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A Late Quaternary Pollen Record from Cedarburg Bog, Wisconsin

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Abstract: Late Quaternary (from the last glaciation to present) forest history is inferred from the Cedarburg Bog fossil pollen record. Analysis of fossil pollen samples extend over 4 meters of continuous core recovered from near the center of the bog. The deepest and oldest of the fossil pollen assemblages (ca. 12,000 years ago) suggest open spruce woodlands unlike any in the contemporary boreal ecosystem. Pollen from the Pleistocene-Holocene transition (11,000 years ago) is marked by a number of abrupt changes in forest composition related to rapid climate change, species immigration, and progressive soils and ecosystem maturation. By 9,000 years ago most of the modern forest plant species were established. These mixed deciduous forests persisted until the historical deforestation.

Introduction

Pollen analysis is the primary tool used to measure and describe long-term vegetation change during the late Quaternary. The analysis of sequential samples from lake or bog cores is analogous to sampling vegetation plots over thousands of years (Jacobson, 1988). Pollen analysis has already provided evidence for regional vegetation history of eastern Wisconsin (Winkler et al., 1986; Winkler, 1988; Webb, 1987; Maher, 1982; Baker et al., 1992; Huber and Rapp, 1992). Our objective in this preliminary analysis of fossil pollen, is the establishment of the general chronology and history of vegetation at Cedarburg Bog. Although previous studies have established radiocarbon ages of the Cedarburg Bog sediments spanning the last 12,500 years (Kean and Klebold, 1981), pollen analysis has not been attempted. The preliminary nature of our project will not provide the detail needed to resolve the history of local vegetation communities such as the shrub carr or string bog. It will add to the growing body of evidence of regional vegetation and climate change in eastern Wisconsin.

Methods

A modified Livingstone corer was used to obtain an undistorted, continuous sample of sediments. The core was taken adjacent to the boardwalk on the outermost portion of the end loop. The coring locality is near the center of the string bog community at Cedarburg Bog (Grittinger, 1970; 1984). Core segments were described, labeled, and wrapped for transportation to the UWM Soils and Physical Geography Laboratory. In the lab, 12 volumetric samples of sediment were taken. Sample intervals were irregular. Because changes in deposition often coincide with changes in climate and vegetation, closer interval sampling was done around major sedimentary breaks. Zones of consistent sediments were sampled at large intervals. A modified heavy liquid separation method was used to concentrate fossil pollen (Johnson and Fredlund, 1984). The method includes selective oxidation of carbonates and organic matter plus mechanical separation of pollen from clastic mineral sediments. Isolated pollen residues were then stored in vials. Representative sub-samples of the extraction were next mounted on standard biological microscope slides in a glycerin solution. Cover slips were sealed with paraffin to stabilize material. Pollen slides were counted by standard techniques using light microscopy at 400X magnification, with 1000X used to identify individual grains. Standard references (eg. McAndrews et al., 1973) and modern comparative collections were used to identify pollen grains. A minimum of 300 pollen grains were identified for each sample. Sample counts were converted to relative frequencies (percentages) of the total pollen sum including aquatics and sedges. These percentages were used to construct a standard pollen diagram for the core (Figure 1). Taxa are arranged from left to right, with needle-leaf conifers on the left, followed by deciduous arboreal taxa, and non-arboreal pollen taxa. Because pollen taxa differ in rates of production, modes of dispersal, and rates of preservation, interpretations must be based on the analysis of modern pollen assemblages (Davis, 1963).

Results and Discussion

Total core length recovered was just over 4.3 meters below the water surface at the time of sampling. The upper 34 cm was a brown peat. The peat grades downward into gray-brown organic lake sediments (or gyttja). An abrupt change in sedimentary stratigraphy occurred at 1.8 meters below surface to a gray silty-clay gyttja. This silty-clay gyttja is interrupted by several 10 to 20 cm thick strata of organic gyttja. At 2.7 m below the surface the sediments change abruptly again to a silty clay with little organic matter. This silty clay becomes courser with depth down to outwash sands and gravels at 4.3 m. The

stratigraphy and composition of the sediments suggests that the lower zone (4.3 to 2.7 m) was rapidly deposited in the late Pleistocene, periglacial environment. Deposition shifts abruptly to open standing water (clay-gyttja) deposition (2.7 to 1.8 m). Deposition abruptly switched a second time to slower lake sedimentation (gray-brown organic gyttja). The open water lake deposition (gyttja) grades into a peat forming environment as open water lake gave way to the bog vegetation dominating the coring site today.

Changes in the pollen record extracted from these cores show several major shifts in vegetation (Figure 1). Three primary pollen zones were identified (ages approximate): a) late Pleistocene (12,500 to 11,000 years ago) spruce and non-arboreal pollen (NAP), b) early Holocene (11,000 to 9,000 years ago) birch-pine transition, and c) a mixed deciduous Holocene forest (9,000 years ago to present). Note that the Pleistocene-Holocene transition straddles the sediment change at 2.7 m below surface. Pollen concentration (grains per cm^3) is relatively low below this stratigraphic break, and increases above.

The late Pleistocene zone (2.9 to 4.3 m) is dominated by spruce pollen (30 to 55%). Both white (*Picea glauca*) and black (*P. mariana*) spruce are probably present. The relatively low percentages (< 15 %) of pine (*Pinus*) and oak (*Quercus*) and maple (*Acer*) pollen probably represents long distance transport rather than local populations of these taxa. The relative importance of pollen such as these from long distances is amplified because of low local productivity by the vegetation in the recently deglaciated landscape (Wright 1981). On the other hand, modern pollen studies suggest that even the modest percentages (2 or 3 %) of fir (*Abies*) represent significant local populations. Alder (*Alnus*) pollen within this zone does represent a local population, likely growing along the margins of the wetland. In addition to these important arboreal pollen types, this lowermost zone includes significant percentages of four non-arboreal pollen taxa: ragweed (*Ambrosia*-type), Chen-Am type (Chenopodiaceae and Amaranthaceae families), sedges (Cyperaceae), and wormwood/sage (*Artemisia*). This relatively high complement of NAP types in the late Pleistocene forest is generally regarded as indicative of the open structure of the vegetation. Such open spruce forest, lacking in both pine and birch, is without a modern analogue (Wright 1981). This zone likely spans the period from about 12,500 to 11,000 yrs. B.P.

The Pleistocene-Holocene transitional zone includes that portion of the pollen record adjacent to the major change in sedimentary stratigraphy (2.5 to 2.9 m). Several pollen profiles exhibit spikes or peaks in relative occurrence within this zone including birch (*Betula*), pine (*Pinus*), hophornbeam (*Ostrya*

CEDARBURG BOG, Pollen Percentages

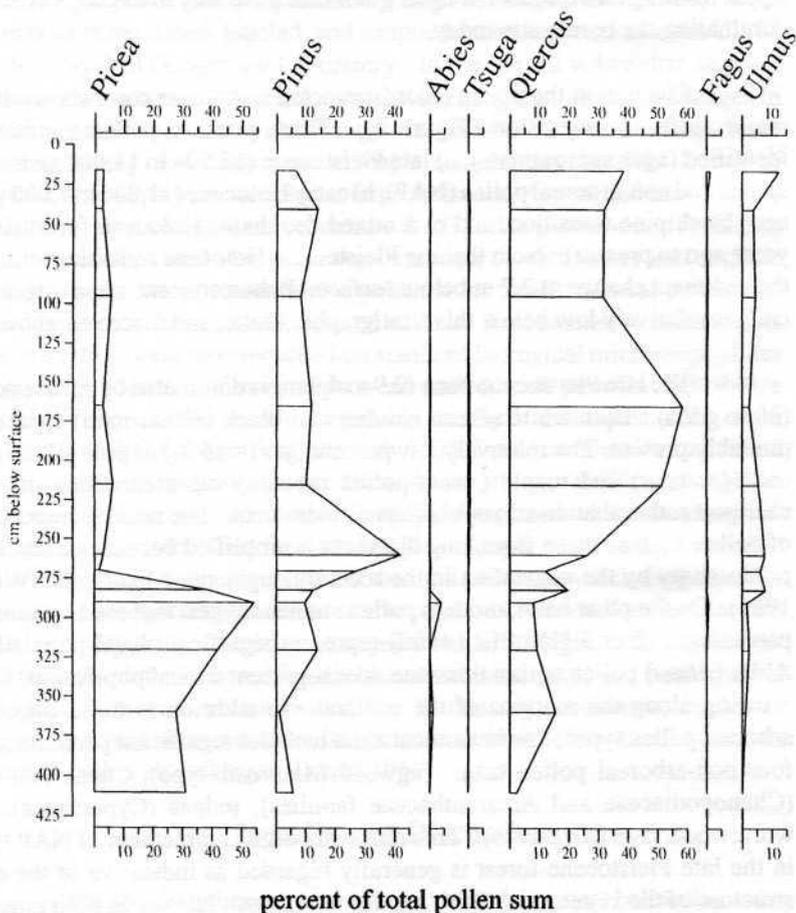
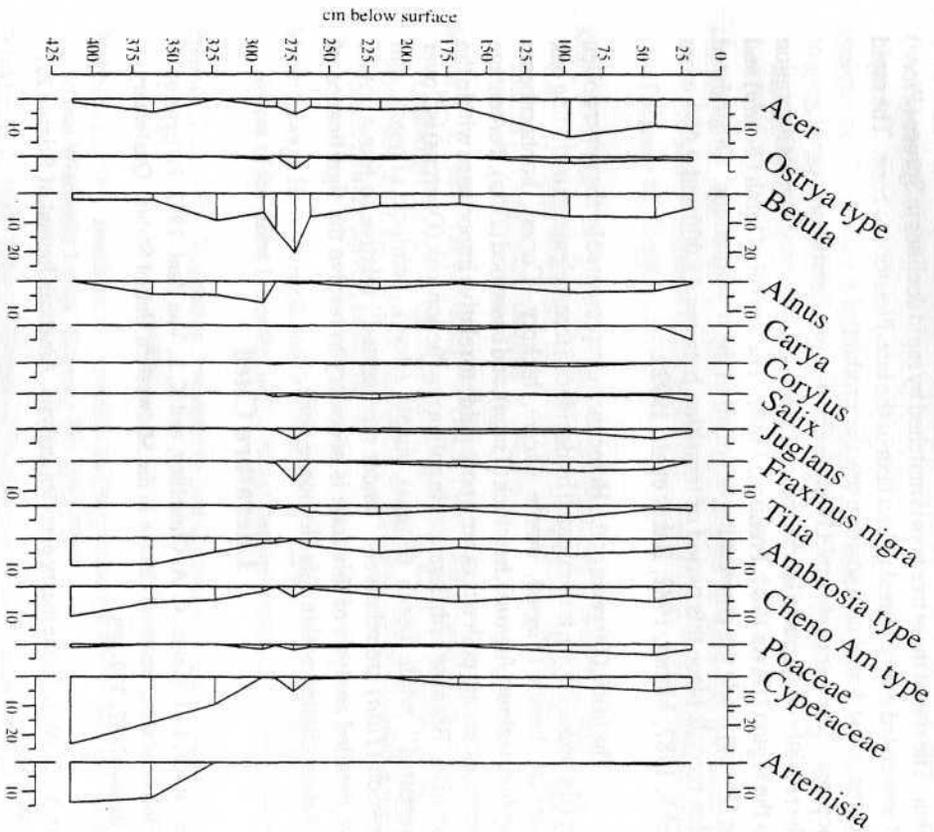


Figure 1. Pollen percentages diagram from Cedarburg Bog. Percentages based on total pollen sum including all arboreal and non-arboreal taxa.



type), and black ash (*Fraxinus nigra* type), which characterized this portion of the fossil record. These peaks likely represent a rapid rise in local populations of these taxa. Also of note is the sharp rise in oak (*Quercus*) and elm (*Ulmus*) pollen. The rise of these tree taxa is matched by rapid declines in Spruce (*Picea*) and associated non-arboreal pollen taxa of the late-Pleistocene zone. The rapid changes in the forest composition are the product of a variety of converging processes. These include rapid climate change, progressive soil development in the recently deglaciated landscape, and successive waves of species migration into the region (Davis 1984; Prentice, 1986). The arrival of birch (*Betula*) and pine (*Pinus*) made the greatest impact of all of the immigrations. Other dated pollen records place this period of transition between 11,000 and 9,000 years (Webb, 1987; Maher, 1982; Baker et al., 1992).

The last 9,000 years of the Holocene, as represented by the upper pollen zone (the upper 2.5 m), is dominated by deciduous forest elements including oak (*Quercus*), beech (*Fagus*), maple (*Acer*), hickory (*Carya*), hophornbeam (*Corylus*), walnut (*Juglans*), hemlock (*Tsuga*), and basswood (*Tilia*). Percentage differences among pollen taxa are a poor guide to relative importance within the vegetation. Because of differences in pollen production, oak (*Quercus*) is "over represented" while beech (*Fagus*), maple (*Acer*), hemlock (*Tsuga*), and basswood (*Tilia*) are relatively "under represented" relative to forest cover. More detailed analysis of this zone is necessary to resolve the significance of vegetation change within this Holocene zone.

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