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**LATE QUATERNARY VEGETATION HISTORY OF SULPHUR LAKE,
SOUTHWEST YUKON TERRITORY, CANADA**

A thesis submitted to
the School of Graduate Studies and Research
in partial fulfilment of the requirements
for the degree Master of Arts

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Abstract

Palaeoecological studies based on the analysis of pollen in lake sediments offer the potential for high resolution and well-dated independent records of past vegetation and climate. Sulphur Lake, located in the southwest Yukon (60.95°N, 137.95°W; 847 m), was chosen for a paleoecological study to explore postglacial vegetation dynamics in this region of the boreal forest. A 5 m sediment core was raised from the deepest section of Sulphur Lake using a modified Livingstone piston corer. The sequence spans the full postglacial and reveals significant late glacial and Holocene vegetation changes that provide new information on the regional paleoecological history of the southwest Yukon. The pollen spectra indicate that between approximately 12,000 and 11,250 yr BP, the vegetation was an open alpine tundra marked by the presence of *Artemisia*. The vegetation then progressed from an open birch shrub tundra to a poplar woodland at 10,250 yr BP. *Juniperus* populations expanded at 9500 yr BP and by 8400 yr BP, spruce invaded the region. The relatively closed white spruce forest that occupies the region today was established by approximately 8000 yr BP. *Alnus crispa* increased at 6000 yr BP, however the increase in *Picea mariana* found at this time at most sites in the Yukon was not present at Sulphur Lake. Black spruce was not a dominant component of the vegetation in the Shkwak Trench as it was to the immediate southeast. The basal radiocarbon date demonstrates that the chronology of regional deglaciation needs to be more firmly established.

Résumé

Les études paléoécologiques basées sur l'analyse de pollens de sédiments lacustres offrent la possibilité d'obtenir une chronologie de la paléovégétation et du paléoclimat à haute résolution et avec une datation précise. Sulphur Lake, situé au sud-ouest du Yukon (60.95°N, 137.95°W; 847 m), a été choisi pour une étude paléoécologique afin d'explorer les changements de la végétation postglaciaire de cette région de la forêt boréale. Une carotte de sédiment de 5 m a été prélevée dans la section la plus profonde de Sulphur Lake, utilisant un carottier Livingstone modifié. La séquence couvre complètement la période postglaciaire et révèle des changements significatifs dans la végétation durant le tardiglaciaire et l'Holocène. Ceux-ci fournissent de nouvelles informations sur l'histoire paléoécologique du sud-ouest du Territoire du Yukon. Les spectres polliniques montrent que entre 12,000 et 11,250 ans BP, la végétation a été une toundra ouverte marquée par la présence d'*Artemisia*. La végétation a progressivement changé, passant d'une toundra arbustive à bouleau à une région boisée de peuplier vers 10,250 ans BP. Les populations de *Juniperus* ont augmenté vers 9500 ans BP et vers 8400 ans BP, l'épinette a colonisé la région. La forêt relativement fermée d'épinettes blanches, qui occupe la région aujourd'hui, s'est établie vers 8000 ans BP. *Alnus crispa* s'est répandu il y a environ 6000 ans BP. Alors qu'on retrouve une augmentation de *Picea mariana* à cette époque dans la plupart des sites dans le Territoire du Yukon, celle-ci n'a pas eu lieu à Sulphur Lake. L'épinette noire n'a pas été une composante dominante de la végétation de la Shkwak Trench comme elle l'a été vers le sud-est. La date du sédiment basal remet en question la chronologie de la déglaciation régionale.

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Chapter 1

Introduction

The southwest Yukon is a region that warrants detailed biogeographical and paleoenvironmental investigation. Many species characteristic of the North American boreal forest, including black spruce (*Picea mariana*), larch (*Larix laricina*), and paper birch (*Betula papyrifera*) are rare or absent in the southwest Yukon. Yet, with a large number of disjunct species and species endemic to Alaska and the Yukon (*Stellaria alaskana*, *Salix setchelliana*, *Androsace alaskana*, *Castilleja yukonis*, *Artemisia alaskana*, *Aster yukonensis*, and *Claytonia bostockii*) (Murray and Douglas, 1980), there is considerable ecological diversity. Due to high elevation and proximity to alpine glaciers, the southwest Yukon displays steep environmental gradients. It is influenced by cold, dry Arctic air masses, while the warm, moist Pacific air masses are modified in transit over the St. Elias Mountains. Lying at the boundary between these two major climate systems, the southwest Yukon is sensitive to even minor environmental changes.

Although a number of paleoecological studies have been undertaken in the southwest Yukon, there remain unresolved questions. The direction of spruce migration in this region is still not fully understood. Cwynar (1982, 1988) and MacDonald (1984) suggested that spruce migrated from the upper Liard River to the Yukon River drainage system into the southern Yukon but cautioned that more sites are required before a precise migration route can be determined. A second question concerns the early suggestion that extensive grasslands were present in the southwest Yukon for much of the Holocene (Johnson and Raup, 1964; MacNeish, 1964; Workman, 1978). Stuart *et al.* (1989), Cwynar (1988) and Keenan and Cwynar (1992) found no evidence in their study areas to support this suggestion, but more extensive data are needed for a complete rejection of this hypothesis. Third, widespread increases in black spruce and green alder occurred throughout most of the Yukon between 6.5 and 6.0 ka (Cwynar and Spear,

1995). These vegetational changes are less clear in the southwest Yukon, and thus require further investigation.

These questions can be addressed with a well-dated, high resolution reconstruction of postglacial vegetation history in the southwest Yukon Territory. To this end, a paleoecological study at Sulphur Lake in the Kluane Lake region of the southwest Yukon was conducted to further define the vegetation history of this region. The objective of the research was to reconstruct the postglacial ecological history of Sulphur Lake. Given the limited scope and methodological difficulties of paleoecological previous research in the southwest Yukon, the aim of the present research was to produce a well-dated, high resolution postglacial reconstruction of vegetation. The pollen of white spruce was distinguished from black spruce using the qualitative technique of Hansen and Engstrom (1985). *Alnus crispa* and *A. rugosa* were also discriminated. The pollen record from Sulphur Lake, in combination with other available records, will be discussed with particular focus paid to 1) spruce migration routes; 2) increases in black spruce and green alder at about 6000 yr BP; and 3) the grassland hypothesis. Lake sediment cores recovered from Sulphur Lake in August 1996 served as the primary source of information.

1.1. Regional Setting

The Kluane Lake region (Fig. 1.1) lies within the Shikwak Trench which divides the Yukon Plateau to the northeast from the glaciated St. Elias Mountains to the southwest (Bostock, 1948). The St. Elias Mountains and other surrounding mountains include Canada's highest peaks, with Mount Logan at 6050 m. These mountains are still tectonically active and are of interest due to the potential impact on ecosystems. The White River volcanic ash, dated at 1147 cal yr BP (1300 +/- 90 yr BP) (Clague *et al.*, 1995), from a source in the Wrangell Mountains, Alaska (Downes, 1985), covered the region to varying degrees and serves as an important stratigraphic horizon. The geology of the region has been summarized by Kodybka (1992).

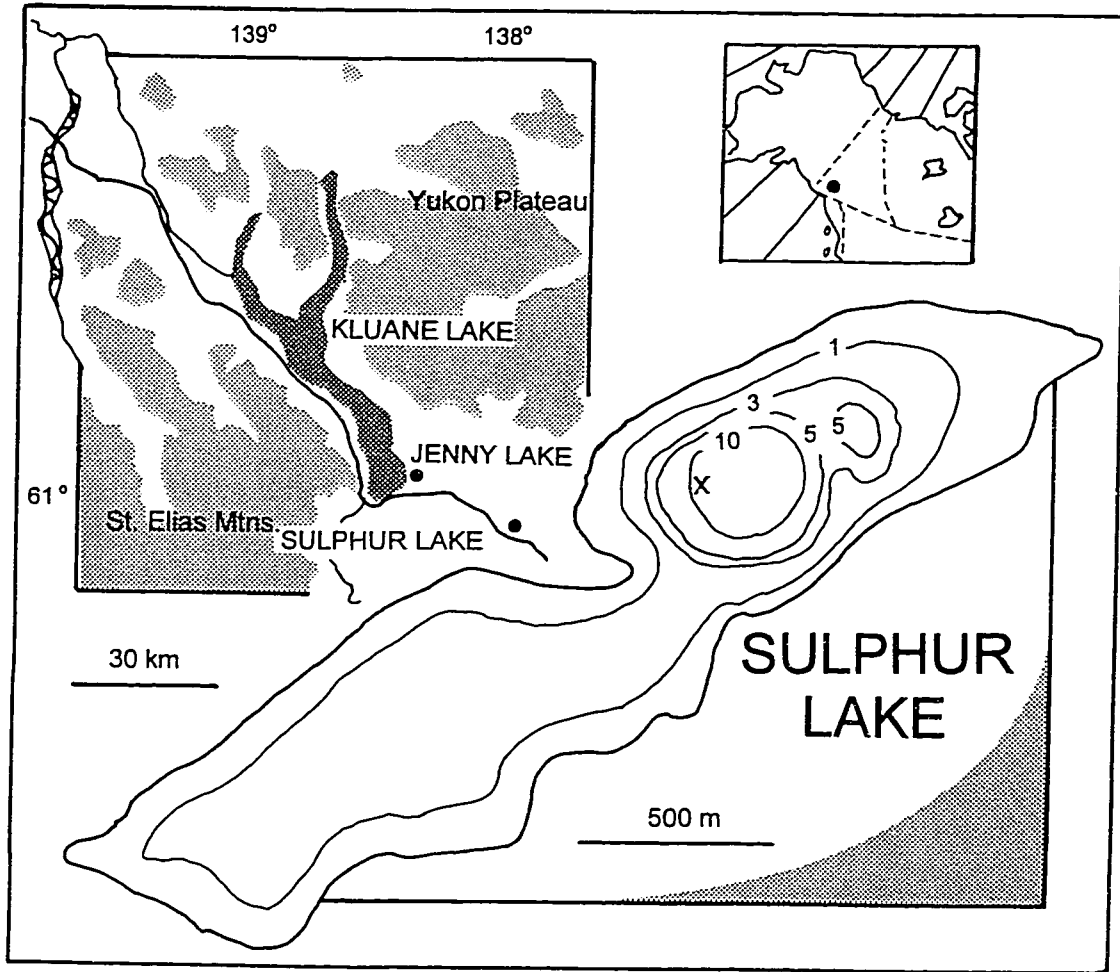


Fig. 1.1: Map of the Kluane Lake region showing the location of Sulphur Lake, its bathymetry and the coring location (X). Shading indicates elevation over 1525 m.

1.1.1. Quaternary Glacial History

Several successive advances of glaciers in the St. Elias Mountains have occurred in the Quaternary. During the Pleistocene, the glaciers of the St. Elias Mountains coalesced in the Shakwak Valley entering via the Slims, Donjek and White River valleys (Bostock, 1948, 1952). St. Elias ice eventually joined glaciers from the Coast Mountains in northwestern British Columbia, producing a centre of Cordilleran flow to the north and northwest. When the Kluane glaciation was at its maximum, the eastern side of the Shakwak trench and Ruby Ranges were

exposed (Denton and Stuiver, 1967). They proposed that after 12,500 yr BP, during the Slims nonglacial interval, the Shakwak Trench was free of ice. This proposition is, however based solely on one bulk sediment date from the bottom of nearby Jenny Lake (Fig. 1.1) (Denton and Stuiver, 1966, 1967). Middle and late Holocene glacier fluctuations also illustrate climate variability in interglacial times (Denton and Karlén, 1977).

1.1.2. Climate

Despite its proximity to the Pacific Ocean, the climate of the southwest Yukon is subarctic continental with mean annual temperatures below 0°C (Table 1.1). The combination of high latitude and high altitude leads to a cold climate and scattered permafrost (Brown, 1978). July is the warmest month with mean monthly temperatures between 12.1 and 14.0°C. Precipitation is low, ranging from approximately 200 to 300 mm/yr, as a result of the orographic barrier formed by the St. Elias Mountains. One of the driest portions of the Yukon, the Aishihik basin, rests on the Yukon Plateau. Valleys such as the Shakwak Trench, with northwest to southeast orientations, are extremely windy, at times reaching destructive speeds (Wahl *et al.*, 1987). Loess derived from the dried, silty floodplains of the Slims, Duke and Donjek River valleys contribute to frequent dust storms in the summer season (Nickling, 1978; Marcus, 1980).

Station	Temperature (°C)		Mean Annual Precipitation (mm)	Elevation at Station (m)
	Mean Annual	Mean July		
Aishihik (61.65°N, 137.48°W)	-4.4	12.1	256.3	966
Burwash (61.37°N, 139.5°W)	-4.0	12.5	290.0	799
Kluane Lake (61.17°N, 138.4°W)	-2.7	12.6	223.9	786
Haines Junction (60.77°N, 137.58°W)	-2.9	12.6	305.7	599
Whitehorse (60.72°N, 135.67°W)	-1.0	14.0	268.8	703

Table 1.1: Climate data from 5 stations in the southwest Yukon. (Environment Canada, 1982, 1993)

1.1.3. *Vegetation*

The modern vegetation of the southwest Yukon has been well documented (Oswald and Senyk, 1977; Orłóci and Stanek, 1979; Rowe, 1972; Johnson and Raup, 1964; Douglas, 1974; Murray and Douglas, 1980; Parent, 1988; Birks, 1977; Hoefs *et al.*, 1975; Price, 1971). In the valley bottoms, the vegetation ranges from closed to open boreal forests dominated by white spruce (*Picea glauca*). Black spruce (*P. mariana*), larch (*Larix laricina*) and white birch (*Betula papyifera*), abundant in most parts of the North American boreal forest, are uncommon or absent in the southwest Yukon. Extensive stands of poplar (*Populus tremuloides* and *P. balsamifera*) are common, especially on warmer sites. Shrub willow (*Salix* spp.), dwarf birch (*Betula glandulosa*) and, to a lesser extent, *Shepherdia canadensis* are important constituents of the regional vegetation while alder (*Alnus* spp.) is scarce, present only as scattered shrubs (Johnson and Raup, 1964). Lodgepole pine (*Pinus contorta*) and subalpine fir (*Abies lasiocarpa*) are absent from the region but become increasingly important to the east and south. *Artemisia*-dominated communities and juniper (*Juniperus* spp.) grow on dry south-facing slopes, particularly surrounding Kluane Lake and in Kluane National Park. With increasing altitude the vegetation becomes progressively more open. In the Shawkwak Trench, treeline varies between 1066 and 1220 m (Johnson and Raup, 1964) with alpine tundra at higher elevations.

1.1.4. *Sulphur Lake*

Sulphur Lake (60.95°N, 137.95°W; 847 m) is located in the Shawkwak Trench adjacent to the Alaska Highway, approximately 26 km southeast of Kluane Lake (Fig. 1.1). It lies on the boundary of Oswald and Senyk's (1977) Ruby Range and St. Elias Mountains ecoregions. The surrounding vegetation is a closed white spruce forest. Willows are common, however black spruce and paper birch do not grow locally.

Sulphur Lake is a large lake (~150 ha) and has two main basins (Fig. 1.1); the southwest basin is shallow (2 m depth) while the northeast basin is much deeper (10 m depth). The two basins

are, to some extent, separated by a point that extends into the center of the lake. Sulphur Lake is characterised by Magnesium-rich bicarbonate waters, with low nutrient (0.1 µg/L TPU) and chlorophyll a (0.62 µg/L) levels. However, as observed in the lake water and on pollen slides, there are large amounts of algae, specifically *Pediastrum* spp., present in Sulphur Lake.

A 5 m sediment core was collected from the deepest basin of Sulphur Lake, in 10 m of water (Fig. 1.1). The White River volcanic ash lies 88 cm from the sediment-water interface, which translates into a high sedimentation rate of ~0.8 mm/yr in the uppermost sediments of Sulphur Lake.

The two-basin structure and size of Sulphur Lake make it less than ideal for palynological studies, however, Sulphur Lake is a satisfactory site for the present study. Its geographic location is appropriate for addressing the questions outlined above and it is easily accessible, being located immediately adjacent to the Alaska Highway. Also, the great depth of sediment available from Sulphur Lake and its high sedimentation rate are necessary for the high resolution study presented here.

1.2. Late Quaternary Vegetation History of the southwest Yukon

Several paleoecological studies have been undertaken in the southwest Yukon, most of which have been summarized in either Wang and Geurts (1991a) or Cwynar and Spear (1995). Three of these warrant detailed discussion in light of the present study.

Rampton (1971) provides the longest Quaternary pollen record from the southwest Yukon. A 6.4 m core spanning the last 31,000 radiocarbon years was collected from Antifreeze Pond (62.35°N, 140.83°W) near the Yukon/Alaska border. From 31,000 to 27,000 yr BP, a sedge-moss tundra or fell-field vegetation prevailed and was followed by a shrub tundra stage. Sedge-moss tundra returned to the region from 27,000 to 10,000 yr BP, presumably as a result of a more severe

summer climate. With climatic amelioration, shrub tundra again surrounded Antifreeze Pond from 10,000 to 8700 yr BP. At approximately 8700 yr BP, spruce invaded the region. Alder did not arrive until 5700 yr BP presumably because previous conditions were too dry. With a sharp increase in *Alnus* pollen, along with large amounts of *Picea* and *Betula*, the present spruce forest was established after 5700 yr BP.

At Jenny Lake (61.03°N, 138.37°W), Stuart *et al.* (1989) recovered a 1.73 m core that was subsequently divided into five palynological zones. The oldest zone, from 12,500 to 9500 yr BP, was dominated by a *Betula* shrub tundra which was replaced by an *Alnus* shrub tundra between 9500 and 8500 yr BP. It is important to note that the basal date of 12,500 yr BP was adopted from the bulk sediment date recovered from Jenny Lake by Denton and Stuiver (1966, 1967). By 8500 yr BP, a *Picea* forest developed in the Jenny Lake area until 4500 yr BP when *Picea* decreased to 60% and *Alnus* increased to 25%. Stuart *et al.* (1989) interpret this as a change to a spruce-alder woodland. Spruce again dominated the record from 2000 yr BP to the present. Although these authors did not discriminate the spruce pollen, it is presumably white spruce that dominates in this last zone and potentially throughout the Holocene.

In recent years, the Aishihik basin and adjacent areas have been the focus of several palynological studies (Keenan and Cwynar, 1992; Wang, 1989; Wang and Geurts, 1991b; Geurts and Dewez, 1985; Beaudet, 1986). At Long Last Lake (61.57°N, 137.27°W), Keenan and Cwynar (1992) found that white spruce, which arrived by 8500 yr BP, was the dominant species throughout the record. Prior to the arrival of spruce, the record was dominated by *Betula*, *Juniperus* and *Populus* pollen. Black spruce was established soon after white spruce, but remained only a minor component of the surrounding vegetation. White spruce decreased between 6000 and 5000 yr BP when green alder and black spruce increased. From 1300 yr BP to the present, white spruce dominated the vegetation, however high values of herb pollen indicate that the spruce forests were open.

Other studies in the southwest Yukon include Hansen (1953), who initiated palynological investigations in the southwest Yukon with a study consisting of 40 pollen diagrams from 74 sites along the Alaska Highway. For the most part, only tree pollen was counted, and the majority of sequences were short and undated. More recently, Birks (1980), Bourgeois and Geurts (1983), and de Bastiani and Geurts (1987) conducted studies in the vicinity of the St. Elias Mountains. Campbell (1987) and Wang (1989) also carried out palynological studies in the Ruby Ranges on the Yukon Plateau.

Although several paleoecological studies have been carried out in this region, their methodological difficulties and limited scope leave significant questions requiring further investigation in order to fully reconstruct the postglacial vegetation history of the southwest Yukon. First, some of the pollen records (e.g. Birks, 1980; Bourgeois and Geurts, 1983; Campbell; 1987) cover only the last few thousand years, failing to reconstruct the full postglacial succession. Second, many of the sequences (e.g. Campbell; 1987; Stuart *et al.*, 1989) have not been well-dated; some (e.g. Hansen, 1953; Geurts and Dewez, 1985) have no chronological control whatsoever. Third, low pollen concentrations and/or counts of only 200 grains have allowed for only tenuous reconstructions of vegetation history (e.g. Beaudet, 1986; Wang and Geurts, 1991b). Finally, only three pollen records (Cwynar, 1988; Keenan and Cwynar, 1992), one of which is undated (Keenan and Cwynar, 1992) and all of which lie on the easternmost fringes of the region, have discriminated between black and white spruce pollen. Thus, there is a paucity of well-dated, high resolution reconstructions of postglacial vegetation history that differentiate between *Picea glauca* and *P. mariana* pollen. This lack of reliable paleoecological research in the southwest Yukon prompted the study at Sulphur Lake.

Previous paleoecological research in the southwest Yukon has highlighted a number of interesting questions worthy of further consideration. Spruce migration routes in the region are yet to be fully understood, and thus a spruce arrival date at Sulphur Lake may shed some light

on this question. Southeast of the Shakwak Trench, Cwynar (1988) found that between 6000 and 4000 yr BP, black spruce, indicative of moister conditions, dominated forests surrounding Kettlehole Pond. Black spruce is absent in the present-day vegetation at this site. Keenan and Cwynar (1992) investigated the possibility that black spruce was formerly dominant at two sites north of Kettlehole Pond in the semi-arid Aishihik basin of the southwestern Yukon. They found that although black spruce increased between 5000 and 4000 yr BP, it never reached an abundance similar to that at Kettlehole Pond. This discussion raises the question of whether black spruce was previously more abundant at other sites in the southwest Yukon, a question that can be resolved only through the discrimination of black and white spruce pollen. This paleoecological study at Sulphur Lake explores the possibility of a previous abundance of black spruce in the Shakwak Trench.

Johnson and Raup (1964), MacNeish (1964) and later followed by Workman (1978), suggested that the present grasslands in the southwest Yukon were more extensive for much of the Holocene, based on the assumption that early inhabitants were economically adapted to grasslands and upon the presence of wood bison (*Bison bison athabasca*) fossils in early and middle Holocene sediments in the southwest Yukon. Stuart *et al.* (1989), Keenan and Cwynar (1992), and Wang and Geurts (1991b) found no evidence to support the hypothesis that extensive grasslands were present in the southwest Yukon during the Holocene. This grassland hypothesis is revisited at Sulphur Lake.

In their review article, Cwynar and Spear (1995) note that at approximately 6 ka both *Alnus crispa* and *Picea mariana* increased their populations at most sites in the Yukon, indicating that more mesic conditions prevailed. In the southwest Yukon, Rampton (1971) found that spruce and alder pollen increased at 5.7 ka at Antifreeze Pond, and Cwynar (1988) demonstrated that black spruce, and to some extent, green alder replaced white spruce and juniper at 6.1 ka at Kettlehole Pond. Keenan and Cwynar (1992) found similar increases at Long Last Lake at 5.4 ka.

However, at sites in the Aishihik basin, Wang (1989) and Wang and Geurts (1991a) did not identify significant changes in the pollen records at 6 ka. The semi-arid climate in this area seems to have prevented green alder from expanding its populations. Cooler and moister conditions, implied by increases in black spruce and green alder, are discernable throughout major portions of the Yukon in the early Holocene (Cwynar and Spear, 1995). The possibility that similar vegetational changes had occurred at Sulphur Lake is examined in this study.

Chapter 2

Methods and Techniques

2.1. *Field Methods*

A 5 m lake sediment core (5 cm diameter) was retrieved from the deepest basin of Sulphur Lake in August 1996 using a modified Livingstone piston sampler (Wright, 1967) from a raft anchored at three points. PVC casing was used to direct the corer. The uppermost meter of sediment was sampled in a plastic tube and kept vertical until extrusion. A duplicate core was obtained from an adjacent hole. Maximum depths were determined during surface sampling and through sonar measurements. Cores were extruded in the field and wrapped in plastic and aluminum foil in order to maintain the integrity of each core during transport. At the field station, the uppermost unconsolidated sediment was extruded into plastic bags at 1 cm intervals using a portable extruding device (Glew, 1988). Upon return from the field, the sediment samples were stored at 4°C. Based on the interpretation of the magnetic susceptibility measurements, as discussed below, a second sediment core was retrieved from the deepest section of Sulphur Lake in August 1997.

2.2. *X-Radiography and Magnetic Susceptibility*

Whole core X-radiography and magnetic susceptibility served as non-destructive and efficient methods for correlating core sequences and determining the depth of the White River volcanic ash. X-radiography also revealed changes in sedimentary structures and provided valuable information on the density of the sediment. Dense material appears lighter on radiographic photographs due to higher absorption of radiation. The X-radiography was performed at Laurier X-Ray, an on-campus medical x-ray centre. Magnetic susceptibility measurements reveal reproducible parallel variations in the concentration of ferrimagnetic minerals, and therefore the importance of inorganic materials, from core to core within a lake (Thompson *et al.*, 1975; Thompson *et al.*, 1980; Oldfield *et al.*, 1983).

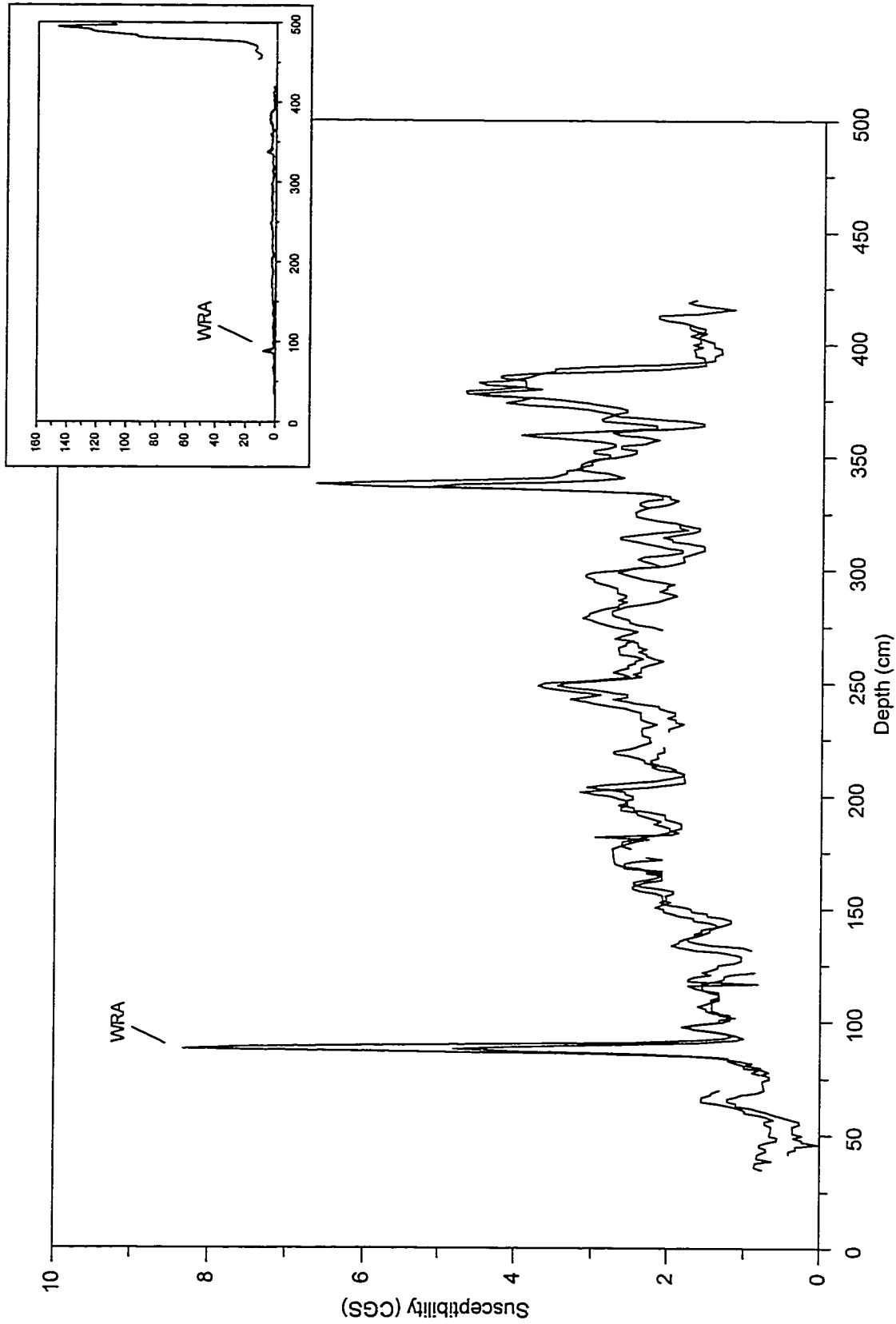


Fig. 2.1: Magnetic susceptibility of 1996 Sulphur Lake sediment cores measured at 1 cm intervals. White River Ash (WRA) lies at 88 cm. Note the coherence between the sequences, the change in scale on the inset graph, and the gap from 422 to 453 cm.

Magnetic susceptibility is therefore an invaluable tool for core correlation. Whole core magnetic susceptibility was measured on all sediment sequences at 1 cm intervals using a Bartington MS2C Core Sensor (6 cm internal diameter). The meter provides a weighted average magnetic susceptibility measurement because it scans sediment on either side as well as directly within the loop sensor. As such, the measurements from the top and bottom of core sections were excluded from core correlation because half of each measurement was of air. The sediment cores were then correlated through visual inspection of the magnetic susceptibility curves. Once correlated, it was apparent that a gap was present in the sediment sampled in 1996 (Fig. 2.1). Based on these measurements, a second entire sediment sequence was retrieved in 1997 from Sulphur Lake and the missing section, which was approximately 30 cm, was obtained.

2.3. Sediment Analysis

2.3.1. Core description and Photography

Core sequences were split, photographed and described to document changes in sediment textures, colour and sedimentary features, and to facilitate the correlation of core segments. Once split, fresh sediment surfaces were photographed, with 25 - 30 cm of core captured in each image. Colour patches were included with each image for calibration of sediment colour changes. Sediment colour was determined with the aid of a Munsell Soil Colour Chart.

2.3.2. Loss-on-ignition and Carbonate content

Sediment sequences were subsampled to estimate the proportion of inorganic and organic materials through loss-on-ignition (LOI) (Dean, 1974). Samples were dried overnight at 95°C and subsequently ignited for 3 hours at 500°C to estimate organic matter. Carbonate content was estimated by removing carbonate from sediment samples with 10% hydrochloric acid (HCl).

2.4. Radiocarbon Dating

Radiocarbon dating was performed using accelerator mass spectrometry (AMS) by Beta Analytic Radiocarbon Dating Laboratory. Four bulk sediment samples, including a basal sample, were sent for radiocarbon dating in order to establish a general chronology. Given the carbonate content of the sediment samples, an offset due to a hardwater effect was suspected. To estimate the hardwater effect, a radiocarbon date (BETA-104734; 1960 +/- 50 yr BP) was obtained at the level of the White River volcanic ash. The WRA had been previously dated at 1147 cal yr BP (1300 +/- 90 yr BP) by Clague *et al.* (1995). This suggests a hardwater error of 660 radiocarbon years for this portion of the core. Due to the offset present in the sediment, three additional radiocarbon dates were obtained from plant macrofossils picked from the sediment cores to enhance chronological control. Thus, a total of 7 radiocarbon dates were acquired. There is however no date available from sediments between 133 and 368 cm due to the lack of datable material.

On the pollen diagram, the uncorrected chronology was used. With only one estimate of the hardwater effect, the remaining radiocarbon dates were not adjusted since it was not possible to determine whether the offset was linear for the period of record. However, the potential offset was considered in the interpretation of the palynological record and when correlating the sequence to other records.

2.5. Pollen Analysis

Subsamples of 1 cm³ were removed at 5 cm intervals along the entire core sequence using a calibrated brass sampler. Pre-acetolysed *Lycopodium* spores in tablet form were added to each sample prior to treatment in order to permit the calculation of pollen concentrations and accumulation rates. Two tablets of batch #307862, each with a mean content of 13,500 +/- 690 spores, were added (Stockmarr, 1971). Subsamples were prepared for pollen analysis following standard methods using 10% hydrochloric acid (HCl), 10% potassium hydroxide (KOH), 50%

hydrofluoric acid (HF) and acetolysis solution sequentially (Faegri and Iversen, 1989). Safranin was used for staining. To dehydrate the residue, 95% ethanol and tertiary butyl alcohol (TBA) were used. The residue was mounted on slides with 2000 cs silicone oil. Samples with high clay content, particularly basal sediments, were sieved through a 7 μm Nitex® membrane after disaggregating the sediment with 5% sodium pyrophosphate (Cwynar *et al.*, 1979).

Slides were counted using a transmitted light microscope, with regularly spaced transects across the cover slip until a minimum sum of 500 pollen and spores, excluding aquatic species, was achieved. Occasionally, a sum of 500 grains was not reached due to low pollen concentrations. The average pollen sum was 491 grains with a minimum sum of 271 and a maximum sum of 657.5 grains (Appendix B). All *Lycopodium* marker grains encountered were also counted. Pollen was identified with the aid of keys (Moore *et al.*, 1991; McAndrews *et al.*, 1973; Faegri and Iversen, 1989) and the pollen reference collection. The differentiation of *Picea glauca* and *P. mariana* was based upon morphological characteristics outlined by Hansen and Engstrom (1985) that included saccus shape, saccus attachment to the corpus and the density of the internal reticulation of the saccus. All undifferentiated *Picea* grains were assigned to either *P. glauca* or *P. mariana* based on the proportional distribution of grains identified to species. Similarly for *Pinus*, all undifferentiated *Pinus* grains were assigned to either the type diploxylon or haploxylon. Pollen accumulation rates (PARs) ($\text{grains}/\text{cm}^2/\text{yr}$) are calculated from the concentration of pollen in the sediment, with each sample corrected for time as indicated by the thickness of the sampled sediment. Through linear interpolation, the differences in age between the radiocarbon dates, excluding the basal date, are used to calculate deposition times (yr/cm).

Chapter 3

Late Quaternary vegetation history of Sulphur Lake, southwest Yukon Territory, Canada

Abstract

Paleoecological studies based on the analysis of pollen in lake sediments offer the potential for high resolution and well-dated independent records of past vegetation and climate. A 5 m sediment core was raised from the deepest section of Sulphur Lake, located in the southwest Yukon (60.95°N, 137.95°W; 847 m). The pollen spectra indicate that between approximately 12,000 and 11,250 yr BP, the vegetation was an open alpine tundra marked by the presence of *Artemisia*. The vegetation then progressed from an open birch shrub tundra to a poplar woodland at 10,250 yr BP. *Juniperus* populations expanded at 9500 yr BP and by 8400 yr BP, spruce invaded the region. The relatively closed white spruce forest that occupies the region today was established by approximately 8000 yr BP. *Alnus crispa* increased at 6000 yr BP, however the increase in *Picea mariana* found at this time at most sites in the Yukon was not present at Sulphur Lake. Black spruce was not a dominant component of the vegetation in the Shakhwak Trench as it was to the immediate southeast. The basal radiocarbon date demonstrates that the chronology of regional deglaciation needs to be more firmly established.

3.1. Introduction

The southwest Yukon is a region which warrants detailed biogeographical and paleoenvironmental investigation. Many species characteristic of the North American boreal forest, including black spruce (*Picea mariana*), larch (*Larix laricina*), and paper birch (*Betula papyrifera*) are rare or absent in the southwest Yukon. Yet, with a large number of disjunct species and species endemic to Alaska and the Yukon (*Stellaria alaskana*, *Salix setchelliana*, *Androsace alaskana*, *Castilleja yukonis*,

Artemisia alaskana, *Aster yukonensis*, and *Claytonia bostockii*) (Murray and Douglas, 1980), there remains substantial ecological diversity. Due to high elevation and proximity to alpine glaciers, the southwest Yukon displays steep environmental gradients. It is influenced by cold, dry Arctic air masses, while the warm, moist Pacific air masses are modified in transit over the St. Elias Mountains. Lying at the boundary between these two major climate systems, the southwest Yukon is sensitive to even minor environmental changes.

Although a number of paleoecological studies have been undertaken in the southwest Yukon, there remain unresolved questions. The direction of spruce migration in this region is still not fully understood. Cwynar (1982, 1988) and MacDonald (1984) suggested that spruce migrated from the upper Liard River to the Yukon River drainage system into the southwest Yukon but cautioned that more sites are required before a precise migration route can be determined. A second question concerns the early suggestion that extensive grasslands were present in the southwest Yukon for much of the Holocene (Johnson and Raup, 1964; MacNeish, 1964; Workman, 1978). Cwynar (1988), Stuart *et al.* (1989), Wang and Geurts (1991b), and Keenan and Cwynar (1992) found no evidence in their study areas to support this suggestion but more data are needed for a complete rejection of this hypothesis. Widespread increases in black spruce and green alder occurred throughout most of the Yukon between 6.5 and 6.0 ka (Cwynar and Spear, 1995). These vegetational changes are less clear in the southwest Yukon, and thus require further investigation.

These questions can be addressed with well-dated, high resolution reconstructions of postglacial vegetation history in the southwest Yukon Territory. To this end, a paleoecological study at Sulphur Lake in the Kluane Lake region of the southwest Yukon was conducted to further define the vegetation history of this region. The main objective of the research was to reconstruct the full postglacial ecological history of Sulphur Lake.

3.2. Study Area

The modern vegetation of the southwest Yukon has been well studied (Oswald and Senyk, 1977; Orłóci and Stanek, 1979; Rowe, 1972; Johnson and Raup, 1964; Douglas, 1974; Murray and Douglas, 1980; Parent, 1988; Birks, 1977; Hoefs *et al.*, 1975; Price, 1971). In valley bottoms, the cover ranges from closed to open boreal forests dominated by white spruce (*Picea glauca*). Black spruce (*P. mariana*), larch (*Larix laricina*) and white birch (*Betula papyifera*), abundant in most of the North American boreal forest, are uncommon or absent in the southwest Yukon. Extensive stands of poplar (*Populus tremuloides* and *P. balsamifera*) are common, especially on warmer sites. Shrub willow (*Salix glauca*), dwarf birch (*Betula glandulosa*), and, to a lesser extent, *Shepherdia canadensis* are important constituents of the regional vegetation while alder (*Alnus* spp.) is scarce, present only as scattered shrubs (Johnson and Raup, 1964). Lodgepole pine (*Pinus contorta*) and subalpine fir (*Abies lasiocarpa*) are absent from the region but become increasingly important to the east and south. *Artemisia*-dominated communities occur on dry south-facing slopes, particularly surrounding Kluane Lake and in Kluane National Park. In the Shakwak Trench, treeline varies between 1066 and 1220 m (Johnson and Raup, 1964) with alpine tundra at higher elevations.

Sulphur Lake (60.95°N, 137.95°W; 847 m) is located in the Shakwak Trench adjacent to the Alaska Highway, approximately 26 km southeast of Kluane Lake (Fig. 3.1). It is a large lake (~150 ha) and has two main basins; the southwest basin is shallow (2 m depth) while the northeast basin is much deeper (10 m depth). The two basins are, to some extent, separated by a point that extends into the center of the lake. Sulphur Lake is characterised by Magnesium-rich bicarbonate waters, with low nutrient (0.1 µg/L TPU) and chlorophyll *a* (0.62 µg/L) levels.

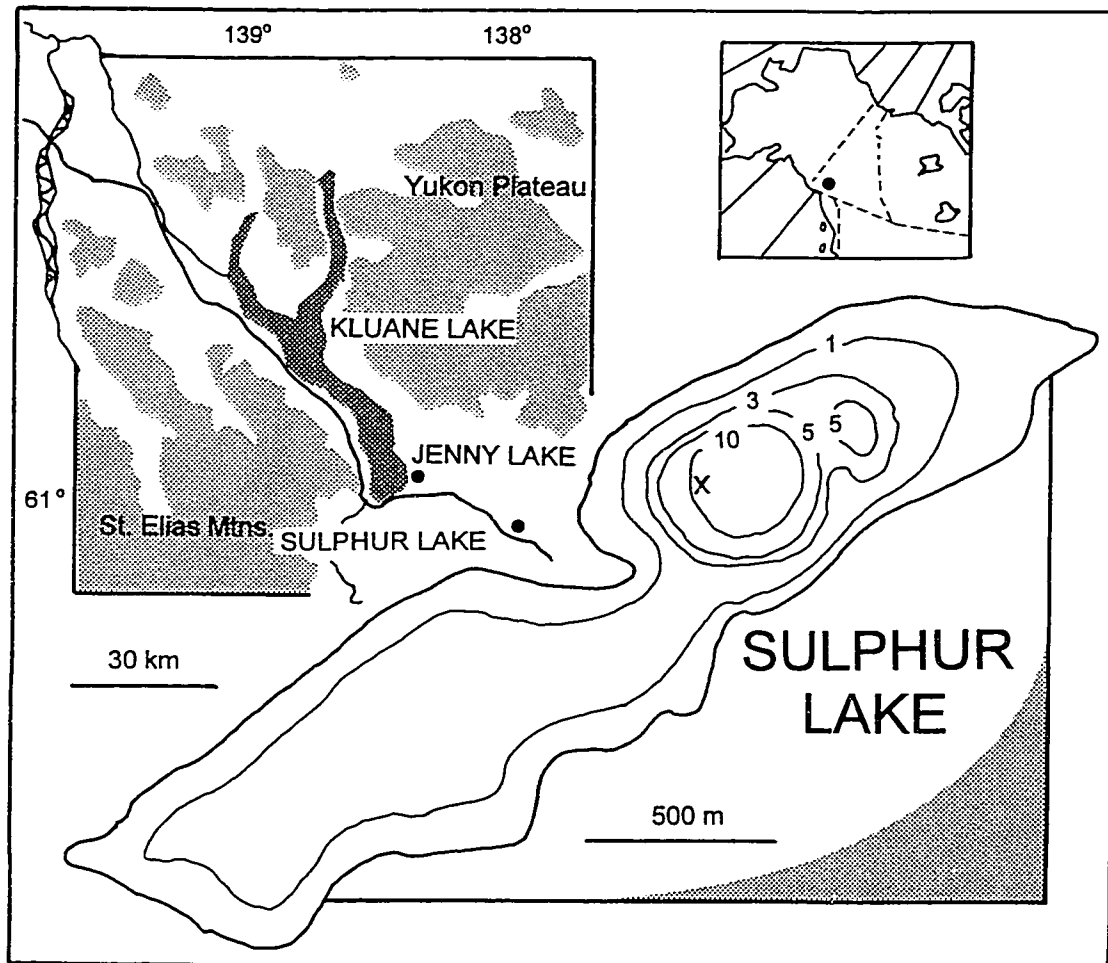


Fig. 3.1: Map of the Kluane Lake region showing the location of Sulphur Lake, its bathymetry and the coring location (X). Shading indicates elevation over 1525 m.

3.3. *Methods*

Three duplicate sediment cores, 5 cm in diameter, were recovered from the deepest basin of Sulphur Lake (Fig. 3.1) using a modified Livingstone piston sampler (Wright, 1967) from a raft anchored at three points. PVC casing was used to direct the corer. Lake bathymetry was determined through sonar measurements. Cores were extruded in the field and wrapped in plastic and aluminium foil in order to maintain the integrity of each core during transport. The uppermost unconsolidated sediment was extruded at 1 cm intervals using a portable extruding device (Glew,

1988). Whole core X-radiography and magnetic susceptibility served as non-destructive methods for correlating core segments and determining the depth of the White River volcanic ash. Whole core magnetic susceptibility was measured at 1 cm intervals using a Bartington MS2C Core sensor (6 cm internal diameter).

A calibrated brass sampler was used for removing 1 cc subsamples at 5 cm intervals for pollen analysis. Pre-acetolysed *Lycopodium* spores in tablet form were added to each subsample in order to determine pollen concentrations and accumulation rates (Benninghoff, 1962). Standard methods for pollen analysis were followed (Faegri and Iversen 1989; Cwynar *et al.* 1979). A minimum sum of 500 grains was counted for each subsample. The differentiation of *Picea glauca* and *P. mariana* pollen grains was based upon morphological characteristics outlined by Hansen and Engstrom (1985). All undifferentiated *Picea* grains were assigned to either *P. glauca* or *P. mariana* based on the proportional distribution of the grains identified to species. Plant macrofossils were recovered from the core and were identified where possible. Four bulk sediment samples and three plant macrofossils were submitted to Beta Analytic Radiocarbon Dating Laboratory for accelerator-mass spectrometer (AMS) ^{14}C dating. Sediment cores were subsampled to estimate the portion of inorganic and organic materials through loss-on-ignition (LOI) (Dean, 1974) and carbonate content was estimated by removing carbonate with 10% HCl.

3.4. Results

3.4.1. Sediment Stratigraphy

A 5 m long sediment core (Fig. 3.3) was recovered from Sulphur Lake. The first 315 cm consists of homogeneous brown gyttja. The White River Ash (WRA) (Lerbekmo *et al.*, 1975; Clague *et al.*, 1995), identified based on geographic location, x-radiography, magnetic susceptibility and visual inspection, lies at 88 cm from the water-sediment interface. Between 315 and 415 cm, the sediment is blackish brown silty gyttja intermittently laminated with fine-grained layers that are lighter in colour.

The basal sediments, from 415 to 500 cm, are dark grey to black fine-grained sediments with increasing magnetic susceptibility with depth, indicating an increase in grain size and inorganic content towards the base of the sequence (Thompson *et al.*, 1980).

Laboratory No.	Depth of sample (cm)	Radiocarbon age (BP +/- 1 SD)	Material
BETA-104734	87.5 – 89.5	1 960 +/- 50	bulk sediment
BETA-109436	131.0 – 132.5	2 700 +/- 70	<i>Picea</i> seed and <i>Cyperaceae</i> leaves
BETA-109437	320.3 – 321.7	6 240 +/- 50	shrub branch
BETA-109438	368.0 – 370.0	8 240 +/- 50	<i>Picea</i> seed and <i>Drepanocladus</i> sp.
BETA-104735	410.5 – 412.5	9 530 +/- 60	bulk sediment
BETA-104736	454.0 – 457.0	10 820 +/- 90	bulk sediment
BETA-104737	496.0 – 499.0	17 370 +/- 140	bulk sediment

Table 3.1: Radiocarbon dates from Sulphur Lake.

3.4.2. Chronology

The 7 radiocarbon dates (Table 3.1, Fig. 3.2) are in chronological order irrespective of the type of material that was dated. There is a hard water effect as shown by our bulk sediment date of 1960 +/- 50 yr BP for sediment at the position of the White River Ash (BETA-104734). Based on 4 dates, Clague *et al.* (1995) assigned a weighted mean of 1147 cal yr BP (1300 +/- 90 yr BP) to the ash. This suggests a hardwater error of 660 radiocarbon years for this portion of the core. When only the White River Ash and the one date (BETA-109437) based entirely on a terrestrial sample are used, the remaining dates all fall above a linear fit line and the deviation from that line increases with depth. With only one estimate of the hardwater effect, the remaining radiocarbon dates were not adjusted since it was not feasible to determine whether the offset was linear for the period of record. Therefore, the uncorrected chronology was used. However, the potential offset was considered in the interpretation of the palynological record.

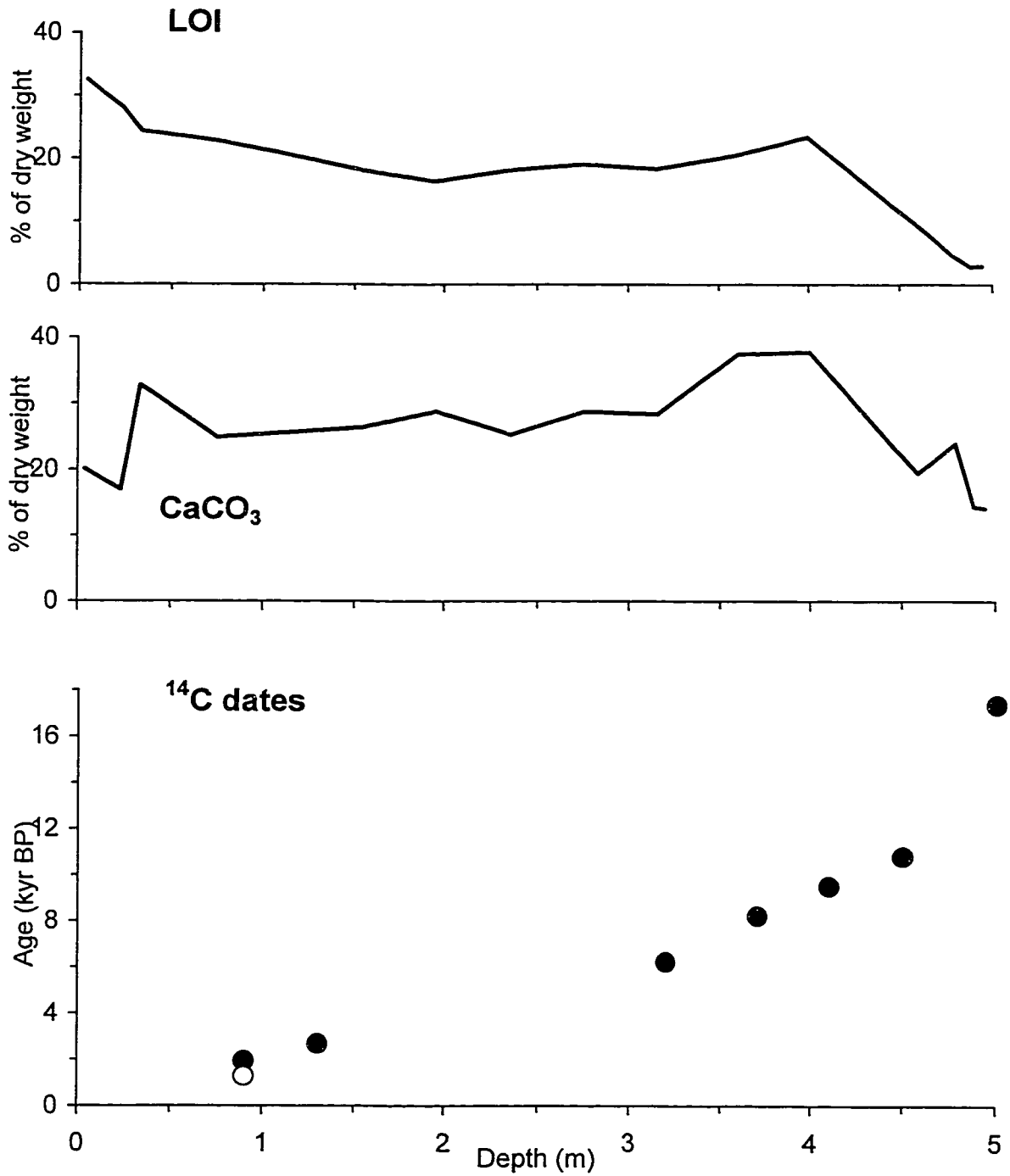


Fig. 3.2: Sulphur Lake radiocarbon dates, carbonate content and LOI versus sediment depth. The open circle represents the Clague *et al.* (1995) date of the Whiter River ash.

The basal date of 17,370 yr BP (BETA-104737) appears to be too old given the accepted date of 12,500 yr BP for clearance of ice from the Shakwak Trench (Denton and Stuiver, 1966, 1967). This 12.5 kyr date is from sediment from nearby Jenny Lake (Fig. 3.1) that has a carbonate content that ranges from 70 - 80% in basal sediments (P. Johnson, pers. comm.). Bulk sediment dates are often problematic where carbonate content is high. The carbonate content of the basal sediments at Sulphur Lake is only 14% (Fig. 3.2), considerably lower than basal sediments at Jenny Lake. On the other hand, the LOI indicates that there is less than 5% organic matter in the basal sediments of Sulphur Lake (Fig. 3.2). For these reasons, the basal date of 17,370 yr BP is problematic however it does suggest that perhaps the chronology of deglaciation, and more specifically the clearance of ice from the Shakwak Trench, needs to be more firmly dated. For the pollen diagram, levels below 10,820 yr BP (BETA-104736) are dated through linear extrapolation using the sedimentation rate of the section from 411.5 to 455.5 cm, putting the base of the sequence at roughly 12,000 yr BP. This was done as the upper 6 dates are all well aligned. The chronology of the basal sediments may need to be revised using the basal date of 17,370 yr BP if deglaciation was earlier than 12.5 kyr BP. However, the high carbonate content of basal sediments at Jenny Lake suggests that even Denton and Stuiver's (1966) date of 12.5 kyr for clearance of ice from the Shakwak Trench may be too old.

3.4.3. *Palynological Record*

The Sulphur Lake pollen percentage diagram (Fig. 3.3) is divided into 5 zones.

Zone 1 (*Betula* - *Artemisia* - *Salix*, >11,250 yr BP; 470 - 500 cm): This zone is dominated by high percentages of *Betula* (35 - 81%), *Artemisia* (4 - 27%), *Salix* (5 - 18%), and Cyperaceae (3 - 11%). *Artemisia*, *Salix* and Cyperaceae reach their maximum for the period of record in this zone.

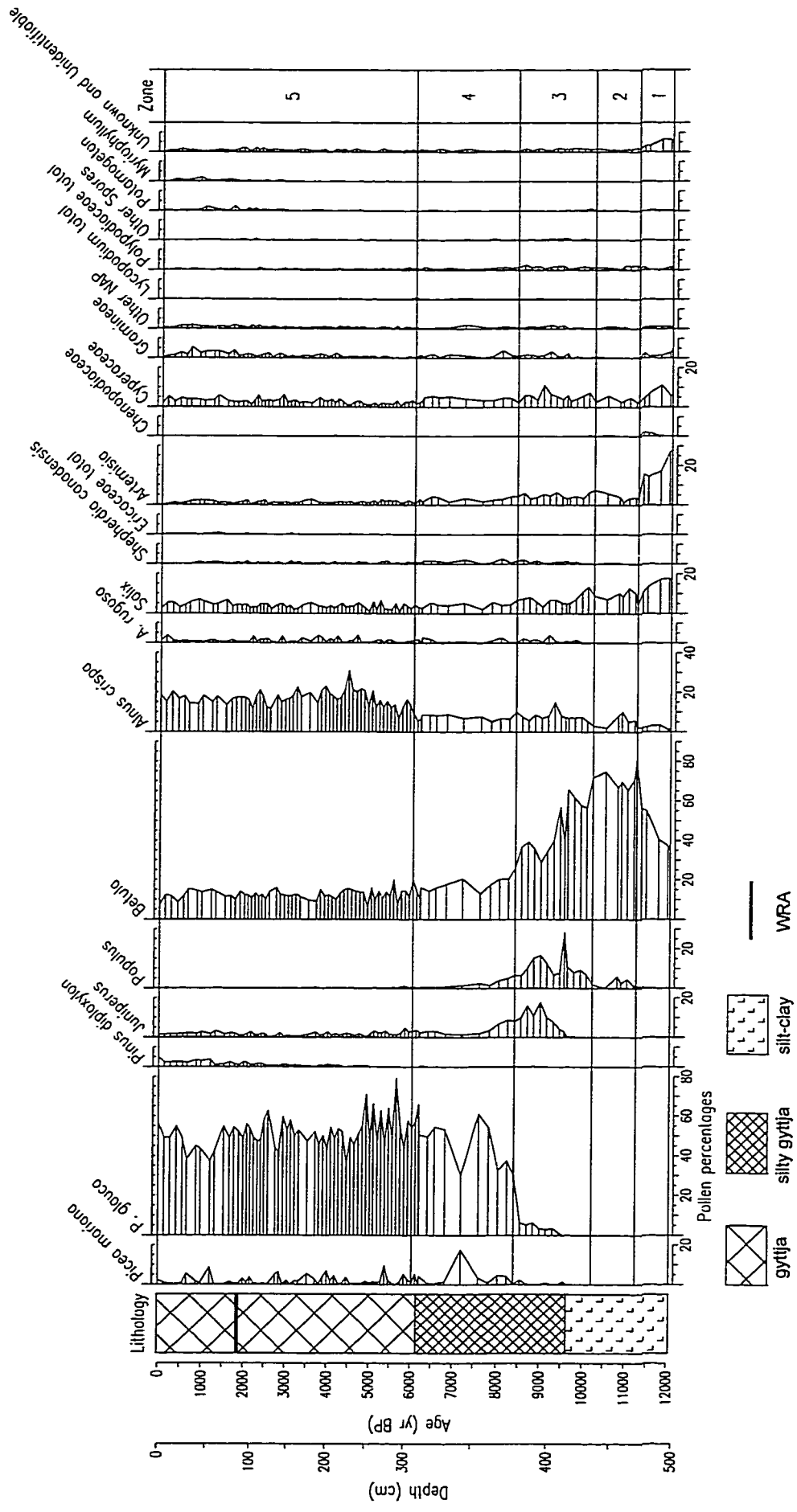


Fig. 3.3: Summary pollen percentage diagram from Sulphur Lake.

Zone 2 (*Betula*, 11,250 – 10,250 yr BP; 435 - 470 cm): *Betula* reaches its maximum (81%) for the period of record during this zone. *Salix* is relatively abundant (5 - 13%). *Populus* pollen is present in this zone but remains less than 6%. *Alnus crispa* rises and total herb pollen decreases.

Zone 3 (*Populus* - *Juniperus*, 10,250 - 8400 yr BP; 374 - 435 cm): This zone is marked by a significant decline in *Betula* (26 - 66%) and an increase in *Populus* (6 - 29%). *Juniperus* arrives by 9500 yr BP and accounts for up to 18% of the pollen sum. *Picea* pollen is present in low amounts.

Zone 4 (*Picea glauca*, 8400 - 6000 yr BP; 310 - 374 cm): Zone 4 is characterised by the arrival of *Picea*, the majority of which is *P. glauca*. *Picea glauca* rises from 6 to 60% in a period of roughly 900 years. *Betula* remains more or less constant until the present. *Juniperus* and *Populus* pollen both decline to trace amounts. *Alnus crispa*, *Salix*, *Artemisia* and Cyperaceae remain constant at low levels.

Zone 5 (*Picea glauca* - *Alnus?*, 6000 yr BP - present; 310 cm to surface): *Picea glauca* remains at high levels throughout this zone, with some variability including a marked decrease at roughly 1250 to 600 yr BP. *Alnus crispa* increases gradually from 6000 to roughly 4500 yr BP, reaching values up to 30%. *Pinus* pollen is continuously present by 5000 yr BP and increases shortly after the deposition of the White River ash. *Salix*, Gramineae and aquatic pollen increase around 1500 yr BP.

Total pollen accumulation rates (PARs) increase from the base of the record to a maximum between 5000 and 6000 yr BP (Fig. 3.4). This maximum is largely due to the increase in *Picea glauca* PARs at this time and corresponds to the maximum in *Picea glauca* and *Alnus crispa* in the percentage pollen diagram (Fig. 3.3). Cyperaceae, *Salix* and *Artemisia* PARs as well as other herb PARs are low in the basal sediments whereas in the pollen percentage diagram (Fig. 3.3) these types are at a maximum. *Salix* PARs reach their maximum later during the birch shrub tundra stage and

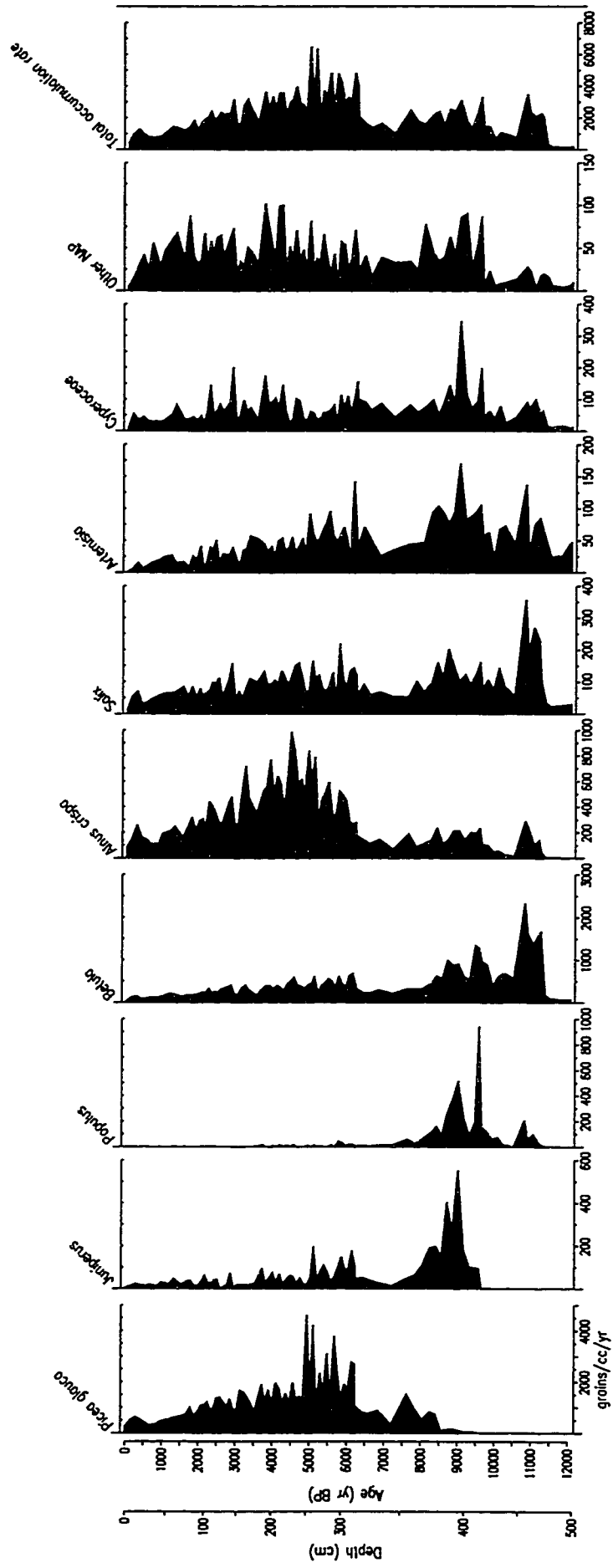


Fig. 3.4: Pollen accumulation rates for selected taxa from Sulphur Lake. Note scale changes.

maximum NAP PARs occur around 9000 yr BP during the *Populus - Juniperus* zone (Fig. 3.4). In the late Holocene, both *Picea glauca* and *Alnus crispa* PARs gradually decrease until the present.

3.5. Discussion

Immediately following deglaciation, the pollen assemblages were dominated primarily by *Betula*, *Artemisia*, *Salix*, and Cyperaceae. This basal zone represents a low tundra marked by relatively low amounts of birch, high NAP and the presence of *Artemisia*. Total pollen accumulation rates (PARs) are low at this time (Fig. 3.4), suggesting that the vegetation was an open tundra environment (Davis *et al.*, 1984; Delcourt and Delcourt, 1991). Today, *Artemisia*-dominated communities in the southwest Yukon grow primarily in open, dry habitats on warm south-facing slopes (Johnson and Raup, 1964; Douglas, 1974). The modern influx of *Artemisia* pollen is considerably lower than in late glacial sediments. Given the relatively high influx of *Artemisia* pollen following deglaciation, *Artemisia* communities must have been more extensive than they are today. However, these are not comparable habitats. The presence of *Betula*, *Salix* and other NAP in the late glacial indicate an open tundra community whereas today in the southwest Yukon *Artemisia* spp. are found in localised grass-forb communities.

By roughly 11,250 yr BP, this tundra was replaced by a birch shrub tundra. Total PARs (Fig. 3.4) increased significantly with the establishment of a birch shrub tundra, indicating that a more continuous vegetative cover prevailed. *Alnus crispa* began to rise slowly, however it is less than clear whether alder was growing locally. Modern pollen assemblages in the Shakwak Trench indicate that *Alnus* is significantly overrepresented (Appendix A). The first appearance of *Populus* coincides with this dominance of shrub birch. *Populus* probably grew in some of the drier habitats previously occupied by *Artemisia*. By 10,250 yr BP, *Betula* declined due to a lower tolerance of arid conditions and the birch shrub tundra was gradually replaced by a poplar woodland with an understory of shrub birch. Both trembling aspen (*Populus tremuloides*) and balsam poplar (*P.*

balsamifera) are abundant in the Kluane Lake region today however only trace amounts of *Populus* pollen are found in modern surface samples (Appendix A). This underrepresentation of *Populus* in surface sediments suggests that the peak in *Populus* between 10,250 and 8000 yr BP represents the establishment of a significant poplar community in the southwest Yukon. This kind of zone is found in late glacial sediments throughout Canada (Mott, 1978).

Juniperus, the first conifer to colonise the area, arrived by 9500 yr BP, the presence of which indicates openings in the woodland vegetation (Ritchie, 1987). The addition of juniper to the poplar woodland, corresponds with a change in the sediment stratigraphy at 415 cm (Fig. 3.3), suggesting widespread changes in edaphic parameters at this time.

Trace amounts of *Picea* pollen are present by roughly 9500 yr BP and by 8400 yr BP, white spruce dominates the landscape until the present. A spruce seed, dated at 8240 +/- 50 yr BP (BETA-109438), confirms the local presence of spruce. The combination of white spruce, poplar, shrub birch, willow and juniper indicates that a boreal forest, similar in structure and composition to the boreal forest present in the southwest Yukon today, had been established by approximately 8000 yr BP. Too few sites have been studied in the southwest Yukon to draw concrete conclusions on the pattern of spruce migration. However, Cwynar (1982, 1988) and MacDonald (1984) proposed that spruce migrated from northern British Columbia through the upper Liard River to the Yukon River drainage system and then into the southern Yukon. Wang and Geurts (1991a) suggested that spruce migrated into the Aishihik Basin and its adjacent area from the Tintina Trench via the Yukon River plain. Spruce arrived west of the Liard Plain at Kettlehole Pond at 9250 yr BP (Cwynar, 1988), and in the central Aishihik basin by 8600 yr BP (Wang, 1989). It is therefore conceivable that spruce migrated from northern British Columbia to the Liard River and then into the Tintina Trench to migrate further north. The mean spruce arrival date for the northern Yukon and adjacent Northwest Territories is 9050 yr BP (Ritchie, 1984). From the Tintina Trench, spruce could have also migrated

south into the Aishihik basin and eventually into the Shakwak Trench. The spruce arrival at Sulphur Lake at 8400 yr BP and at nearby Jenny Lake at 8500 yr BP (Stuart *et al.*, 1989), are in agreement with this potential migration route. However, as both Cwynar (1988) and Wang and Geurts (1991a) noted, additional sites, particularly in the Pelly Mountains and along the Yukon River plain, are required to secure the pattern of spruce migration into the southwestern Yukon.

Green alder increased significantly at 6000 yr BP, indicating cooler and moister conditions, as suggested by Cwynar and Spear (1995). The increase in *Picea glauca* and *Alnus crispa* PARs (Fig. 3.4) at this time suggests that forest cover was more continuous. This change in vegetation and hence climate occurs simultaneously with a lithological change at Sulphur Lake (Fig. 3.3) which suggests that edaphic parameters that affected sediment deposition also changed at this time. For example, with moister conditions and increased forest cover, loess input to Sulphur Lake would have decreased (Nickling, 1978), explaining in part the transition from silty gyttja to homogenous brown gyttja at 315 cm. Throughout the Yukon, the increase in *Alnus crispa* in the mid-Holocene is usually accompanied by an increase in *Picea mariana* (Cwynar and Spear, 1995). The history of *Picea mariana* in the Shakwak Trench is less clear (Cwynar, 1988). At Sulphur Lake, black spruce was never a significant component of the vegetation. Conditions may have been too dry to support black spruce. However, this is the first diagram from the Shakwak Trench to differentiate white and black spruce pollen and so with additional sites the importance of black spruce could be better determined. Ritchie (1987) suggests that the increase in *Alnus* in the mid-Holocene is linked to increased wildfires. Stuart *et al.* (1989) interpret the rise in alder at nearby Jenny Lake at 4500 yr BP to represent the establishment of a spruce-alder woodland. However, modern pollen assemblages indicate that alder is overrepresented in the southwest Yukon (Appendix A). It is possible that alder was not as important a constituent of the regional vegetation as the sequence suggests but merely that its pollen was transported long distances.

Only minor adjustments occurred following the rise in green alder at 6000 yr BP. At approximately 1500 yr BP, *Betula*, *Salix*, and total NAP increased at the expense of *Picea glauca*. In view of the 660 year difference between the accepted date of the White River ash (Clague *et al.*, 1995) and the date obtained from Sulphur Lake, the decrease in white spruce may correspond to the Little Ice Age during which it is known that glaciers advanced in the St. Elias Mountains (Denton and Karlén, 1977). The increase in aquatics at this time is probably associated with local changes in the physical or chemical conditions of Sulphur Lake. For example, higher lake levels would have allowed aquatics to expand on the margins of Sulphur Lake. *Pinus* pollen increased shortly after the deposition of the White River tephra but has remained at low levels (<5%). To the southeast, at Kettehole Pond, Cwynar (1988) found *Pinus contorta* to be the dominant tree by 1900 yr BP. Given that pine has not reached Sulphur Lake, the increase in *Pinus* pollen is presumably a function of transport linked to the dramatic increase in growing populations of pine to the south.

Johnson and Raup (1964), MacNeish (1964) and later followed by Workman (1978), suggested that extensive grassland communities occupied the southwest Yukon following deglaciation until roughly 3000 yr BP. This hypothesis was largely speculative and was based on the presence of wood bison (*Bison bison athabascaae*) fossils in early and middle Holocene sediments in the southwest Yukon and the assumption that early inhabitants (Little Arm and Gladstone cultural phases) were adapted to the hunting of grassland species including muskox (*Ovibos moschatus*), caribou (*Rangifer tarandus*) and bison (*Bison* sp.). However, based on the Sulphur Lake pollen diagram as well as other nearby postglacial vegetation reconstructions (Stuart *et al.*, 1989; Rampton, 1971), it is clear that a white spruce boreal forest has dominated the Shakhwak Trench since at least 8000 yr BP. Extensive grasslands were not present in the southwest Yukon in the early Holocene, or at any time, as proposed by previous archaeological histories. In fact, grasses account for less than 5% of the pollen sum for the period of record. As Stuart *et al.* (1989) indicate, regional archaeological reconstructions that indicate that early hunters and gatherers in the southern Yukon were adapted

to widespread grassland environments (i.e. Johnson and Raup, 1964; MacNeish, 1964; Workman, 1978) will have to be revised accordingly.

3.6. Summary

At Sulphur Lake, an open tundra marked by the presence of *Artemisia* was present during the late-glacial and early Holocene. With a marked decrease in *Artemisia* and an increase in *Betula*, a birch shrub tundra prevailed between 11,250 and 10,250 yr BP. Between 10,250 and 8400 yr BP, a poplar woodland with an understory of juniper scrub and dwarf birch was supported. Spruce invaded the region at 8400 yr BP and since about 8000 yr BP, the present white spruce boreal forest was established. Green alder increased at 6000 yr BP at Sulphur Lake as it did throughout most of the Yukon however, black spruce did not increase. The basal radiocarbon date of 17,370 yr BP from Sulphur Lake and Denton and Stuiver's (1966) 12,500 yr BP date suggest that the chronology of clearance of ice from the Shakwak Trench needs to be more firmly dated. If the regional deglaciation history is revised, the interpretation of the Sulphur Lake pollen diagram would need to be revisited.

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Chapter 4

Summary

Paleoecological studies based on the analysis of pollen in lake sediments offer the potential for high resolution and well-dated independent records of past vegetation and climate. A 5 m sediment core was raised from the deepest basin of Sulphur Lake, located in the southwest Yukon (60.95°N, 137.95°W; 847 m). The Sulphur Lake pollen diagram reveals significant late glacial and Holocene changes in vegetation that provide new information on the regional paleoecological history of the boreal forest in the southwest Yukon. The fossil pollen assemblages indicate that between approximately 12,000 and 11,250 yr BP, the vegetation was an open alpine tundra marked by the presence of *Artemisia* and dwarf birch. The vegetation then progressed from an open birch shrub tundra to a poplar woodland at 10,250 yr BP. *Juniperus* populations expanded by 9500 yr BP and by 8400 yr BP, spruce invaded the region. The relatively closed white spruce forest that occupies the region today was established by approximately 8000 yr BP. *Alnus crispa* increased at 6000 yr BP, however the increase in *Picea mariana* also found at this time at most sites in the Yukon did not occur at Sulphur Lake. The Sulphur Lake diagram indicates that black spruce was not a dominant component of the vegetation in the Shakwak Trench at any time as it was to the southeast at Kettlehole Pond (Cwynar, 1988). There are small scale variations within the sequence but, in general, there was a rapid warming following deglaciation that eventually permitted the migration of white spruce into the Shakwak Trench by 8000 yr BP and since approximately 6000 yr BP, the climate has been fairly constant.

The pattern of spruce migration in the southwest Yukon has been previously investigated but remains uncertain. Spruce arrived west of the Liard Plain at Kettlehole Pond at 9250 yr BP (Cwynar, 1988), and in the central Aishihik basin by 8600 yr BP (Wang, 1989). It is possible that

following deglaciation spruce migrated from northern British Columbia via the Liard River into the Tintina Trench and the Yukon River drainage system. It could have then migrated south into the Aishihik basin and eventually into the Shakwak Trench. The spruce arrival at Sulphur Lake at 8400 yr BP and at nearby Jenny Lake at 8500 yr BP (Stuart *et al.*, 1989) are in agreement with this migration route. Additional sites, particularly in the Pelly Mountains and along the Yukon River, are required in order to confirm the direction of spruce migration in this region. Future palynological studies in this region must differentiate between white and black spruce pollen in order to effectively ascertain the migration pattern of each species. Once migration patterns and rates are firmly established, it may be possible to determine whether the present distribution is limited by migration or whether climate is the most significant ecological control of species distributions.

The early suggestion that extensive grasslands occupied much of the southwest Yukon following deglaciation until roughly 3000 yr BP is not supported by the Sulphur Lake diagram. Cwynar (1988), Stuart *et al.* (1989), and Keenan and Cwynar (1992) also found no evidence to support this proposal. Regional archaeological reconstructions that indicate that early hunters and gatherers in the southwest Yukon were adapted to widespread grasslands (i.e. Johnson and Raup, 1964; MacNeish, 1964; Workman, 1978) will have to be revised accordingly.

The basal radiocarbon date of 17,370 yr BP (BETA-104737) appears to be too old given the accepted date of 12,500 yr BP for clearance of ice from the Shakwak Trench (Denton and Stuiver, 1966, 1967). However, given the tenuous basis of this accepted date – a bulk sediment date from the carbonate-rich basal sediments of Jenny Lake – this new date suggests that the chronology of regional deglaciation for the southwest Yukon needs to be more firmly established. Even if the date of basal sediments from Sulphur Lake is too old, deglaciation could predate the 12.5 kyr date currently accepted. However, it is probable that deglaciation occurred

later than 12,500 yr BP as the high carbonate content of Jenny Lake sediments would have resulted in dates that were too old. If the deglaciation history of the southwest Yukon is revised, the interpretation of the Sulphur Lake pollen diagram would in turn need to be revisited.

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Appendix A

Modern pollen assemblages in the Shakwak Trench, southwest Yukon Territory

Introduction

Reconstructions of past vegetation require an accurate understanding of how modern vegetation composition and pattern are recorded by pollen assemblages in lake sediments. Thus, the first step in reconstructing past vegetation changes at Sulphur Lake was to examine modern pollen assemblages in this region of the boreal forest. Modern sediment samples were used to aid in the interpretation of fossil pollen assemblages. Surface sediment samples from 16 lakes along a transect from the Donjek River to the Yukon/British Columbia provincial border (Fig. A.1) were collected to aid in the interpretation of the Sulphur Lake pollen diagram.

Methods

Candidate lakes were first selected by consulting topographic maps. Modern sediment samples were collected at 16 lakes, along a transect from the Donjek River to the Yukon/British Columbia provincial border. Only two sites, Upper Fly Lake and West Twin Lake, were at treeline. Surface sediment samples were collected from the center of each lake using a Glew mini-corer (Glew, 1991). Maximum depths were determined during surface sampling and, at some sites, through sonar measurements. The sediment was extruded into plastic bags at 0.5 or 1.0 cm intervals using a portable extruding device (Glew, 1988). Upon return from the field, sediment samples were stored at 4°C. Water temperature and conductivity were measured using a YSI S-C-T Meter (model 33) and dissolved oxygen was measured using a YSI Oxygen Meter (model 51b). Secchi depth and pH were also measured in the field. The uppermost centimeter of sediment from each lake was prepared for pollen analysis following standard



Fig. A.1: Map of the study area showing the location of the 16 lakes. Shading indicates elevation over 1525 m. An asterisk indicates an official name.

methods (Faegri and Iversen, 1989; Cwynar *et al.*, 1979). Slides were counted using a transmitted light microscope, with regularly spaced transects across the cover slip, until a minimum sum of 500 pollen and spores per sample (excluding aquatic species) was achieved. The differentiation of *Picea glauca* and *P. mariana* was based upon morphological characteristics outlined by Hansen and Engstrom (1985). All undifferentiated *Picea* grains were assigned to either *P. glauca* or *P. mariana* based on the relative proportional distribution of grains identified to species. Similarly for *Pinus*, all undifferentiated *Pinus* grains were assigned to either the type diploxylon or haploxylon.

Results

Physical Limnology

The physical conditions of the 16 sites are summarised in Table A.1. The study lakes are all shallow (0.8 to 12.5 m) and mildly to strongly alkaline, with pH ranging from 7.7 to 9.0. Surface conductivity varies from 100 to 610 ($\mu\text{S}/\text{cm}$). Although most of the lakes are non-stratified, a few had low amounts of O_2 at depth.

Site	Lat. ($^{\circ}\text{N}$)	Long. ($^{\circ}\text{W}$)	Elev. (m)	Max. Depth (m)	Secchi (m)	Temp. ($^{\circ}\text{C}$)	pH	Cond. ($\mu\text{S}/\text{cm}$)	Oxygen (mg/L)
Donjek Kettle	61.69	139.77	732	5.5	-	15.0	8.2	243	8.2
Ash Pond	61.62	139.59	803	0.8	0.8	12.5	8.2	115	8.6
Trout Lake	61.58	139.38	727	2.0	2.0	13.5	9.0	170	8.6
Rat Lake	61.17	138.43	790	10.1	2.9	14.0	8.3	258	8.7
Small Lake	61.16	138.43	800	6.7	5.2	15.0	8.6	370	8.4
Grayling Lake	61.16	138.43	790	10.5	2.9	13.8	8.5	258	9.0
Fox Point Lake	61.12	138.43	790	10.5	5.5	14.5	8.6	610	8.8
Keyhole Lake	61.08	138.37	826	4.5	4.5	8.8	8.6	475	16.0
Emerald Lake	61.07	138.38	820	8.0	5.8	16.0	8.7	600	8.5
Jenny Lake	61.05	138.36	817	4.0	3.2	16.0	8.6	600	8.0
Upper Fly Lake	61.04	138.09	1326	4.2	-	22.0	7.7	100	-
Patrick's Lake	60.95	138.10	900	2.0	2.0	12.0	8.3	368	-
Sulphur Lake	60.95	137.95	847	10.0	1.9	14.5	8.8	610	8.2
Pine Lake	60.81	137.45	670	12.5	12.0	14.5	8.3	232	8.2
Blanchard Pond	59.94	138.80	915	2.0	2.0	11.0	8.4	108	-
West Twin Lake	59.89	136.73	914	4.5	-	10.1	8.4	148	-

Table A.1: Summary of limnological data for the 16 lakes. Temperature, pH, conductivity, and oxygen were measured at the surface.

Modern Pollen Assemblages

Pollen percentages from surface samples analysed from 12 sites are arranged from north to south in Figure A.2. All of the sites are dominated by *Picea glauca* (35 - 82%). *Picea mariana*, rare or absent in the Shakwak Trench, accounts for up to 5% of the pollen percentages. At Jenny Lake, which is entirely surrounded by a well-developed spruce forest, *Picea glauca* accounts for 82% of the pollen sum. *Alnus crispa* (6 - 30%), *Betula* (3 - 19%) and *Salix* (1 - 9%) pollen are also relatively abundant. *Pinus* pollen, most of which is of the type diploxylon, increases to the south where *Pinus contorta* grows more extensively. Sites at the Donjek River (Donjek Kettle, Ash Pond, and Trout Lake) have high amounts of *Betula* and *Alnus* pollen where these species are more common. Sites to the immediate east of Kluane Lake are dominated by *Picea glauca* pollen with low but significant amounts of *Populus*, *Artemisia* and Gramineae at the expense of *Betula* and *Alnus*. Poplar groves and *Artemisia*-dominated grasslands presently surround these sites. Sites to the south of Kluane Lake along the Alaska Highway, including Sulphur Lake, show average pollen assemblages for the region that reflect the vegetation in the Shakwak Trench.

Discussion

Total *Alnus* pollen in the Shakwak Trench accounts for between 7 and 35% of the modern pollen rain. The plant however is uncommon in the Kluane Lake region, present only as scattered shrubs (Johnson and Raup, 1964). In the Klutlan region of the southwest Yukon, Birks (1980) found that *Alnus* contributed 27% to the pollen sum even though alder is rare in the region. Where green alder was found growing locally at one site in the shrub tundra east of the Klutlan Glacier in the St. Elias Mountains, Birks (1977) found *Alnus* to be 52% of the modern pollen assemblage. Rampton (1971) also found high values of *Alnus* pollen, up to 40%, in surface samples in the Snag-Klutlan area of the southwestern Yukon. It is therefore apparent

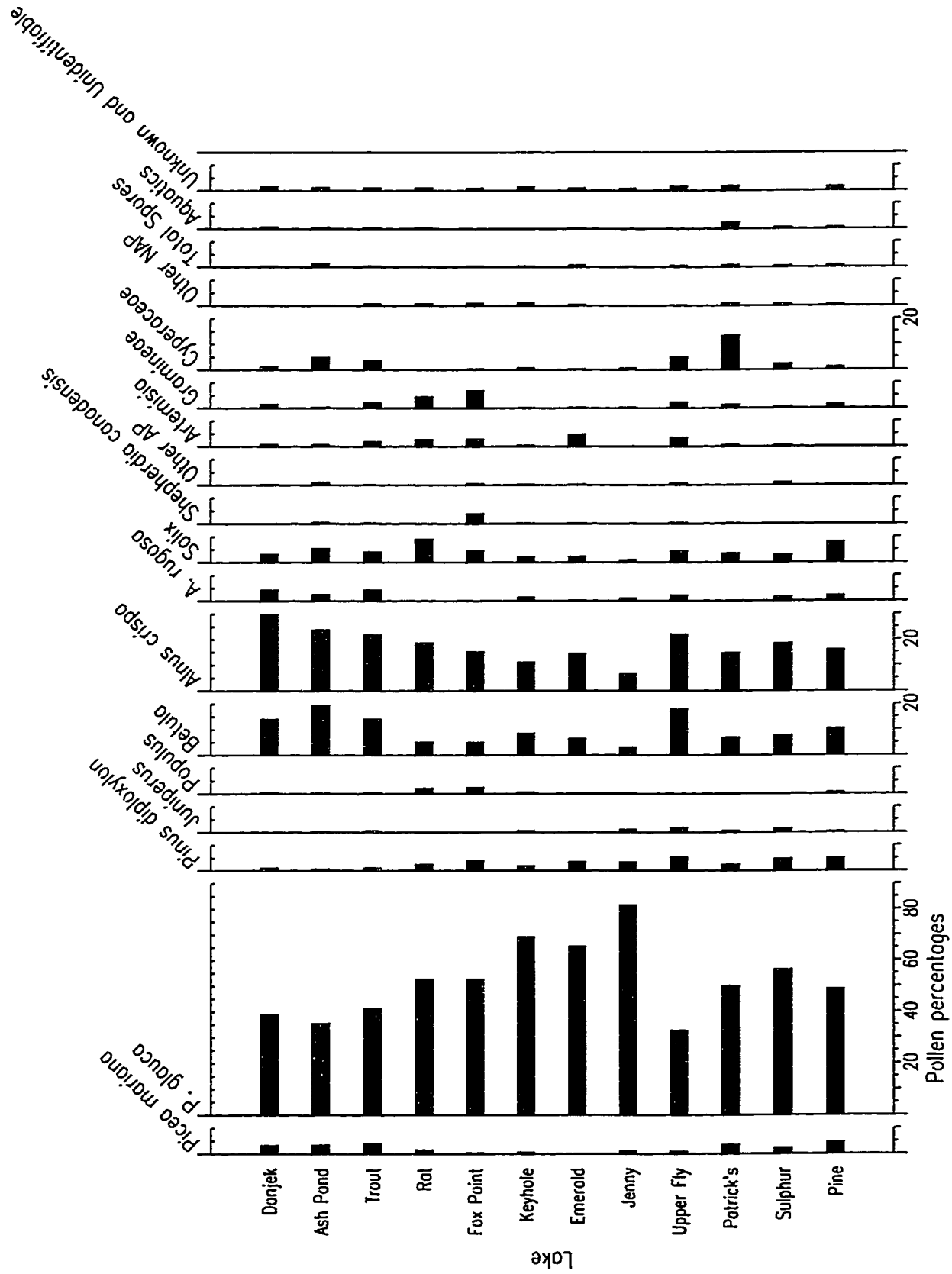


Fig. A.2: Summary pollen percentage diagram for surface samples from the Shakwak Trench. Sites are arranged from north to south.

that alder pollen is overrepresented in surface sediments in the southwest Yukon. Alder has been found to be overrepresented in other regions, including the Mackenzie Delta (Ritchie, 1974). Alder grows much more abundantly to the south and north of the Kluane Lake region and so its pollen in surface sediments in the Shakwak Trench is at least in part a function of regional transport.

Both trembling aspen and balsam poplar grow abundantly in the Shakwak Trench at present, yet there are only trace amounts of *Populus* pollen in the surface sediments. *Populus* pollen reaches up to only 2.5% at sites to the immediate east of Kluane Lake where poplar groves are extensive. Birks (1977) found *Populus* values of 67% in one moss polster within a pure *P. balsamifera* forest in the St. Elias Mountains but only 11% on the edge of that forest. Thus, poplar is seriously underrepresented in surface sediments in the southwest Yukon, as is the case in other regions (Litchi-Federovich and Ritchie, 1965, 1968; Mott, 1969, 1978). Similarly, *Salix* values are relatively low (1 - 9%) given the abundance of willow in the Shakwak Trench. Birks (1980) also found low values of *Salix* in the St. Elias Mountains. This underrepresentation of *Salix* is partially explained by the fact that it is poorly dispersed (Jackson, 1990). Andersen *et al.* (1991) indicate that willow is a low pollen producer and is typically underrepresented in modern pollen spectra across the arcto-boreal region of North America. *Shepherdia canadensis* is also poorly represented in the Shakwak Trench modern pollen rain but is locally abundant (Birks, 1977, 1980).

White spruce accounts for roughly 30% of the pollen sum in Upper Fly Lake. Upper Fly Lake lies at treeline and so the majority of pollen is brought upslope. Rampton (1971) also found large amounts of *Picea* at a site above treeline in the St. Elias Mountains. *Pinus*, largely absent from the Shakwak Trench, contributes 6% to the pollen sum at Upper Fly Lake due to its efficient dispersal properties and its large source area (Jackson, 1990; Fall, 1992). High Cyperaceae

values (13%) at Patrick's Lake result from the abundant sedges currently growing around the margins of the lake.

Summary

In general, the modern pollen assemblages from surface sediments collected in the Shakwak Trench reflect the regional vegetation. *Picea glauca* is the principal contributor as this region of the boreal forest is dominated by white spruce. *Alnus* and *Pinus* are overrepresented while *Populus*, *Salix*, and *Shepherdia* are underrepresented. Additional sites will be required in order for the relation between modern pollen rain and local and regional vegetation in the southwest Yukon to be more firmly established.

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Appendix B

Pollen Data

Depth (cm)	Age (yr BP)	<i>Picea</i> undif.	<i>Picea glauca</i>	<i>Picea mariana</i>	<i>Abies</i>	<i>Pinus</i> undif.	<i>Pinus</i> diploxylon	<i>Pinus</i> haploxylon	<i>Populus</i>	<i>Tsuga</i>	<i>Alnus</i> crispa	<i>Alnus</i> rugosa	<i>Betula</i>	<i>Cornus stolonifera</i>	<i>Ericaceae</i> undif.	<i>Andromeda</i>	<i>Cassiope</i>	<i>Ledum</i>
0.0	0.0	27.5	280.0	11.0	0.0	14.0	13.0	2.0	0.0	0.0	100.0	8.0	41.0	0.0	0.0	0.0	0.0	0.0
6.2	137.3	15.5	236.5	5.0	0.0	4.5	7.0	0.0	1.0	0.0	78.0	20.0	64.0	0.0	1.0	0.0	0.0	0.0
12.4	274.6	16.0	236.0	1.0	0.0	7.0	5.0	0.0	0.0	0.0	105.0	6.0	60.0	0.0	1.0	0.0	0.0	0.0
18.6	411.9	21.0	229.5	1.0	0.0	1.0	10.0	0.0	0.0	0.0	76.0	3.0	39.0	0.0	1.0	0.0	0.0	0.0
25.0	553.7	18.5	230.0	3.5	0.0	3.0	9.0	2.0	1.0	0.0	92.0	6.0	61.0	0.0	2.0	0.0	0.0	0.0
29.8	659.1	23.0	97.5	14.5	0.0	3.5	3.0	0.0	0.0	0.0	44.0	2.0	47.0	0.0	0.0	1.0	0.0	0.0
39.0	863.7	16.0	188.0	6.5	0.0	3.5	12.0	0.0	0.0	0.0	64.0	4.0	65.0	0.0	0.0	0.0	0.0	0.0
44.0	974.5	16.5	193.0	3.0	0.0	3.0	11.0	0.0	0.0	0.0	88.0	3.0	66.0	0.0	1.0	0.0	0.0	0.0
54.0	1195.9	31.0	116.5	27.5	0.0	6.5	7.0	0.0	0.0	0.0	57.0	6.0	57.0	0.0	0.0	0.0	0.0	2.0
59.0	1306.7	11.0	179.5	1.0	0.0	0.5	3.0	0.0	1.0	1.0	81.0	3.0	63.0	0.0	3.0	0.0	1.0	0.0
69.0	1528.1	3.0	251.0	0.0	0.0	2.5	4.0	0.0	0.0	0.0	63.0	3.0	53.0	0.0	1.0	0.0	0.0	0.0
75.0	1661.0	22.0	148.5	4.5	0.0	4.5	4.0	0.0	0.0	0.0	58.0	5.0	41.0	0.0	0.0	0.0	0.0	0.0
80.0	1771.8	12.0	259.0	2.0	0.0	1.0	6.0	0.0	0.0	0.0	87.0	3.0	49.0	0.0	1.0	0.0	0.0	0.0
85.0	1882.5	10.5	264.5	2.0	0.0	1.5	3.0	0.0	0.0	0.0	92.0	3.0	75.0	0.0	0.0	0.0	0.0	0.0
90.0	1985.7	32.5	212.5	13.0	1.0	5.5	7.0	0.0	0.0	0.0	86.0	3.0	61.0	0.0	3.0	0.0	0.0	0.0
95.0	2071.2	21.5	249.0	4.0	0.0	2.5	8.0	1.0	1.0	0.0	77.0	4.0	60.0	0.0	0.0	0.0	0.0	0.0
100.0	2156.8	35.0	165.5	11.5	0.0	1.0	3.0	0.0	0.0	0.0	43.0	13.0	40.0	0.0	0.0	0.0	0.0	0.0
105.0	2242.3	16.0	230.5	3.5	0.0	0.5	5.0	0.0	1.0	0.0	91.0	3.0	66.0	0.0	0.0	0.0	0.0	0.0
110.0	2327.9	6.0	201.0	1.0	0.0	6.0	1.0	0.0	0.0	0.0	93.0	8.0	50.0	0.0	0.0	0.0	1.0	0.0
115.0	2413.4	28.0	219.0	1.0	0.0	4.5	4.0	0.0	1.0	0.0	93.0	9.0	65.0	0.0	1.0	0.0	0.0	0.0
120.0	2499.0	17.0	277.0	3.0	0.0	0.5	4.0	0.0	0.0	0.0	62.0	11.0	51.0	0.0	0.0	0.0	0.0	0.0
125.0	2584.5	5.5	239.0	0.0	0.0	0.5	1.0	0.0	0.0	0.0	46.0	3.0	55.0	0.0	0.0	0.0	0.0	0.0
135.0	2760.8	55.0	178.5	20.5	0.0	2.0	2.0	0.0	0.0	0.0	96.0	1.0	83.0	0.0	0.0	0.0	0.0	0.0
140.0	2854.3	47.5	192.5	29.5	0.0	2.0	2.0	3.0	0.0	0.0	85.0	20.0	71.0	0.0	0.0	0.0	0.0	0.0
145.0	2947.8	16.0	262.0	0.0	0.0	1.5	5.0	0.0	0.0	0.0	76.0	0.0	56.0	0.0	0.0	0.0	1.0	0.0
150.0	3041.4	49.5	204.5	8.0	0.0	2.0	2.0	0.0	0.0	0.0	80.0	4.0	56.0	0.0	4.0	0.0	0.0	0.0
155.0	3134.9	2.5	288.5	0.0	0.0	1.0	2.0	0.0	0.0	0.0	92.0	4.0	60.0	0.0	0.0	0.0	0.0	0.0
160.0	3228.4	19.5	230.5	8.0	0.0	1.5	3.0	0.0	0.0	0.0	114.0	3.0	64.0	0.0	1.0	0.0	0.0	0.0
165.0	3322.0	32.5	235.5	7.0	0.0	2.0	1.0	0.0	0.0	0.0	90.0	13.0	58.0	0.0	0.0	0.0	0.0	0.0
176.0	3527.7	42.5	200.0	23.5	0.0	2.0	1.0	0.0	1.0	0.0	100.0	4.0	48.0	0.0	0.0	0.0	0.0	0.0
186.0	3714.8	48.5	214.0	11.0	0.0	3.0	0.0	0.0	2.0	1.0	72.0	19.0	46.0	0.0	0.0	0.0	0.0	0.0
191.0	3808.3	35.5	264.5	1.0	0.0	3.5	2.0	0.0	0.0	0.0	139.0	18.0	99.0	0.0	0.0	0.0	0.0	0.0
196.0	3901.8	42.0	213.0	15.5	0.0	0.0	3.0	0.0	0.0	0.0	116.0	2.0	59.0	0.0	1.0	0.0	0.0	0.0
201.0	3995.4	31.5	191.0	30.5	0.0	0.0	6.0	0.0	2.0	0.0	97.0	11.0	62.0	0.0	0.0	0.0	0.0	0.0
206.0	4088.9	26.0	249.0	8.0	0.0	1.0	3.0	0.0	0.0	0.0	90.0	5.0	56.0	1.0	0.0	0.0	0.0	0.0
211.0	4182.4	40.5	223.0	23.0	0.0	1.5	2.0	0.0	2.0	0.0	87.0	19.0	53.0	0.0	0.0	0.0	0.0	1.0
216.0	4275.9	5.5	272.5	2.0	0.0	0.5	3.0	0.0	1.0	0.0	90.0	3.0	68.0	0.0	1.0	0.0	0.0	0.0
221.0	4369.5	24.0	214.0	2.0	0.0	0.0	0.0	0.0	2.0	0.0	100.0	1.0	69.0	1.0	1.0	0.0	0.0	0.0
226.0	4463.0	27.5	162.5	16.5	0.0	1.0	0.0	1.0	0.0	0.0	162.0	6.0	81.0	0.0	2.0	0.0	0.0	0.0
231.0	4556.5	3.5	245.5	2.0	0.0	0.0	1.0	0.0	2.0	0.0	108.0	6.0	75.0	0.0	0.0	0.0	0.0	0.0
236.0	4650.0	23.0	205.5	2.0	0.0	0.0	2.0	0.0	0.0	0.0	101.0	20.0	71.0	0.0	0.0	0.0	0.0	0.0
241.0	4743.6	4.5	262.0	1.0	0.0	0.0	2.0	0.0	0.0	0.0	115.0	1.0	71.0	0.0	0.0	0.0	0.0	0.0
246.0	4837.1	11.0	266.0	2.0	0.0	0.0	2.0	0.0	0.0	0.0	104.0	3.0	68.0	0.0	0.0	0.0	0.0	0.0
251.0	4930.6	57.5	395.0	9.0	0.0	3.0	1.0	0.0	1.0	3.0	82.0	4.0	41.0	0.0	0.0	0.0	1.0	0.0
256.0	5024.1	10.0	231.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	106.0	3.0	82.0	0.0	1.0	0.0	0.0	0.0
260.0	5099.0	43.5	299.0	6.0	0.0	0.0	0.0	0.0	1.0	0.0	64.0	7.0	50.0	0.0	1.0	0.0	0.0	0.0
265.0	5192.5	9.0	184.5	3.0	0.0	0.0	0.0	0.0	0.0	0.0	65.0	7.0	58.0	0.0	0.0	0.0	0.0	0.0
270.0	5286.0	29.0	290.0	7.0	0.0	0.5	0.0	0.0	1.0	0.0	63.0	1.0	54.0	0.0	0.0	0.0	0.0	0.0
275.0	5379.6	65.0	185.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	80.0	9.0	72.0	0.0	1.0	0.0	0.0	0.0
280.0	5473.1	49.5	276.5	9.0	0.0	2.5	0.0	0.0	0.0	0.0	62.0	8.0	58.0	0.0	0.0	0.0	0.0	0.0
285.0	5566.6	7.0	247.0	2.0	0.0	0.0	0.0	0.0	3.0	0.0	72.0	2.0	106.0	0.0	0.0	0.0	0.0	0.0
290.0	5660.1	3.5	399.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.0	2.0	38.0	0.0	0.0	0.0	0.0	0.0
295.0	5753.7	28.5	261.0	6.0	0.0	0.0	0.0	0.0	5.0	0.0	64.0	2.0	76.0	0.0	1.0	0.0	0.0	0.0

Depth (cm)	Age (yr BP)	<i>Picea undiff.</i>	<i>Picea glauca</i>	<i>Picea mariana</i>	<i>Abies</i>	<i>Pinus undiff.</i>	<i>Pinus diploxylon</i>	<i>Pinus haploxylon</i>	<i>Populus</i>	<i>Tsuga</i>	<i>Alnus crispa</i>	<i>Alnus rugosa</i>	<i>Betula</i>	<i>Cornus stolonifera</i>	<i>Ericaceae undiff.</i>	<i>Andromeda</i>	<i>Cassiope</i>	<i>Ledum</i>
300.0	5847.2	36.0	189.5	23.5	0.0	0.0	0.0	0.0	5.0	0.0	84.0	5.0	74.0	0.0	0.0	0.0	0.0	0.0
305.0	5940.7	17.0	277.5	12.0	0.0	2.0	0.0	0.0	1.0	0.0	69.0	5.0	57.0	0.0	0.0	0.0	0.0	0.0
310.0	6034.2	21.5	252.0	3.0	0.0	0.0	0.0	0.0	3.0	0.0	46.0	7.0	103.0	0.0	0.0	0.0	0.0	0.0
315.0	6127.8	39.5	118.5	11.0	0.0	2.0	0.0	0.0	1.0	0.0	15.0	5.0	38.0	0.0	0.0	0.0	0.0	0.0
319.0	6202.6	18.0	342.5	1.0	0.0	0.0	0.0	0.0	1.0	0.0	37.0	1.0	59.0	0.0	0.0	0.0	0.0	0.0
320.0	6221.3	45.0	218.0	17.5	0.0	2.0	1.0	0.0	2.0	0.0	44.0	14.0	82.0	0.0	1.0	0.0	0.0	0.0
325.0	6406.7	25.0	215.0	3.0	0.0	1.0	0.0	1.0	3.0	0.0	42.0	9.0	69.0	0.0	0.0	0.0	0.0	0.0
329.0	6573.3	13.5	257.5	2.0	0.0	0.0	0.0	0.0	2.0	1.0	41.0	1.0	79.0	0.0	0.0	0.0	0.0	0.0
335.0	6823.3	24.5	247.5	6.0	0.0	0.0	0.0	0.0	4.0	0.0	45.0	3.0	91.0	0.0	0.0	0.0	0.0	0.0
344.0	7198.3	52.0	90.0	52.0	0.0	0.0	0.0	1.0	5.0	0.0	28.0	3.0	83.0	0.0	0.0	0.0	0.0	0.0
354.0	7615.0	30.0	282.0	16.0	0.0	0.0	1.0	0.0	12.0	0.0	39.0	0.0	66.0	0.0	0.0	0.0	0.0	0.0
359.0	7823.3	25.0	250.0	3.5	0.0	0.5	1.0	0.0	7.0	0.0	26.0	6.0	89.0	0.0	0.0	0.0	0.0	0.0
364.0	8031.7	38.5	99.0	14.0	0.0	0.5	0.0	0.0	16.0	0.0	28.0	11.0	83.0	0.0	1.0	0.0	0.0	0.0
369.0	8240.0	51.5	198.0	22.0	1.0	2.5	0.0	0.0	32.0	0.0	42.0	0.0	133.0	0.0	0.0	0.0	0.0	0.0
374.0	8391.8	6.0	160.0	0.0	0.0	0.0	1.0	0.0	36.0	0.0	55.0	2.0	142.0	0.0	0.0	0.0	0.0	0.0
379.0	8543.5	10.0	23.5	8.5	0.0	1.0	0.0	0.0	31.0	0.0	37.0	11.0	182.0	0.0	0.0	0.0	0.0	0.0
384.0	8695.3	0.0	26.5	1.0	0.0	0.0	0.0	0.0	54.0	0.0	29.0	5.0	205.0	0.0	0.0	0.0	0.0	0.0
389.0	8847.1	7.0	25.5	0.0	0.0	0.0	1.0	0.0	79.0	0.0	45.0	9.0	185.0	0.0	1.0	0.0	0.0	0.0
394.0	8998.8	2.5	16.5	0.0	0.0	0.5	1.0	0.0	97.0	0.0	40.0	2.0	168.0	0.0	0.0	0.0	0.0	0.0
399.0	9150.6	8.0	8.0	2.5	0.0	0.5	0.0	0.0	63.0	0.0	41.0	21.0	176.0	0.0	0.0	0.0	0.0	0.0
404.0	9302.4	3.5	13.5	0.0	0.0	0.0	0.0	0.0	33.0	0.0	75.0	4.0	203.0	0.0	0.0	0.0	0.0	0.0
409.0	9454.1	0.5	6.0	1.0	0.0	0.0	0.0	0.0	41.0	0.0	42.0	2.0	292.0	0.0	0.0	0.0	0.0	0.0
412.5	9559.3	4.5	0.0	3.0	0.0	1.0	0.0	0.0	152.0	0.0	38.0	5.0	204.0	0.0	0.0	0.0	0.0	0.0
415.0	9632.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	55.0	0.0	37.0	2.0	343.0	0.0	0.0	0.0	0.0	0.0
420.0	9779.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	36.0	8.0	311.0	0.0	0.0	0.0	0.0	0.0
425.0	9925.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.0	0.0	37.0	0.0	284.0	0.0	0.0	0.0	0.0	0.0
430.0	10072.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.0	0.0	26.0	1.0	283.0	0.0	0.0	0.0	0.0	0.0
435.0	10219.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	0.0	15.0	1.0	361.0	0.0	0.0	0.0	0.0	0.0
445.0	10512.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	383.0	0.0	2.0	0.0	0.0	0.0
455.0	10805.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.0	0.0	42.0	0.0	339.0	0.0	0.0	0.0	0.0	0.0
458.0	10893.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.0	0.0	52.0	0.0	353.0	0.0	1.0	0.0	0.0	0.0
463.0	11039.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.0	0.0	27.0	0.0	346.0	0.0	0.0	0.0	0.0	0.0
468.0	11186.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	0.0	31.0	1.0	362.0	0.0	0.0	0.0	0.0	0.0
470.0	11245.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	13.0	0.0	428.0	0.0	0.0	0.0	0.0	0.0
474.0	11362.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	11.0	0.0	288.0	0.0	0.0	0.0	0.0	0.0
478.0	11479.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	206.0	0.0	1.0	0.0	0.0	0.0
488.0	11772.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	112.0	0.0	0.0	0.0	0.0	0.0
495.5	11992.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	105.0	0.0	0.0	0.0	0.0	0.0
497.5	12051.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	0.0	176.0	0.0	0.0	0.0	0.0	0.0

Depth (cm)	Age (yr BP)	<i>Pyrola</i>	<i>Juglans</i>	<i>Juniperus</i>	<i>Salix</i>	<i>Shepherdia canadensis</i>	<i>Ambrosia</i>	<i>Artemisia</i>	Caryophyllaceae	Chenopodiaceae	<i>Cornus canadensis</i>	Cruciferae	Cyperaceae	<i>Epilobium</i>	<i>Gallium</i>	Gramineae	Liguliflorae	<i>Oxyria</i>
0.0	0.0	1.0	0.0	7.0	15.0	0.0	0.0	2.0	1.0	0.0	0.0	0.0	12.0	0.0	0.0	3.0	0.0	0.0
6.2	137.3	0.0	0.0	7.0	28.0	0.0	0.0	3.0	0.0	0.0	0.0	1.0	28.0	0.0	1.0	6.0	0.0	0.0
12.4	274.6	0.0	1.0	9.0	28.0	1.0	0.0	6.0	1.0	0.0	0.0	1.0	14.0	0.0	0.0	8.0	0.0	0.0
18.6	411.9	0.0	0.0	8.0	14.0	0.0	0.0	3.0	1.0	0.0	0.0	4.0	21.0	0.0	0.0	13.0	0.0	0.0
25.0	553.7	0.0	0.0	9.0	23.0	1.0	0.0	7.0	1.0	0.0	0.0	2.0	20.0	0.0	1.0	8.0	0.0	0.0
29.8	659.1	0.0	0.0	7.0	18.0	0.0	0.0	6.0	1.0	0.0	0.0	1.0	12.0	0.0	0.0	17.0	0.0	0.0
39.0	863.7	0.0	0.0	8.0	32.0	5.0	0.0	11.0	0.0	0.0	0.0	0.0	17.0	0.0	0.0	11.0	0.0	0.0
44.0	974.5	0.0	0.0	13.0	29.0	2.0	0.0	11.0	1.0	0.0	0.0	0.0	15.0	1.0	0.0	16.0	0.0	0.0
54.0	1195.9	0.0	0.0	6.0	17.0	4.0	0.0	7.0	0.0	0.0	0.0	0.0	14.0	0.0	2.0	13.0	0.0	0.0
59.0	1306.7	0.0	0.0	15.0	22.0	4.0	0.0	5.0	1.0	0.0	2.0	1.0	27.0	0.0	0.0	16.0	0.0	0.0
69.0	1528.1	0.0	0.0	7.0	32.0	2.0	0.0	6.0	0.0	1.0	0.0	0.0	14.0	0.0	0.0	9.0	0.0	0.0
75.0	1661.0	0.0	0.0	8.0	13.0	1.0	0.0	2.0	0.0	0.0	0.0	0.0	9.0	0.0	0.0	14.0	0.0	0.0
80.0	1771.8	0.0	0.0	10.0	23.0	4.0	0.0	7.0	1.0	0.0	1.0	0.0	12.0	0.0	0.0	5.0	0.0	0.0
85.0	1882.5	0.0	0.0	5.0	21.0	1.0	0.0	8.0	0.0	0.0	0.0	0.0	14.0	0.0	0.0	8.0	0.0	0.0
90.0	1985.7	0.0	0.0	5.0	23.0	7.0	0.0	12.0	1.0	0.0	0.0	0.0	14.0	0.0	0.0	10.0	0.0	0.0
95.0	2071.2	0.0	0.0	9.0	14.0	2.0	0.0	2.0	2.0	0.0	0.0	0.0	6.0	0.0	0.0	8.0	0.0	0.0
100.0	2156.8	0.0	0.0	11.0	12.0	0.0	0.0	3.0	1.0	0.0	0.0	0.0	12.0	0.0	0.0	3.0	0.0	0.0
105.0	2242.3	0.0	0.0	6.0	15.0	4.0	0.0	8.0	1.0	0.0	0.0	2.0	30.0	0.0	0.0	4.0	0.0	0.0
110.0	2327.9	0.0	0.0	5.0	22.0	2.0	0.0	8.0	0.0	0.0	0.0	2.0	13.0	0.0	0.0	7.0	0.0	0.0
115.0	2413.4	0.0	0.0	10.0	24.0	3.0	0.0	13.0	1.0	0.0	0.0	0.0	16.0	0.0	0.0	11.0	0.0	0.0
120.0	2499.0	0.0	0.0	9.0	24.0	4.0	0.0	3.0	0.0	0.0	0.0	0.0	18.0	0.0	0.0	12.0	0.0	0.0
125.0	2584.5	0.0	0.0	0.0	9.0	0.0	0.0	5.0	1.0	0.0	0.0	0.0	11.0	2.0	0.0	2.0	0.0	0.0
135.0	2760.8	0.0	0.0	4.0	24.0	5.0	0.0	6.0	0.0	0.0	0.0	0.0	20.0	0.0	2.0	12.0	0.0	0.0
140.0	2854.3	0.0	0.0	13.0	28.0	1.0	0.0	7.0	0.0	0.0	1.0	1.0	36.0	1.0	0.0	8.0	0.0	0.0
145.0	2947.8	0.0	0.0	2.0	14.0	1.0	0.0	7.0	1.0	0.0	0.0	0.0	11.0	0.0	0.0	2.0	0.0	0.0
150.0	3041.4	0.0	0.0	5.0	20.0	7.0	0.0	3.0	0.0	0.0	1.0	0.0	14.0	0.0	0.0	6.0	0.0	0.0
155.0	3134.9	0.0	0.0	3.0	9.0	2.0	0.0	6.0	0.0	0.0	1.0	0.0	17.0	0.0	0.0	3.0	0.0	0.0
160.0	3228.4	0.0	0.0	3.0	13.0	6.0	0.0	6.0	0.0	0.0	0.0	2.0	10.0	0.0	0.0	4.0	1.0	0.0
165.0	3322.0	0.0	0.0	3.0	21.0	1.0	0.0	11.0	0.0	0.0	0.0	1.0	14.0	0.0	0.0	7.0	0.0	0.0
176.0	3527.7	0.0	0.0	7.0	28.0	3.0	0.0	15.0	2.0	0.0	0.0	0.0	10.0	1.0	0.0	5.0	0.0	0.0
186.0	3714.8	0.0	0.0	13.0	18.0	2.0	0.0	6.0	0.0	0.0	0.0	0.0	24.0	0.0	0.0	10.0	0.0	0.0
191.0	3808.3	0.0	0.0	6.0	23.0	7.0	0.0	8.0	1.0	1.0	0.0	0.0	22.0	1.0	0.0	11.0	0.0	0.0
196.0	3901.8	0.0	0.0	7.0	14.0	1.0	0.0	6.0	0.0	0.0	0.0	1.0	14.0	0.0	1.0	4.0	0.0	0.0
201.0	3995.4	0.0	0.0	14.0	20.0	2.0	0.0	5.0	1.0	0.0	0.0	0.0	20.0	0.0	0.0	5.0	0.0	0.0
206.0	4088.9	0.0	0.0	4.0	13.0	6.0	0.0	7.0	0.0	2.0	0.0	0.0	10.0	0.0	0.0	12.0	0.0	0.0
211.0	4182.4	0.0	0.0	10.0	20.0	2.0	0.0	8.0	2.0	0.0	0.0	0.0	22.0	2.0	1.0	8.0	0.0	0.0
216.0	4275.9	0.0	0.0	5.0	27.0	3.0	0.0	8.0	0.0	0.0	0.0	0.0	14.0	1.0	0.0	2.0	0.0	0.0
221.0	4369.5	0.0	0.0	7.0	14.0	3.0	0.0	6.0	1.0	0.0	0.0	3.0	4.0	0.0	0.0	3.0	0.0	0.0
226.0	4463.0	0.0	0.0	10.0	19.0	3.0	0.0	9.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	4.0	0.0	1.0
231.0	4556.5	0.0	0.0	7.0	19.0	0.0	0.0	4.0	1.0	0.0	0.0	0.0	13.0	0.0	0.0	5.0	0.0	0.0
236.0	4650.0	0.0	0.0	4.0	27.0	6.0	1.0	7.0	0.0	0.0	0.0	0.0	16.0	0.0	0.0	3.0	0.0	0.0
241.0	4743.6	0.0	0.0	9.0	22.0	4.0	0.0	10.0	0.0	0.0	0.0	0.0	8.0	0.0	0.0	4.0	0.0	0.0
246.0	4837.1	0.0	0.0	4.0	14.0	5.0	0.0	6.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	4.0	0.0	0.0
251.0	4930.6	0.0	0.0	2.0	7.0	0.0	0.0	9.0	1.0	0.0	0.0	0.0	6.0	0.0	0.0	5.0	0.0	0.0
256.0	5024.1	0.0	0.0	10.0	30.0	1.0	0.0	11.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	4.0	0.0	0.0
260.0	5099.0	0.0	0.0	16.0	9.0	2.0	0.0	4.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0
265.0	5192.5	0.0	0.0	9.0	28.0	5.0	0.0	12.0	0.0	0.0	0.0	1.0	9.0	0.0	0.0	4.0	0.0	0.0
270.0	5286.0	0.0	0.0	11.0	11.0	6.0	0.0	9.0	1.0	0.0	1.0	0.0	8.0	1.0	0.0	5.0	0.0	0.0
275.0	5379.6	0.0	0.0	17.0	11.0	7.0	0.0	12.0	0.0	0.0	0.0	0.0	9.0	0.0	0.0	3.0	0.0	0.0
280.0	5473.1	0.0	0.0	8.0	9.0	1.0	0.0	10.0	0.0	1.0	0.0	0.0	7.0	0.0	0.0	1.0	0.0	0.0
285.0	5566.6	0.0	0.0	7.0	27.0	4.0	0.0	12.0	2.0	0.0	1.0	0.0	17.0	0.0	0.0	2.0	0.0	0.0
290.0	5660.1	0.0	0.0	6.0	4.0	3.0	0.0	5.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	1.0	0.0	0.0
295.0	5753.7	0.0	0.0	12.0	27.0	3.0	0.0	7.0	1.0	0.0	0.0	0.0	14.0	0.0	1.0	2.0	0.0	0.0

Depth (cm)	Age (yr BP)	<i>Pyrola</i>	<i>Juglans</i>	<i>Juniperus</i>	<i>Salix</i>	<i>Shepherdia canadensis</i>	<i>Ambrosia</i>	<i>Artemisia</i>	Caryophyllaceae	Chenopodiaceae	<i>Cornus canadensis</i>	Cruciferae	Cyperaceae	<i>Epilobium</i>	<i>Gallium</i>	Gramineae	Liguliflorae	<i>Oxyria</i>
300.0	5847.2	0.0	0.0	25.0	18.0	6.0	0.0	12.0	1.0	1.0	0.0	0.0	12.0	1.0	0.0	4.0	0.0	0.0
305.0	5940.7	0.0	0.0	14.0	13.0	3.0	0.0	8.0	0.0	0.0	0.0	0.0	17.0	1.0	0.0	3.0	0.0	0.0
310.0	6034.2	0.0	0.0	15.0	22.0	5.0	0.0	4.0	1.0	0.0	0.0	0.0	9.0	0.0	1.0	2.0	0.0	0.0
315.0	6127.8	0.0	0.0	10.0	8.0	2.0	0.0	8.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	4.0	0.0	0.0
319.0	6202.6	0.0	0.0	15.0	16.0	5.0	0.0	9.0	0.0	2.0	0.0	1.0	21.0	0.0	0.0	3.0	0.0	0.0
320.0	6221.3	0.0	0.0	12.0	15.0	8.0	0.0	10.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	4.0	1.0	0.0
325.0	6406.7	1.0	0.0	15.0	27.0	8.0	0.0	21.0	0.0	0.0	0.0	0.0	27.0	1.0	0.0	10.0	0.0	0.0
329.0	6573.3	0.0	0.0	15.0	21.0	6.0	0.0	19.0	0.0	0.0	0.0	0.0	24.0	0.0	0.0	3.0	0.0	0.0
335.0	6823.3	0.0	0.0	8.0	21.0	4.0	0.0	8.0	1.0	0.0	0.0	0.0	27.0	1.0	0.0	9.0	0.0	0.0
344.0	7198.3	0.0	0.0	5.0	21.0	9.0	0.0	14.0	2.0	0.0	1.0	1.0	17.0	1.0	0.0	5.0	0.0	0.0
354.0	7615.0	0.0	0.0	10.0	11.0	1.0	0.0	9.0	0.0	1.0	1.0	0.0	17.0	0.0	0.0	2.0	0.0	0.0
359.0	7823.3	0.0	0.0	18.0	29.0	4.0	0.0	13.0	0.0	0.0	0.0	0.0	17.0	0.0	0.0	5.0	0.0	1.0
364.0	8031.7	0.0	0.0	28.0	17.0	11.0	0.0	12.0	0.0	0.0	1.0	0.0	19.0	0.0	0.0	16.0	0.0	0.0
369.0	8240.0	0.0	0.0	57.0	29.0	4.0	0.0	28.0	0.0	0.0	0.0	2.0	29.0	0.0	0.0	8.0	0.0	0.0
374.0	8391.8	0.0	0.0	45.0	37.0	9.0	0.0	24.0	0.0	0.0	0.0	1.0	12.0	0.0	0.0	5.0	0.0	0.0
379.0	8543.5	0.0	0.0	49.0	37.0	10.0	0.0	30.0	0.0	1.0	2.0	0.0	30.0	0.0	0.0	8.0	0.0	0.0
384.0	8695.3	0.0	0.0	84.0	42.0	3.0	0.0	16.0	0.0	0.0	0.0	0.0	30.0	0.0	0.0	8.0	0.0	0.0
389.0	8847.1	0.0	0.0	56.0	31.0	8.0	0.0	20.0	1.0	0.0	0.0	2.0	18.0	0.0	0.0	5.0	1.0	0.0
394.0	8998.8	0.0	0.0	104.0	19.0	3.0	0.0	32.0	2.0	1.0	1.0	1.0	65.0	0.0	0.0	8.0	0.0	0.0
399.0	9150.6	0.0	0.0	51.0	35.0	3.0	0.0	24.0	0.0	0.0	2.0	1.0	33.0	0.0	1.0	17.0	0.0	0.0
404.0	9302.4	0.0	0.0	38.0	34.0	5.0	0.0	33.0	0.0	0.0	0.0	0.0	27.0	0.0	0.0	5.0	0.0	0.0
409.0	9454.1	0.0	0.0	21.0	27.0	5.0	0.0	21.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	4.0	0.0	0.0
412.5	9559.3	0.0	0.0	15.0	26.0	7.0	0.0	17.0	0.0	0.0	0.0	0.0	32.0	0.0	0.0	13.0	0.0	0.0
415.0	9632.6	0.0	0.0	1.0	27.0	4.0	0.0	20.0	0.0	0.0	0.0	0.0	16.0	1.0	0.0	0.0	0.0	0.0
420.0	9779.2	0.0	0.0	1.0	37.0	5.0	0.0	22.0	0.0	1.0	0.0	0.0	22.0	0.0	0.0	4.0	0.0	0.0
425.0	9925.8	0.0	0.0	0.0	54.0	1.0	0.0	17.0	0.0	1.0	0.0	0.0	28.0	0.0	0.0	1.0	0.0	0.0
430.0	10072.4	0.0	0.0	0.0	68.0	2.0	0.0	32.0	0.0	2.0	0.0	0.0	37.0	0.0	0.0	1.0	0.0	0.0
435.0	10219.0	0.0	0.0	0.0	45.0	0.0	0.0	38.0	0.0	1.0	0.0	0.0	13.0	0.0	0.0	4.0	0.0	0.0
445.0	10512.2	0.0	0.0	0.0	36.0	3.0	0.0	30.0	0.0	3.0	0.0	0.0	29.0	0.0	1.0	0.0	0.0	0.0
455.0	10805.3	0.0	0.0	0.0	52.0	3.0	0.0	20.0	0.0	0.0	2.0	0.0	13.0	0.0	0.0	1.0	0.0	0.0
458.0	10893.3	0.0	0.0	0.0	43.0	0.0	0.0	7.0	0.0	1.0	0.0	3.0	16.0	0.0	0.0	0.0	0.0	0.0
463.0	11039.9	0.0	0.0	0.0	68.0	1.0	0.0	19.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	1.0	0.0	0.0
468.0	11186.5	0.0	0.0	0.0	52.0	0.0	0.0	19.0	1.0	0.0	0.0	0.0	12.0	0.0	0.0	3.0	0.0	0.0
470.0	11245.1	0.0	0.0	0.0	25.0	0.0	0.0	19.0	0.0	4.0	0.0	0.0	16.0	0.0	0.0	1.0	0.0	0.0
474.0	11362.4	0.0	0.0	0.0	56.0	0.0	0.0	80.0	0.0	11.0	0.0	0.0	24.0	0.0	0.0	13.0	0.0	0.0
478.0	11479.7	0.0	0.0	0.0	51.0	1.0	0.0	54.0	0.0	6.0	0.0	0.0	26.0	0.0	0.0	3.0	0.0	0.0
488.0	11772.8	0.0	0.0	0.0	48.0	0.0	0.0	48.0	0.0	1.0	0.0	0.0	31.0	0.0	0.0	4.0	0.0	0.0
495.5	11992.7	0.0	0.0	0.0	50.0	0.0	0.0	77.0	0.0	0.0	0.0	0.0	16.0	0.0	0.0	8.0	0.0	0.0
497.5	12051.4	0.0	0.0	0.0	83.0	0.0	0.0	138.0	0.0	2.0	0.0	0.0	34.0	0.0	0.0	24.0	0.0	0.0

Depth (cm)	Age (yr BP)	<i>Polemonium</i>	Ranunculaceae	<i>Thalictrum</i>	Rosaceae undiff.	<i>Dryas</i>	<i>Potentilla</i>	<i>Rubus chamaemorus</i>	<i>Sanguisorba canadensis</i>	<i>Rumex</i>	<i>Saxifraga oppositifolia</i>	Tubuliflorae	Umbelliferae	<i>Botrychium undiff.</i>	<i>Botrychium simplex</i>	<i>Equisetum</i>	<i>Lycopodium undiff.</i>	<i>Lycopodium annotinum</i>
0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	1.0
6.2	137.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.4	274.6	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.6	411.9	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
25.0	553.7	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0
29.8	659.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	1.0
39.0	863.7	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	3.0	0.0	0.0	0.0	1.0	0.0	0.0
44.0	974.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	1.0	0.0	1.0
54.0	1195.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
59.0	1306.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
69.0	1528.1	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.0	0.0	0.0	0.0	0.0	0.0
75.0	1661.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0
80.0	1771.8	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
85.0	1882.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0
90.0	1985.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
95.0	2071.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0
100.0	2156.8	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	1.0
105.0	2242.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	1.0	0.0
110.0	2327.9	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
115.0	2413.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	1.0
120.0	2499.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	1.0	0.0	0.0
125.0	2584.5	1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0
135.0	2760.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
140.0	2854.3	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
145.0	2947.8	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
150.0	3041.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	1.0	0.0
155.0	3134.9	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
160.0	3228.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
165.0	3322.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
176.0	3527.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	2.0	1.0	0.0
186.0	3714.8	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
191.0	3808.3	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0
196.0	3901.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0
201.0	3995.4	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
206.0	4088.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
211.0	4182.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	1.0	1.0	1.0
216.0	4275.9	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
221.0	4369.5	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
226.0	4463.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	1.0
231.0	4556.5	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	1.0
236.0	4650.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0
241.0	4743.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0
246.0	4837.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0
251.0	4930.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	2.0	0.0	1.0	0.0	0.0
256.0	5024.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
260.0	5099.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0
265.0	5192.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0
270.0	5286.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
275.0	5379.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	1.0	0.0	0.0
280.0	5473.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
285.0	5566.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0
290.0	5660.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	2.0
295.0	5753.7	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	1.0	0.0	0.0

Depth (cm)	Age (yr BP)	<i>Polemonium</i>	Ranunculaceae	<i>Thalictrum</i>	Rosaceae undiff.	<i>Dryas</i>	<i>Potentilla</i>	<i>Rubus chamaemorus</i>	<i>Sanguisorba canadensis</i>	<i>Rumex</i>	<i>Saxifraga oppositifolia</i>	Tubuliflorae	Umbelliferae	<i>Botrychium undiff.</i>	<i>Botrychium simplex</i>	<i>Equisetum</i>	<i>Lycopodium undiff.</i>	<i>Lycopodium annolinum</i>
300.0	5847.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
305.0	5940.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
310.0	6034.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	5.0
315.0	6127.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
319.0	6202.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
320.0	6221.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
325.0	6406.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0
329.0	6573.3	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
335.0	6823.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0
344.0	7198.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.0	1.0	0.0	0.0	0.0	2.0
354.0	7615.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0
359.0	7823.3	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
364.0	8031.7	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
369.0	8240.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
374.0	8391.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	1.0	0.0	1.0
379.0	8543.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	1.0	0.0	1.0
384.0	8695.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	1.0	0.0	0.0
389.0	8847.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0
394.0	8998.8	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	1.0	0.0	1.0
399.0	9150.6	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	3.0	1.0	0.0	1.0	2.0	0.0	1.0
404.0	9302.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	3.0	0.0	1.0
409.0	9454.1	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	1.0	1.0	2.0	0.0	0.0	5.0	0.0	0.0
412.5	9559.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	3.0	0.0	1.0
415.0	9632.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0
420.0	9779.2	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
425.0	9925.8	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	2.0	0.0	0.0
430.0	10072.4	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
435.0	10219.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
445.0	10512.2	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
455.0	10805.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
458.0	10893.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
463.0	11039.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
468.0	11186.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
470.0	11245.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
474.0	11362.4	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	1.0	0.0	1.0	0.0	0.0
478.0	11479.7	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
488.0	11772.8	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
495.5	11992.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
497.5	12051.4	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0

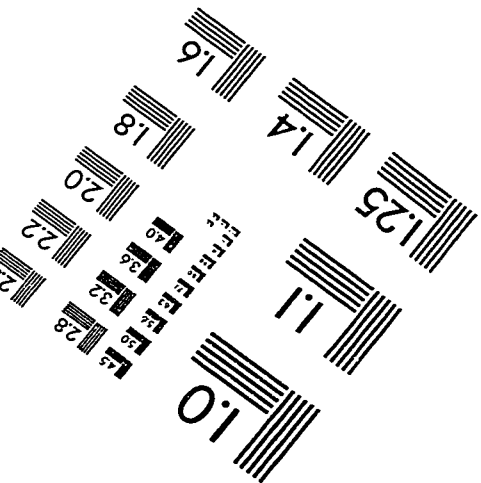
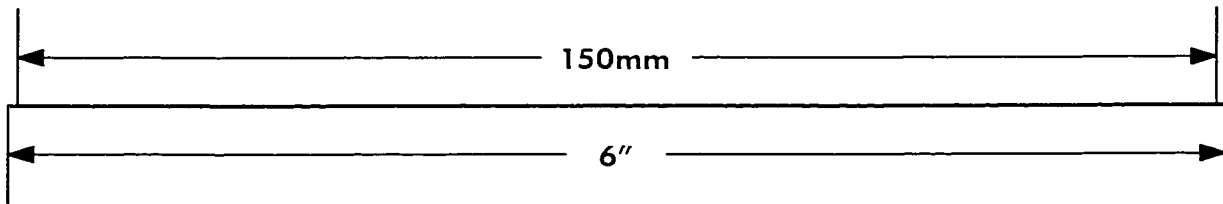
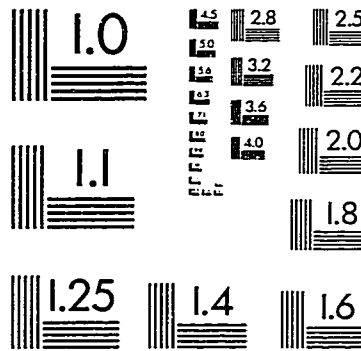
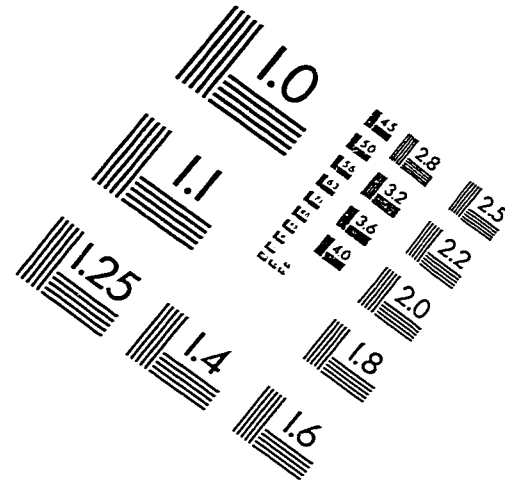
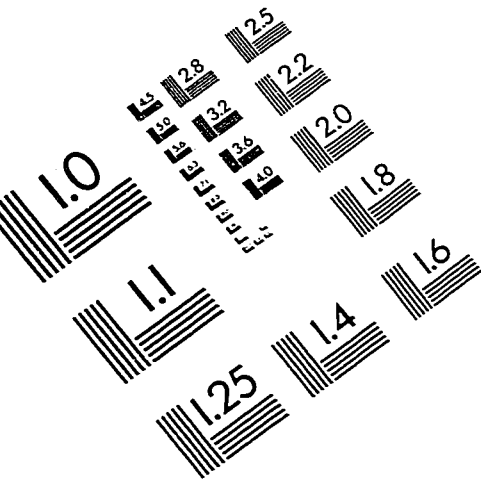
Depth (cm)	Age (yr BP)	<i>Lycopodium clavatum</i>	<i>Lycopodium complanatum</i>	<i>Lycopodium obscurum</i>	<i>Osmunda</i>	Polypodiaceae undiff.	<i>Athyrium filix-femina</i>	<i>Cystopteris bulbifera</i>	<i>Cystopteris fragilis</i>	<i>Dryopteris undiff.</i>	<i>Dryopteris thelypteris</i>	<i>Polypodium</i>	<i>Polystichum</i>	<i>Pteris</i>	<i>Woodsia ilvensis</i>	<i>Selaginella selaginoides</i>	<i>Sphagnum</i>	Trilete spore
0.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.2	137.3	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.4	274.6	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.6	411.9	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.0	553.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29.8	659.1	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39.0	863.7	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44.0	974.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
54.0	1195.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
59.0	1306.7	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
69.0	1528.1	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75.0	1661.0	0.0	1.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80.0	1771.8	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
85.0	1882.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.0
90.0	1985.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
95.0	2071.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100.0	2156.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
105.0	2242.3	0.0	0.0	0.0	0.0	4.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
110.0	2327.9	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
115.0	2413.4	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
120.0	2499.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
125.0	2584.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
135.0	2760.8	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
140.0	2854.3	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
145.0	2947.8	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
150.0	3041.4	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
155.0	3134.9	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
160.0	3228.4	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
165.0	3322.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
176.0	3527.7	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
186.0	3714.8	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
191.0	3808.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
196.0	3901.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
201.0	3995.4	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
206.0	4088.9	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
211.0	4182.4	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
216.0	4275.9	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
221.0	4369.5	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
226.0	4463.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
231.0	4556.5	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
236.0	4650.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
241.0	4743.6	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
246.0	4837.1	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
251.0	4930.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
256.0	5024.1	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
260.0	5099.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
265.0	5192.5	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
270.0	5286.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
275.0	5379.6	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
280.0	5473.1	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
285.0	5566.6	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
290.0	5660.1	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
295.0	5753.7	0.0	0.0	0.0	0.0	3.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Depth (cm)	Age (yr BP)	<i>Lycopodium clavatum</i>	<i>Lycopodium complanatum</i>	<i>Lycopodium obscurum</i>	<i>Osmunda</i>	Polypodiaceae undiff.	<i>Athyrium filix-femina</i>	<i>Cystopteris bulbifera</i>	<i>Cystopteris fragilis</i>	<i>Dryopteris undiff.</i>	<i>Dryopteris thelypteris</i>	<i>Polypodium</i>	<i>Polystichum</i>	<i>Pteris</i>	<i>Woodsia ilvensis</i>	<i>Selaginella selaginoides</i>	<i>Sphagnum</i>	Trilete spore
300.0	5847.2	0.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
305.0	5940.7	0.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
310.0	6034.2	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
315.0	6127.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
319.0	6202.6	0.0	0.0	1.0	0.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
320.0	6221.3	0.0	0.0	0.0	0.0	5.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
325.0	6406.7	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
329.0	6573.3	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
335.0	6823.3	0.0	0.0	1.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
344.0	7198.3	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
354.0	7615.0	0.0	0.0	0.0	0.0	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
359.0	7823.3	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
364.0	8031.7	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
369.0	8240.0	0.0	0.0	0.0	0.0	5.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
374.0	8391.8	0.0	0.0	0.0	0.0	4.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
379.0	8543.5	0.0	0.0	0.0	0.0	9.0	2.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
384.0	8695.3	0.0	0.0	0.0	0.0	4.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
389.0	8847.1	0.0	0.0	0.0	0.0	8.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
394.0	8998.8	0.0	0.0	0.0	0.0	3.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
399.0	9150.6	0.0	0.0	0.0	0.0	6.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
404.0	9302.4	0.0	0.0	0.0	0.0	6.0	2.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
409.0	9454.1	1.0	0.0	0.0	0.0	5.0	3.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
412.5	9559.3	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
415.0	9632.6	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
420.0	9779.2	0.0	0.0	0.0	0.0	4.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
425.0	9925.8	0.0	0.0	0.0	0.0	7.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
430.0	10072.4	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
435.0	10219.0	0.0	0.0	0.0	1.0	5.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
445.0	10512.2	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
455.0	10805.3	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
458.0	10893.3	0.0	0.0	0.0	0.0	7.0	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
463.0	11039.9	0.0	0.0	0.0	0.0	8.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
468.0	11186.5	0.0	0.0	0.0	0.0	11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
470.0	11245.1	0.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
474.0	11362.4	0.0	0.0	0.0	0.0	5.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
478.0	11479.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
488.0	11772.8	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
495.5	11992.7	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
497.5	12051.4	0.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0

Depth (cm)	Age (yr BP)	Menyanthes	Myriophyllum	Potamogeton	Typha	Unidentifiable	Unknown	Pollen sum	Total trees and shrubs	Total non-arboreal pollen	Exotics	Pollen concentration (grains/cm ³)	Deposition time (yr/cm)	Pollen accumulation (grains/cm ² /yr)
0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	543.5	519.5	21.0	1496.0	9809.2	22.1	442.9
6.2	137.3	0.0	0.0	1.0	0.0	2.0	2.0	511.5	467.5	39.0	635.0	21748.8	22.1	982.0
12.4	274.6	0.0	6.0	0.0	0.0	4.0	0.0	514.0	476.0	32.0	493.0	28150.1	22.1	1271.1
18.6	411.9	0.0	3.0	1.0	0.0	7.0	0.0	455.5	403.5	44.0	582.0	21131.4	22.1	954.1
25.0	553.7	0.0	3.0	1.0	0.0	4.0	1.0	509.0	461.0	43.0	785.0	17507.0	22.1	790.5
29.8	659.1	0.0	3.0	1.0	0.0	2.0	1.0	306.5	260.5	40.0	478.0	17312.8	22.1	781.7
39.0	863.7	0.0	9.0	3.0	0.0	2.0	0.0	452.0	404.0	44.0	700.0	17434.3	22.1	787.2
44.0	974.5	0.0	3.0	10.0	0.0	2.0	0.0	480.5	428.5	47.0	566.0	22921.4	22.1	1035.0
54.0	1195.9	0.0	1.0	3.0	0.0	2.0	1.0	379.5	337.5	37.0	323.0	31722.9	22.1	1432.4
59.0	1306.7	0.0	2.0	3.0	0.0	5.0	0.0	451.0	389.0	54.0	398.0	30595.5	22.1	1381.5
69.0	1528.1	0.0	5.0	1.0	0.0	4.0	0.0	460.5	421.5	34.0	471.0	26398.1	22.1	1192.0
75.0	1661.0	0.0	3.0	9.0	0.0	3.0	0.0	347.5	309.5	32.0	291.0	32242.3	22.1	1455.8
80.0	1771.8	0.0	1.0	1.0	0.0	6.0	2.0	498.0	457.0	30.0	333.0	40378.4	22.1	1823.2
85.0	1882.5	0.0	0.0	0.0	0.0	7.0	4.0	527.5	478.5	35.0	521.0	27336.9	21.4	1277.9
90.0	1985.7	0.0	4.0	7.0	0.0	5.0	0.0	501.5	459.5	37.0	419.0	32316.2	18.9	1712.3
95.0	2071.2	0.0	0.0	2.0	0.0	3.0	0.0	482.0	453.0	25.0	399.0	32616.5	17.1	1906.3
100.0	2156.8	0.0	1.0	4.0	0.0	1.0	7.0	368.0	335.0	21.0	289.0	34380.6	17.1	2009.4
105.0	2242.3	0.0	1.0	1.0	0.0	4.0	1.0	502.5	441.5	50.0	326.0	41618.1	17.1	2432.4
110.0	2327.9	0.0	0.0	3.0	1.0	8.0	1.0	439.0	396.0	31.0	359.0	33016.7	17.1	1929.7
115.0	2413.4	0.0	4.0	2.0	0.0	3.0	3.0	515.5	462.5	45.0	406.0	34282.0	17.1	2003.6
120.0	2499.0	0.0	0.0	2.0	0.0	4.0	1.0	504.5	462.5	35.0	342.0	39828.9	17.1	2327.8
125.0	2584.5	0.0	0.0	1.0	0.0	3.0	2.0	389.0	359.0	23.0	274.0	38332.1	17.5	2196.0
135.0	2760.8	0.0	5.0	4.0	0.0	6.0	0.0	518.0	471.0	40.0	338.0	41378.7	18.0	2300.4
140.0	2854.3	0.0	1.0	3.0	0.0	3.0	2.0	561.5	494.5	56.0	257.0	58990.3	18.7	3153.6
145.0	2947.8	0.0	0.0	1.0	0.0	4.0	0.0	464.5	434.5	24.0	423.0	29648.9	18.7	1585.0
150.0	3041.4	0.0	0.0	0.0	0.0	2.0	2.0	477.0	442.0	27.0	426.0	30232.4	18.7	1616.2
155.0	3134.9	0.0	0.0	1.0	0.0	5.0	0.0	501.0	464.0	28.0	255.0	53047.1	18.7	2835.9
160.0	3228.4	0.0	1.0	0.0	0.0	7.0	1.0	499.5	466.5	24.0	229.0	58893.0	18.7	3148.4
165.0	3322.0	0.0	0.0	1.0	0.0	7.0	0.0	506.0	464.0	34.0	281.0	48619.2	18.7	2599.2
176.0	3527.7	0.0	0.0	2.0	0.0	1.0	2.0	503.0	450.0	34.0	412.0	32963.6	18.7	1762.2
186.0	3714.8	0.0	0.0	3.0	0.0	3.0	1.0	500.5	449.5	44.0	198.0	67840.9	18.7	3626.8
191.0	3808.3	0.0	0.0	1.0	0.0	8.0	1.0	657.5	598.5	49.0	362.0	49040.1	18.7	2621.7
196.0	3901.8	0.0	0.0	1.0	0.0	0.0	0.0	502.5	473.5	28.0	218.0	62236.2	18.7	3327.2
201.0	3995.4	0.0	0.0	0.0	0.0	1.0	0.0	503.0	467.0	33.0	278.0	48852.5	18.7	2611.7
206.0	4088.9	0.0	0.0	0.0	0.0	6.0	1.0	502.0	462.0	31.0	204.0	66441.2	18.7	3552.0
211.0	4182.4	0.0	2.0	1.0	0.0	2.0	2.0	539.0	484.0	45.0	217.0	66691.2	18.7	3565.3
216.0	4275.9	0.0	0.0	1.0	0.0	5.0	2.0	518.5	481.5	27.0	342.0	40934.2	18.7	2188.4
221.0	4369.5	0.0	0.0	0.0	0.0	1.0	1.0	459.0	438.0	18.0	224.0	55325.9	18.7	2957.7
226.0	4463.0	0.0	0.0	2.0	0.0	5.0	0.0	520.5	491.5	21.0	237.0	59297.5	18.7	3170.1
231.0	4556.5	0.0	0.0	1.0	0.0	3.0	5.0	506.0	469.0	26.0	184.0	74250.0	18.7	3969.4
236.0	4650.0	0.0	1.0	3.0	0.0	2.0	2.0	501.5	461.5	29.0	248.0	54598.8	18.7	2918.9
241.0	4743.6	0.0	0.0	0.0	0.0	4.0	0.0	524.5	491.5	27.0	272.0	52064.3	18.7	2783.4
246.0	4837.1	0.0	0.0	0.0	0.0	2.0	1.0	503.0	479.0	17.0	297.0	45727.3	18.7	2444.6
251.0	4930.6	0.0	1.0	0.0	0.0	1.0	0.0	634.5	606.5	23.0	141.0	121500.0	18.7	6495.4
256.0	5024.1	0.0	0.0	0.0	0.0	0.0	0.0	506.5	476.5	25.0	262.0	52196.6	18.7	2790.5
260.0	5099.0	0.0	0.0	0.0	0.0	3.0	2.0	515.5	498.5	10.0	117.0	118961.5	18.7	6359.7
265.0	5192.5	0.0	0.0	0.0	0.0	5.0	2.0	408.5	368.5	29.0	339.0	32535.4	18.7	1739.4
270.0	5286.0	0.0	1.0	0.0	0.0	2.0	3.0	505.5	473.5	26.0	197.0	69213.2	18.7	3700.2
275.0	5379.6	0.0	1.0	1.0	0.0	4.0	1.0	525.0	487.0	27.0	227.0	62444.9	18.7	3338.3
280.0	5473.1	0.0	1.0	1.0	0.0	3.0	0.0	508.5	483.5	19.0	151.0	90476.8	18.7	4836.9
285.0	5566.6	0.0	0.0	0.0	0.0	4.0	0.0	522.0	477.0	38.0	303.0	46514.9	18.7	2486.7
290.0	5660.1	0.0	0.0	1.0	0.0	2.0	0.0	506.5	490.5	9.0	153.0	89382.4	18.7	4778.4
295.0	5753.7	0.0	0.0	0.0	0.0	5.0	1.0	524.5	485.5	28.0	178.0	79559.0	18.7	4253.3

Depth (cm)	Age (yr BP)	Menyanthes	Myriophyllum	Potamogeton	Typha	Unidentifiable	Unknown	Pollen sum	Total trees and shrubs	Total non-arboreal pollen	Exotics	Pollen concentration (grains/cm ³)	Deposition time (yr/cm)	Pollen accumulation (grains/cm ² /yr)
300.0	5847.2	0.0	0.0	0.0	0.0	1.0	1.0	508.0	466.0	33.0	247.0	55530.4	18.7	2968.7
305.0	5940.7	0.0	0.0	1.0	0.0	4.0	3.0	511.5	470.5	29.0	224.0	61292.4	18.7	3276.7
310.0	6034.2	0.0	1.0	0.0	0.0	1.0	0.0	507.5	477.5	19.0	237.0	57816.5	18.7	4829.9
315.0	6127.8	0.0	0.0	0.0	0.0	3.0	1.0	273.0	250.0	18.0	81.0	90333.3	18.7	4829.3
319.0	6202.6	0.0	2.0	1.0	0.0	2.0	1.0	545.5	495.5	36.0	193.0	76313.5	18.7	4079.8
320.0	6221.3	0.0	0.0	1.0	0.0	3.0	2.0	514.5	461.5	41.0	198.0	70159.1	34.0	2062.7
325.0	6406.7	0.0	0.0	3.0	0.0	3.0	0.0	485.0	419.0	60.0	205.0	63878.0	39.1	1633.1
329.0	6573.3	0.0	1.0	1.0	0.0	7.0	1.0	498.0	439.0	49.0	236.0	56974.6	41.7	1367.4
335.0	6823.3	0.0	0.0	0.0	0.0	2.0	0.0	511.0	454.0	47.0	202.0	68302.0	41.7	1639.2
344.0	7198.3	0.0	0.0	1.0	0.0	5.0	1.0	404.0	349.0	44.0	257.0	42443.6	41.7	1018.6
354.0	7615.0	0.0	0.0	0.0	0.0	2.0	1.0	508.0	468.0	33.0	134.0	102358.2	41.7	2456.6
359.0	7823.3	0.0	0.0	0.0	0.0	2.0	0.0	506.0	459.0	37.0	187.0	73058.8	41.7	1753.4
364.0	8031.7	0.0	0.0	0.0	0.0	2.0	1.0	406.0	347.0	51.0	167.0	65559.9	41.7	1573.4
369.0	8240.0	0.0	0.0	1.0	0.0	1.0	1.0	652.0	572.0	70.0	223.0	78639.0	36.0	2183.8
374.0	8391.8	0.0	0.0	0.0	0.0	2.0	1.0	549.0	493.0	44.0	206.0	71956.3	30.4	2370.7
379.0	8543.5	0.0	0.0	1.0	0.0	6.0	2.0	495.0	400.0	73.0	289.0	46152.3	30.4	1520.5
384.0	8695.3	0.0	0.0	0.0	0.0	3.0	0.0	520.5	449.5	59.0	185.0	75964.9	30.4	2502.7
389.0	8847.1	0.0	0.0	0.0	0.0	4.0	5.0	515.5	447.5	47.0	188.0	74034.6	30.4	2439.1
394.0	8998.8	0.0	0.0	0.0	0.0	3.0	3.0	580.5	453.5	113.0	167.0	93853.3	30.4	3092.1
399.0	9150.6	0.0	0.0	0.0	0.0	3.0	1.0	507.0	409.0	83.0	258.0	53005.8	30.4	1746.3
404.0	9302.4	0.0	0.0	0.0	0.0	7.0	3.0	502.0	409.0	70.0	336.0	40339.3	30.4	1329.0
409.0	9454.1	1.0	0.0	1.0	0.0	4.0	3.0	511.5	437.5	52.0	196.0	70599.5	30.2	2335.3
412.5	9559.3	0.0	0.0	1.0	0.0	4.0	3.0	532.5	455.5	63.0	146.0	98291.1	29.7	3304.0
415.0	9632.6	0.0	0.0	1.0	0.0	7.0	2.0	520.5	469.5	38.0	328.0	42846.0	29.3	1461.4
420.0	9779.2	0.0	0.0	2.0	0.0	6.0	3.0	505.0	438.0	52.0	324.0	42083.3	29.3	1435.4
425.0	9925.8	0.0	0.0	2.0	0.0	7.0	1.0	490.0	421.0	49.0	671.0	19716.8	29.3	672.5
430.0	10072.4	0.0	0.0	5.0	0.0	6.0	0.0	500.0	414.0	73.0	437.0	30892.4	29.3	1053.7
435.0	10219.0	0.0	0.0	1.0	0.0	5.0	3.0	502.0	431.0	56.0	486.0	27888.9	29.3	951.2
445.0	10512.2	0.0	0.0	1.0	0.0	2.0	3.0	512.0	434.0	68.0	620.0	22296.8	29.3	760.5
455.0	10805.3	0.0	0.0	1.0	0.0	3.0	1.0	508.0	466.0	37.0	134.0	102358.2	29.3	3491.3
458.0	10893.3	0.0	0.0	0.0	0.0	5.0	1.0	506.0	462.0	28.0	203.0	67300.5	29.3	2295.5
463.0	11039.9	0.0	0.0	0.0	0.0	5.0	2.0	528.0	466.0	45.0	233.0	61184.6	29.3	2086.9
468.0	11186.5	0.0	0.0	0.0	0.0	10.0	0.0	511.0	453.0	35.0	208.0	66331.7	29.3	2262.5
470.0	11245.1	0.0	0.0	0.0	0.0	5.0	3.0	526.0	471.0	40.0	236.0	60178.0	29.3	2052.6
474.0	11362.4	0.0	0.0	0.0	0.0	10.0	6.0	515.0	359.0	132.0	1549.0	8976.8	29.3	306.2
478.0	11479.7	0.0	0.0	2.0	0.0	10.0	2.0	374.0	269.0	93.0	2056.0	4911.5	29.3	167.5
488.0	11772.8	0.0	0.0	1.0	0.0	12.0	6.0	276.0	170.0	87.0	1706.0	4368.1	29.3	149.0
495.5	11992.7	0.0	0.0	1.0	0.0	14.0	4.0	283.0	157.0	104.0	1596.0	4787.6	29.3	163.3
497.5	12051.4	0.0	0.0	3.0	0.0	17.0	6.0	503.0	271.0	201.0	2663.0	5099.9	29.3	173.9

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