 881.

Subarctic Pacific pollen concentrations (pollen grains tentatively identified as autochthonous/g dry weight sediment [gdws]) range from 0 to 500 grains (Tables 1–3). Pollen is most abundant in Quaternary sediments deposited on the Patton-Murray Seamount; however, we suspect that the higher concentrations of pollen in sediments from Site 887 may reflect pollen grains not recognized as reworked. Pollen concentrations from Pliocene samples from Hole 887A and from samples from cores taken at Sites 883 and 881 are usually 100 grains/gdws or less, except for one sample (Sample 145-881D-6H-CC; 212 mbsf) in which concentration was 400/gdws.

The composition of pollen assemblages from Hole 887A (Fig. 2 and Table 2) reflects various boreal plant communities of the subarctic, including coastal forests with Sitka spruce, shrub thickets with alder and birch, as well as muskeg and tundra communities of sedge, grass, heath, and *Sphagnum* moss (Hulten, 1968). In both Quaternary and Pliocene samples from the Gulf of Alaska, *Alnus* (alder) and *Betula* (birch) are the dominant indigenous pollen types (Heusser, 1985; Heusser and Balsam, 1977). Although some *Pinus* (pine) pollen may represent regional vegetation, percentages of *Pinus* and possibly, to a lesser degree, all pollen in sediments deposited at Site 887 and in the other two sites examined in this study undoubtedly reflect long-distance fluviomarine and aeolian transport (Heusser, 1978).

[1] Rea, D.K., Basov, I.A., Scholl, D.W., and Allan, J.F. (Eds.), 1995. *Proc. ODP, Sci. Results,* 145: College Station, TX (Ocean Drilling Program).

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Table 1. Pollen data, percentages, and concentration (grains/gdws) from Site 881.

Hole:	881C	881D	881C
Core, section:	1H-1	6H-CC	27X-2
Interval (cm):	110–111	CC	20–21
Depth (mbsf):	110	212	240
Raw data			
Pinus	13	21	23
Tsuga	0	0	1
Abies	0	0	1
Picea	2	29	9
Alnus	11	10	17
Betula	10	10	11
Ericaceae	1	0	0
Myrica	0	0	2
Quercus	0	3	3
Gramineae	6	6	9
Cyperaceae	10	5	7
Compositae	20	12	7
Chenopodiaceae	1	11	
Total pollen	74	97	91
Polypodiaceae	14	9	12
Lycopodiaceae	5	5	1
Sphagnum	16	9	6
Total spores	35	23	19
Percentages			
Pinus	18	22	25
Tsuga	0	0	1
Abies	0	0	1
Picea	3	30	10
Alnus	15	10	19
Betula	14	10	12
Ericaceae	1	0	0
Myrica	0	0	2
Quercus	0	3	3
Gramineae	8	6	10
Cyperaceae	14	5	8
Compositae	27	12	8
Chenopodiaceae	1	11	
Polypodiaceae	13	8	11
Lycopodiaceae	5	5	1
Sphagnum	15	8	5
Concentration (pollen grains/gdws)			
Total GDWS	100	400	100
Pinus	1800	8800	2500
Tsuga	0	0	100
Abies	0	0	100
Picea	300	12000	1000
Alnus	1500	4000	1900
Betula	1400	4000	1200
Ericaceae	100	0	0
Myrica	0	0	200
Quercus	0	1200	300
Gramineae	800	2400	1000
Cyperaceae	1400	2000	800
Compositae	2700	4800	800
Chenopodiaceae	100	400	100
Polypodiaceae	1300	3200	1100
Lycopodiaceae	500	2000	100
Sphagnum	1500	3200	500

Note: gdws = gram dry weight sediment.

Pollen from herbaceous vegetation (Gramineae [grass], Cyperaceae [sedge], Compositae, and Chenopodiacae) usually forms ~10%–25% of the pollen sum, and percentages of ferns (Polypodiaceae) range from 6% to 29% .

The composition of Quaternary pollen assemblages from Site 883 (Fig. 3 and Table 3) compares favorably with that of boreal and subarctic vegetation and with contemporaneous pollen assemblages from northeast Asia (Hopkins et al., 1982; Grichuk, 1984; Morley and Heusser, 1991). As in the Gulf of Alaska, samples from these western north Pacific sites are dominated by *Alnus* and *Betula*; however, *Picea* is much more prominent in marine sediments deposited off northeast Asia. Percentages of *Picea* reach 30% in a Pliocene sample from Hole 881D (Sample 145-881D-6H-CC) (Table 1). Pliocene pollen assemblages from Site 881 (Table 1) show changes in composition consistent with those previously described from Deep Sea Drilling Project Sites 438 and 440 (Heusser and Morley, 1993) and from terrestrial sites in northern Japan (Heusser, 1992a).

DISCUSSION

Concentrations of pollen in Neogene subarctic sediments of the North Pacific in Quaternary siliceous silty clays with mixed sediments or in Pliocene diatom oozes are several orders of magnitude lower than pollen concentrations in sediments deposited to the south (Heusser and Balsam, 1977). The low amount of pollen, which is comparable with that found in marine sediments deposited elsewhere in arctic marine settings (Mudie, 1985; de Vernal et al., 1987), undoubtedly reflects dilution by terrigenous detritus and biogenic silica (Kemp, 1975) as well as the comparatively low pollen production of subarctic vegetation.

Comparison of Quaternary samples from Holes 883B and 887A (Figs. 2 and 3; Tables 2 and 3) shows no clear glacial/interglacial variation in pollen concentrations or in the relative abundance of reworked pollen. Glacial/interglacial changes, however, are apparent in the composition of pollen assemblages at these two sites. Glacial samples (e.g., Samples 145-883B-1H-2, 75–79 cm [2.25 mbsf], and -4H-4, 75–79 [32.15 mbsf]) are characterized by low amounts of arboreal pollen and by an abundance of subarctic shrubs (*Alnus* and *Betula*). In contrast, *Picea* and *Pinus* dominate interglacial samples (Samples 145-883B-1H-5, 75–78 cm [6.75 mbsf], and -3H-2, 75–79 cm [19.65 mbsf]). In the northeast Pacific, the abundance of *Picea* and *Pinus* characterizes full glacial pollen assemblages (Heusser and Morley, 1985). In our youngest sample from Hole 887A (Sample 145-887A-1H-1, 44–48 cm [0.45 mbsf]), forest taxa form 25% of the pollen sum and *Sphagnum*, an indicator of mesic tundra, is abundant (35%). During the last glacial maximum (Sample 145-887A-1H-1, 120–123 cm [1.2 mbsf]), forest representatives amount to 6% of the pollen sum.

The two Pliocene samples from Site 881 in the northwestern Pacific also show changes in the abundance of forest taxa (Table 1). At approximately 5 Ma (Sample 145-881C-27X-2, 20–21 cm [240 mbsf]), pollen is present from warm-subtropical taxa that are now extinct in Japan, as are small amounts of temperate taxa such as *Carya* and *Fagus*. At ~4 Ma (Sample 145-881D-6H-CC [212 mbsf]), percentages of *Picea* increase from ~10% to 30% of the pollen sum, and now-extinct Tertiary types are no longer present. These changes in the composition of Neogene pollen assemblages from the subarctic North Pacific are consistent with changes in correlative pollen assemblages onshore (Hopkins et al., 1982; Grichuk, 1984; Heusser and Morley, 1985; Heusser, 1992b; Oka and Igarashi, 1993).

SUMMARY

Initial evaluation of selected samples from cores recovered from Sites 881, 883, and 887 indicates a limited potential for future pollen stratigraphic and paleoclimatic studies. Although Neogene pollen data appear to be consistent with regional subarctic vegetation/climatic trends, reconstructions of vegetation based on this material would be suspect because of the scarcity of pollen at all three sites. Compounding this problem, sediments at Site 887 contain substantial amounts of recycled pollen, which are probably derived from glaciogenic erosion of the massive coal and lignite-bearing Neogene deposits onshore.

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* Abbreviations for names of organizations and publications in ODP reference lists follow the style given in *Chemical Abstracts Service Source Index* (published by American Chemical Society).

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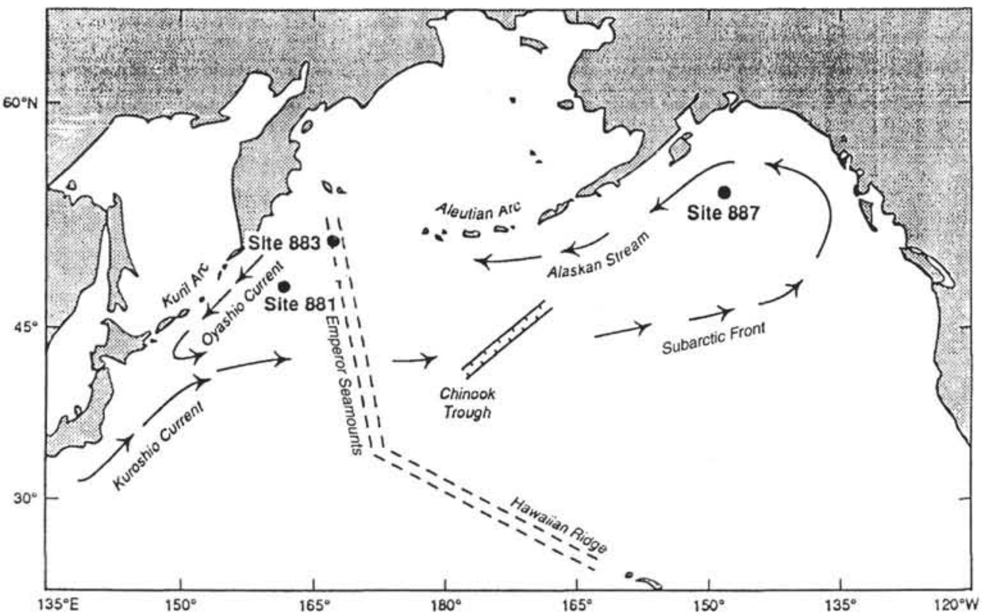

Figure 1. Map of the North Pacific showing locations of Sites 881, 883, and 887.

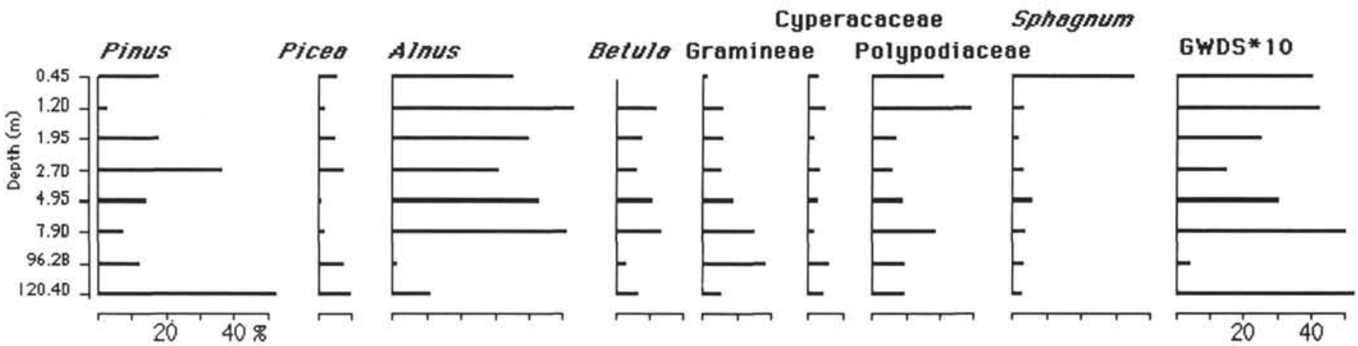

Figure 2. Pollen diagram of selected pollen types from Hole 887A. Percentages are based on the sum of all pollen identified. Concentration (pollen grains/gdws) is shown on the right. Depth (mbsf) of each sample is on the *y*-axis.

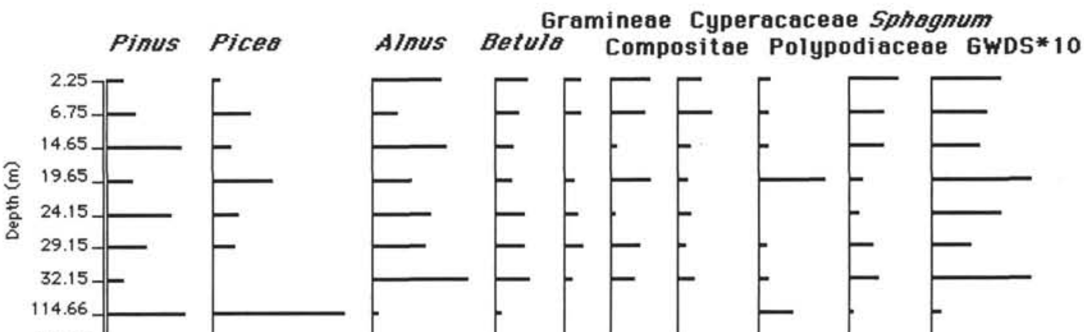

Figure 3. Pollen diagram of selected pollen types from Hole 883B. Percentages are based on the sum of all pollen identified. Concentration (pollen grains/gdws) is shown on the right. Depth (mbsf) of each sample is on the *y*-axis.

Table 2. Pollen data, percentages, and concentration (grains/gdws) from Hole 887A.

Core, section:	1H-1	1H-1	1H-2	1H-2	1H-3	1H-4	2H-1	2H-2	11H-3	11H-5	13H-1	13H-7
Interval (cm):	40–48	120–123	45–48	120–123	45–48	45–48	120–123	47–50	111–112	120–123	45–48	20–21
Depth (m):	0.45	1.2	1.95	2.7	3.45	4.95	7.9	8.67	96.28	99.4	111.65	120.4
Raw counts:												
Pinus	13	5	20	43	8	16	4	3	8	2	1	39
Tsuga	0	1	0	0	1	1	0	0	0	0	0	1
Abies	0	0	0	1	0	0	0	0	0	0	0	2
Picea	5	3	6	9	1	1	1	0	5	0	0	7
Taxus	1	0	1	0	2	4	1	0	9	0	0	1
Alnus	25	77	44	37	4	47	27	7	1	0	0	8
Betula	9	17	9	7	2	12	7	7	2	0	0	5
Ericaceae	0	4	1	0	1	1	0	0	0	0	0	1
Myrica	1	5	1	2	3	7	0	1	0	0	0	0
Rosaceae	3	5	5	5	1	0	0	1	1	0	0	0
Gramineae	1	8	7	6	0	10	8	1	12	0	0	4
Cyperaceae	2	7	2	4	0	3	1	0	4	0	0	3
Compositae	7	12	13	4	3	6	4	0	20	0	0	4
Chenopodiaceae	3	2	2	0	0	1	0	0	3	0	0	0
Total pollen	72	146	112	119	26	110	53	20	65	2	1	75
Polypodiaceae	15	42	8	7	7	10	10	4	6	1	0	7
Lycopodiceae	25	2	0	2	1	0	6	0	1	0	0	3
Sphagnum	25	5	2	4	1	6	2	1	2	0	0	2
Total spores	65	49	10	13	9	16	18	5	9	1	0	12
Percentages:												
Pinus	18	3	18	36	31	15	8	15	12	100	100	52
Tsuga	0	1	0	0	4	1	0	0	0	0	0	1
Abies	0	0	0	1	0	0	0	0	0	0	0	3
Picea	7	2	5	8	4	1	2	0	8	0	0	9
Taxus	1	0	1	0	8	4	2	0	14	0	0	1
Alnus	35	53	39	31	15	43	51	35	2	0	0	11
Betula	13	12	8	6	8	11	13	35	3	0	0	7
Ericaceae	0	3	1	0	4	1	0	0	0	0	0	1
Myrica	1	3	1	2	12	6	0	5	0	0	0	0
Rosaceae	4	3	4	4	4	0	0	5	2	0	0	0
Gramineae	1	5	6	5	0	9	15	5	18	0	0	5
Cyperaceae	3	5	2	3	0	3	2	0	6	0	0	4
Compositae	10	8	12	3	12	5	8	0	31	0	0	5
Chenopodiaceae	4	1	2	0	0	1	0	0	5	0	0	0
Polypodiaceae	21	29	7	6	27	9	19	20	9	50	0	9
Lycopodiceae	35	1	0	2	4	0	11	0	2	0	0	4
Sphagnum	35	3	2	3	4	5	4	5	3	0	0	3
Pollen concentration (pollen grains/gdws):												
Total GDWS	400	420	250	150	250	300	500	300	40	1	1	50
Pinus	7222	1438	4464	5420	7692	4364	3774	4500	492	100	100	2600
Tsuga	0	288	0	0	962	273	0	0	0	0	0	67
Abies	0	0	0	126	0	0	0	0	0	0	0	133
Picea	2778	863	1339	1134	962	273	943	0	308	0	0	467
Taxus	556	0	223	0	1923	1091	943	0	554	0	0	67
Alnus	13889	22151	9821	4664	3846	12818	25472	10500	62	0	0	533
Betula	5000	4890	2009	882	1923	3273	6604	10500	123	0	0	333
Ericaceae	0	1151	223	0	962	273	0	0	0	0	0	67
Myrica	556	1438	223	252	2885	1909	0	1500	0	0	0	0
Rosaceae	1667	1438	1116	630	962	0	0	1500	62	0	0	0
Gramineae	556	2301	1563	756	0	2727	7547	1500	738	0	0	267
Cyperaceae	1111	2014	446	504	0	818	943	0	246	0	0	200
Compositae	3889	3452	2902	504	2885	1636	3774	0	1231	0	0	267
Chenopodiaceae	1667	575	446	0	0	273	0	0	185	0	0	0
Polypodiaceae	8333	12082	1786	882	6731	2727	9434	6000	369	50	0	467
Lycopodiceae	13889	575	0	252	962	0	5660	0	62	0	0	200
Sphagnum	13889	1438	446	504	962	1636	1887	1500	123	0	0	133

Note: grains/gdws = grains/g dry weight sediment.

Table 3. Pollen data, percentages, and concentration (grains/gdws) from Hole 883B.

Core, section: Interval (cm): Depth (m):	1H-5 75–79 2.25	1H-5 75–79 6.75	2H-2 75–79 10.15	2H-5 75–79 14.65	3H-2 75–79 19.65	3H-5 75–78 24.15	4H-2 75–78 29.15	4H-4 75–79 32.15	10H-2 75–79 85.16	11H-2 76–80 95.65	11H-4 74–79 98.64	12H-2 76–80 105.16	12H-5 76–80 109.66	13H-2 76–80 114.66	13H-5 76–80 119.16	14H-2 76–80 124.77	19H-5 137–138 176.77
Raw counts:																	
Pinus	6	10	0	11	9	15	12	12	5	4	24	6	1	12	3	4	6
Tsuga	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
Abies	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Picea	3	13	1	3	20	6	7	2	2	2	2	6	0	20	2	9	7
Alnus	23	9	0	11	13	14	16	65	0	0	1	0	0	1	0	17	4
Betula	11	8	1	3	6	7	9	25	1	2	0	0	0	1	0	13	3
Ericaceae	3	0	0	1	2	1	0	1	0	0	0	0	0	0	0	1	1
Myrica	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0
Rosaceae-type	0	4	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0
Gramineae	6	6	1	0	4	3	6	6	0	0	0	0	0	0	0	5	3
Cyperaceae	13	12	1	1	13	1	9	17	0	0	0	0	0	0	0	10	2
Compositae	8	12	1	2	4	3	3	12	0	0	0	0	0	0	0	4	8
Chenopodiaceae	1	0	0	0	1	1	2	5	0	0	0	0	0	0	0	0	0
Total pollen	74	75	5	32	74	52	67	152	8	8	27	12	1	34	5	70	34
Polypodiaceae	14	30	3	7	500	13	20	39	0	2	10	8	2	21	0	17	4
Lycopodiaceae	3	21	4	4	66	22	3	4	0	0	0	0	0	0	0	4	0
Sphagnum	26	45	2	11	47	38	26	47	0	0	0	0	1	1	1	31	1
Total spores	43	96	9	22	613	73	49	90	0	2	10	8	3	22	1	52	5
Percentages:																	
Pinus	8	13	0	34	12	29	18	8	63	50	89	50	100	35	60	6	18
Tsuga	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
Abies	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Picea	4	17	20	9	27	12	10	1	25	25	7	50	0	59	40	13	21
Alnus	31	12	0	34	18	27	24	43	0	0	4	0	0	3	0	24	12
Betula	15	11	20	9	8	13	13	16	13	25	0	0	0	3	0	19	9
Ericaceae	4	0	0	3	3	2	0	1	0	0	0	0	0	0	0	1	3
Myrica	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	1	0
Rosaceae-type	0	5	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
Gramineae	8	8	20	0	5	6	9	4	0	0	0	0	0	0	0	7	9
Cyperaceae	18	16	20	3	18	2	13	11	0	0	0	0	0	0	0	14	6
Compositae	11	16	20	6	5	6	4	8	0	0	0	0	0	0	0	6	24
Chenopodiaceae	1	0	0	0	1	2	3	3	0	0	0	0	0	0	0	0	0
Polypodiaceae	12	10	2	10	67	2	8	11	0	20	21	14	8	35	0	13	2
Lycopodiaceae	3	7	2	6	9	3	1	1	0	0	0	0	0	0	0	3	0
Sphagnum	22	16	1	16	6	5	11	13	0	0	0	0	4	2	2	24	1
Concentration (pollen grains/gdws):																	
Total gdws	70	56	20	50	100	70	40	100	16	5	10	1	1	10	10	118	94
Pinus	568	747	0	1700	1200	2030	720	800	1008	250	890	50	100	350	600	708	1692
Tsuga	0	75	0	0	100	0	40	0	0	0	0	0	0	0	0	0	0
Abies	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0
Picea	284	971	400	450	2700	840	400	100	400	125	70	50	0	590	400	1534	1974
Alnus	2176	672	0	1700	1800	1890	960	4300	0	0	40	0	0	30	0	2832	1128
Betula	1041	597	400	450	800	910	520	1600	208	125	0	0	0	30	0	2242	846
Ericaceae	284	0	0	150	300	140	0	100	0	0	0	0	0	0	0	118	282
Myrica	0	0	0	0	0	140	0	100	0	0	0	0	0	0	0	118	0
Rosaceae-type	0	299	0	0	0	0	0	100	0	0	0	0	0	0	0	118	0
Gramineae	568	448	400	0	500	420	360	400	0	0	0	0	0	0	0	826	846
Cyperaceae	1230	896	400	150	1800	140	520	1100	0	0	0	0	0	0	0	1652	564
Compositae	757	896	400	300	500	420	160	800	0	0	0	0	0	0	0	708	2256
Chenopodiaceae	95	0	0	0	100	140	120	300	0	0	0	0	0	0	0	0	0
Polypodiaceae	840	560	40	500	6700	140	320	1100	0	100	210	14	8	350	0	1534	188
Lycopodiaceae	210	392	40	300	900	210	40	100	0	0	0	0	0	0	0	354	0
Sphagnum	1540	896	20	800	600	350	440	1300	0	0	0	0	4	20	20	2832	94