Post-Glacial Palynology and Paleoecology of the Brewster Lake basin, Barry County, Michigan as Determined by Evaluation of Sediment Cores

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Introduction

Brewster Lake is a small, inland lake of glacial origin located in Baltimore Township of Barry County, Michigan. It has been isolated from any industrial use, agricultural activity or public access since at least 1952. The lake has been classified as a meso-oligotrophic lake and has been the subject of limited research (Pierce, pers. comm.; Cimo and Wolfson, 2001). One earlier study indicated that the lake system may be more highly enriched than previously thought (Cimo and Wolfson, 2001). The study by Honsowitz and Rohrer (2005) mapped the bathymetry of the lake and collected additional water quality data for use in the classification of the trophic status of this lake ecosystem. This study verified the work of Cimo and Wolfson (2001) and resulted in a mesotrophic classification for the lake.

The lake is located entirely within the Pierce Cedar Creek Institute property and is part of a dedicated nature preserve. The general location of the lake is depicted in Figure 1. Pierce Cedar Creek Institute is located on 661 acres of land in Barry County, Michigan. The current makeup of the property is 40% heavy forest cover, 45% wetlands, 13% prairie, upland forest and fields, and 2% lake surface. The lake is a classic kettle lake likely formed by glacial action where a large block of ice from the receding glaciers left a depression in the surface topography. Bathymetric analyses conducted in 2005 showed that the lake consists of two discrete basins with steep sidewalls. It was determined that the deepest areas of each of the two basins would provide the best areas for sampling sediment cores.

Materials and Methods:

Using the bathymetry map developed in 2005, two sampling sites were selected for the collection of deep cores, one in each of the primary lake basins. Sampling sites are identified on the map in Figure 2. Sediment cores of approximately 50 Cm in depth were collected from each of the two basins in May of 2006 using a simplified Livingston piston coring device manufactured at Central Michigan University (APHA, 2001).

Sediment cores were extruded from the coring device and sectioned at 2 Cm depth intervals to form individual samples. Samples were placed in polyethylene bags and put on ice for transport to the Central Michigan University laboratories in Mount Pleasant, Michigan. Samples were kept frozen in the lab until extracted and prepared for pollen analysis.

Sediment cores consisted of a fairly uniform, gray silty marl from 6 to 50 Cm of depth. The top 6 Cm of sediment consisted of a mixture of the gray silt, darker soil particles, decaying plant material of recent origin and shells of mollusks. For this reason, the top 6 Cm of each core was composited into a single surface sample (see Figure 3.). Some additional sediment cores of only the top 10-15 Cm were also collected using a cutaway soil borer attached to a long piece of PVC pipe (also Figure 3.).

Individual samples were washed through a stainless steel sieve with a mesh size of 10um which removed most of the clay and marl from the samples. This process allowed all particles in excess of 10 um to be retained and this consisted of primarily organic matter, including pollen grains. The remaining organic matter was back washed from the sieve into glass flasks and underwent hydrochloric acid digestion in a fume hood for 24 hours. Samples were brought to a neutral pH and aliquots removed for pollen identification and counting using light microscopy. Addition of contrasting stains to aid in sample identification were made as necessary. Figures 4-9 are examples of some of the gymnosperm pollen identified.

Pollen species were identified to the Genus level using Kapp (2000) and counted for each sample. Results were expressed as percentages of the total pollen counts by genus. Quantitative data are summarized in Table 1 and Table 2 for the respective cores.

Results and Discussion:

Studies of the fossil pollen in lake sediments have been made by a number of researchers and palynology (analysis of fossil pollen in lake sediments) has been used to reconstruct the history of plant succession in the lake basin. Shott and Wright (1999) evaluated a number of published papers and described the likely progression of plant succession in the central Great Lakes basin. Their analyses showed that the approach of the Valders ice front into Michigan in the mini-ice age, approximately 12,500 years before present (YBP), and subsequent glacial retreat, resulted the transition from a tundra-prairie ecosystem to a spruce forest about 12,000 YBP.

Andersen's (1954) research into the very early late-glacial sediments from the George Reserve in Livingston County, Michigan, provided definitive evidence of the presence of tundra-like vegetation in southeast lower Michigan about 13,000 to 14,000 YBP. In his oldest samples, herbs, sedges, wormwood and grasses along with ragweed are dominant in the pollen assemblage. Our deepest samples contained a significant percentage of non-arboreal species, but were likely not taken deep enough to capture the early tundra plant material.

Between 12,000 YBP and 10,500 YBP, tree species migrated into Michigan from more southerly zones and forest cover dominated most of the lower peninsula (Shott and Wright date). Spruce (Abies sp.) Fir ecosystems Studies of Wintergreen Lake in southwestern lower Michigan showed various Pinus species displacing the Abies at about 9,800 YBP (Bailey, 1972).

Results of our sampling showed a dominance of Spruce (Abies sp.) in the early post-glacial forests of the Brewster Lake basin. Spruce pollen comprised from 40% to 60% of samples collected at the deepest depths (42-50 Cm) of our sampling.

This was followed in horizontal deposition by an increase in the frequency of pine (Pinus sp.) pollen which eventually overtook the Abies pollen as the dominant genus in samples at higher horizons. From 30 to 40 Cm. Abies pollen comprised 8 to 22% of the pollen counted while Pinus in the southwest basin ranged from 20 to 52% of the pollen identified. Pinus pollen was

less dominant in the north basin core comprising zero to 20% of the pollen at various sampling intervals. We continued to find smatterings of Abies pollen up to the 10 cm depth samples while Pinus was present up to the top of our sample column in both cores.

Evidence of hardwood pollen was all but absent from sediment core samples greater than 30 cm in depth. Oak (Qercus sp.), Ash (Fraxinus sp.) and Birch (Betula sp.) pollen begin to appear at 30 cm of depth and reach maximum abundance between 12 and 20 Cm of sediment depth. Eventually, various hardwoods such as Quercus (oak), Acer (maple) and Fagus (beech) became dominant in higher horizons. These mirror the composition of the mature forests on the property today. The most recently deposited sediments contained significant proportions of Maple (Acer sp.) pollen along with a mixture of other hardwoods (Beech and Oak) and conifers (Pine and Larch).

It should also be noted that Larix (larch or tamarack) pollen was found throughout the sediment cores at a frequency of 5 to 40 percent. Larix was especially dominant in the northern basin core samples at depths ranging from 0-20 Cm. The northern lake basin to this day is ringed by stands of Larix and the genus may have been present in this area for hundreds, if not thousands of years.

We were unable to determine the likely composition of vegetation communities in the earliest post glacial period as we did not find identifiable species of pioneer forbs and shrubs that would have been expected in the early post-glacial. There were a large number of individual miscellaneous species and unidentifiable spores in deep samples and these could have been part of the early vegetative complex. However, because of the dominance of the gymnosperm Abies in our deepest samples, we may not have cored deep enough to catch the earliest sediment horizons in Brewster Lake.

Core samples were not subjected to radiocarbon dating due to the high cost of such analyses and the scope of this project, however, deep sediments from similar marl lakes in Michigan have been dated to 11,000 to 12,000 years before present (Wetzel and Manny, 1978). Detailed geological records of this region accompanied by radiocarbon dating and pollen analyses of nearby lakes from the published literature indicate retreat of ice from this area by the Valders substage (approximately 11,850 to !2,500 years before present) with increased warming and ice-free conditions in this area of Michigan by 9,500 y.b.p. (Frey, 1959; Wayne and Zumberge, 1965)

Discontinuities and overlap of sediment horizons may explain some of the inconsistencies seen in our samples. Older sediments can be interspersed among younger sediments, especially in precipitously sloped basins such as those seen in Brewster Lake (Wetzel and Manny, 1978) due to sloughing and mixing. It is likely that some of this occurred in Brewster Lake. Overall, pollen in the sediment cores from Brewster Lake can be used to reconstruct a classic succession pattern for woody vegetation in the basin. Initial forest cover consisted of a Spruce forest with intermixed Fir and Larch. This was followed by a Pine forest system which also had an abundance of Larch. The mixed coniferous forest was eventually displaced by the hardwoods with some residual specimens of Pine and Larch.

Recommendations for Further Research:

Association of the various sediment core horizons with actual radiocarbon dates would greatly assist in developing and dating the chronology of plant succession in the basin. In future studies it is recommended that sufficient funds be added to allow this analysis.

Presentation and Dissemination of Results:

The student and faculty mentor have prepared this final report on the project for submission to the Pierce Cedar Creek Institute. Results of this study are also being presented by the student researcher at the September 23, 2006 meeting of the PCCI University Research Consortium Board and PCCI board members at the institute.

Results of this study will also be prepared in poster format for presentation at Central Michigan University's "Posters at the Capitol" symposium in April of 2007. This is an annual event in Lansing that showcases undergraduate research projects from CMU. Research projects presented at this poster session are also promoted by CMU's office of information services which sends out press releases and abstracts of research work presented at this session. This event helps to publicize undergraduate research work at CMU and will bring the Pierce Cedar Creek Institute work to the attention of lawmakers and influential agency staff in the state capitol.

Acknowledgements

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References:

American Public Health Association. 2001. Standard Methods for the Examination of Water and Wastewater. AMPH. Washington, D. C. 974pp.

Anderson, D. V. 1961. A note on the morphology of basins of the Great Lakes. J. Fish. Res. Board. Canada. 18:273-277

Anderson, S. 1954. A late-glacial pollen diagram from southern Michigan, U.S.A. Danmarks Geologiske Undersogelse II 80:140-155.

Bailey, Robert E. 1972. Late and post-glacial environmental changes in northestern Indiana. Ph.D. dissertation. Indiana University. Univ. Microfilms Intnl., Ann Arbor MI

Binford, M.W, E.S. Deevey, and T.L. Chrisman. "Paleolimnolgy: An Historical Perspective on Lacustrine Ecosystems." Annual Review of Ecology and Systematics 14 (1983): 255-286.

Craig, Alan J. "Pollen Influx to Laminated Sediments: A Pollen Diagram from Northeastern Minnesota." Ecology, 53:1 (Jan. 1972): 46-57.

Cimo, L. F. and L. G. Wolfson. 2001. Brewster Lake Qualitative Assessment. Report to the Pierce Cedar Creek Institute (unpublished). 11 pp. + appendices.

DeCosta, John and Claude N. Warren. "Paleolimnology and Prehistory." American Antiquity, 32:1 (Jan. 1967): 31-35

Frey, D. G. 1959. The Two Creeks interval in Indiana pollen diagrams. Inves. Indiana Lakes and Streams. 5, 131-139.

Fritz, Sherilyn. "Paleolimnological Records of Climatic Change in North America." Limnology and Oceanography, 41:5 (July 1996): 882-889.

Halsey, John R. and Michael D. Stafford (eds.). 1999. Retrieving Michigan's Buried Past: The Archaeology of the Great Lakes State. Cranbrook Institute of Science, Bulletin # 64. Bloomfield Hills MI

Janssen, C.R., "Recent Pollen Spectra from the Deciduous and Coniferous-Deciduous Forests or Northeastern Minnesota: A Study of Pollen Dispersal." Ecology, 47:5 (Sept. 1966): 804-825.

Kapp, Ronald O. 2000. Pollen and Spores, Second Edition. American Association of Stratigraphic Palynologists Foundation. 279 pp.

Pierce, Gary. 2005. Personal Communication.

Pierce Cedar Creek Institute. 2006. Web site at www.cedarcreekinstitute.org.

Potter, Hon.W.W., History of Barry County. Ventage-ebooks

Shott, M. J. and H. T. Wright. 1999. The Paleo-Indians: Michigan's First People. Pp. 59-70 in Retrieving Michigan's Buried Past: The Archaeology of the Great Lakes State. Cranbrook Inst. Of Science Bulletin # 64. 478 pp.

Swain, Albert M. "Landscape Patterns and Forest History in the Boundary Waters Canoe Area, Minnesota: A Pollen Study from Hug Lake." Ecology, 61:4(Aug. 1980): 747-754.

Wayne, W. J. and J. H. Zumberge. 1965. Pleistocene geology of Indiana and Michigan. In: H. E. Wright and G. Frey (eds.) The Quaternary of the United States. Pp. 63-80. Princeton University Press, Princeton, N.J.

Webb, Thompson III. "Corresponding Patterns of Pollen and Vegetation in Lower Michigan: A Comparison of Quantitative Data." Ecology, 55:1 (Jan. 1974): 17-28.

Wetzel, Robert G. and Bruce A. Manny. 1978. Postglacial rates of sedimentation, nutrient and fossil pigment deposition in a hardwater marl lake of Michigan. Pol. Arch. Hydrobiol. 25(1/2) 453-469.

Attachments:

Tables and figures follow as attachments.

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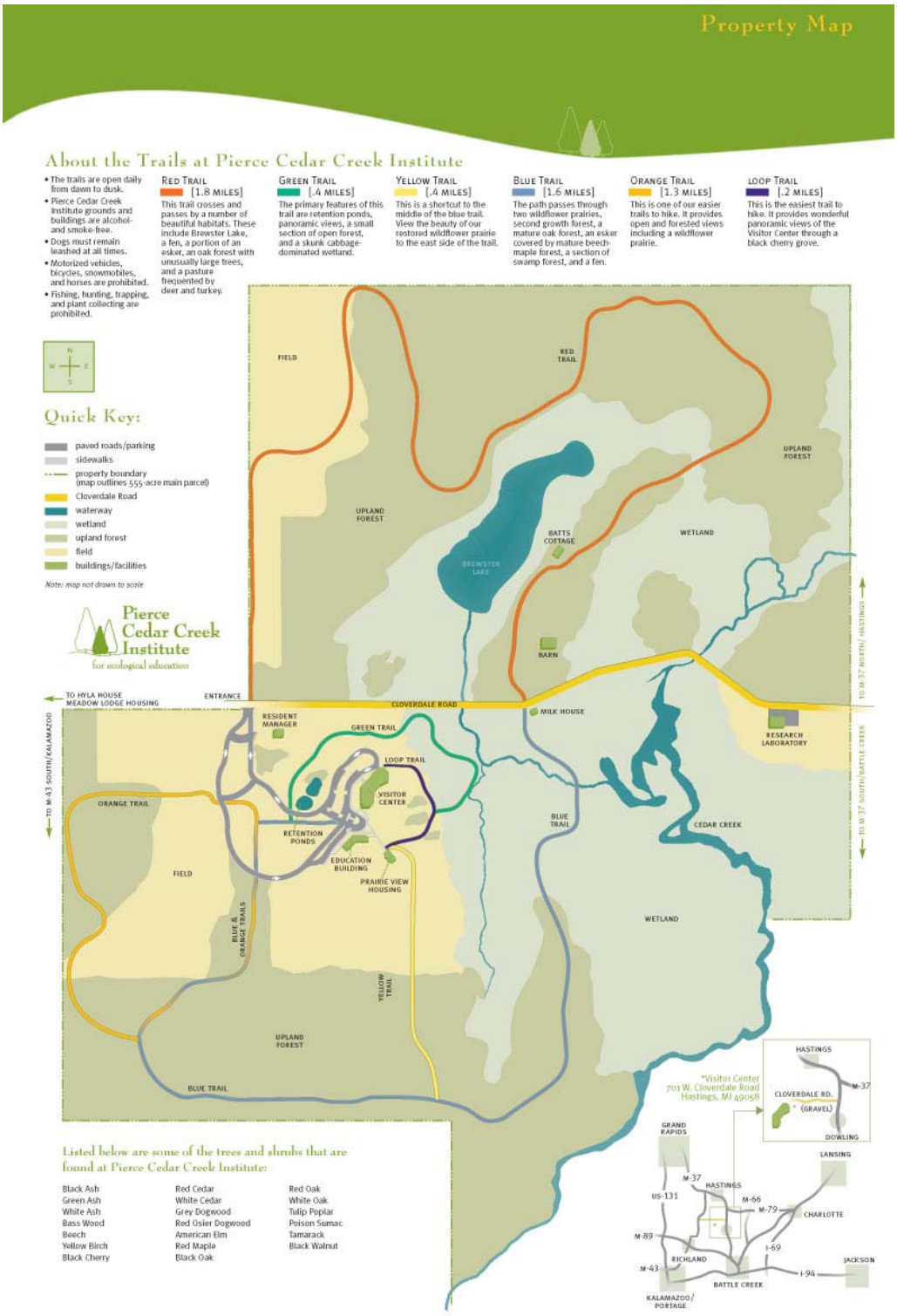

Figure 1. PCCI Map showing location of Brewster Lake

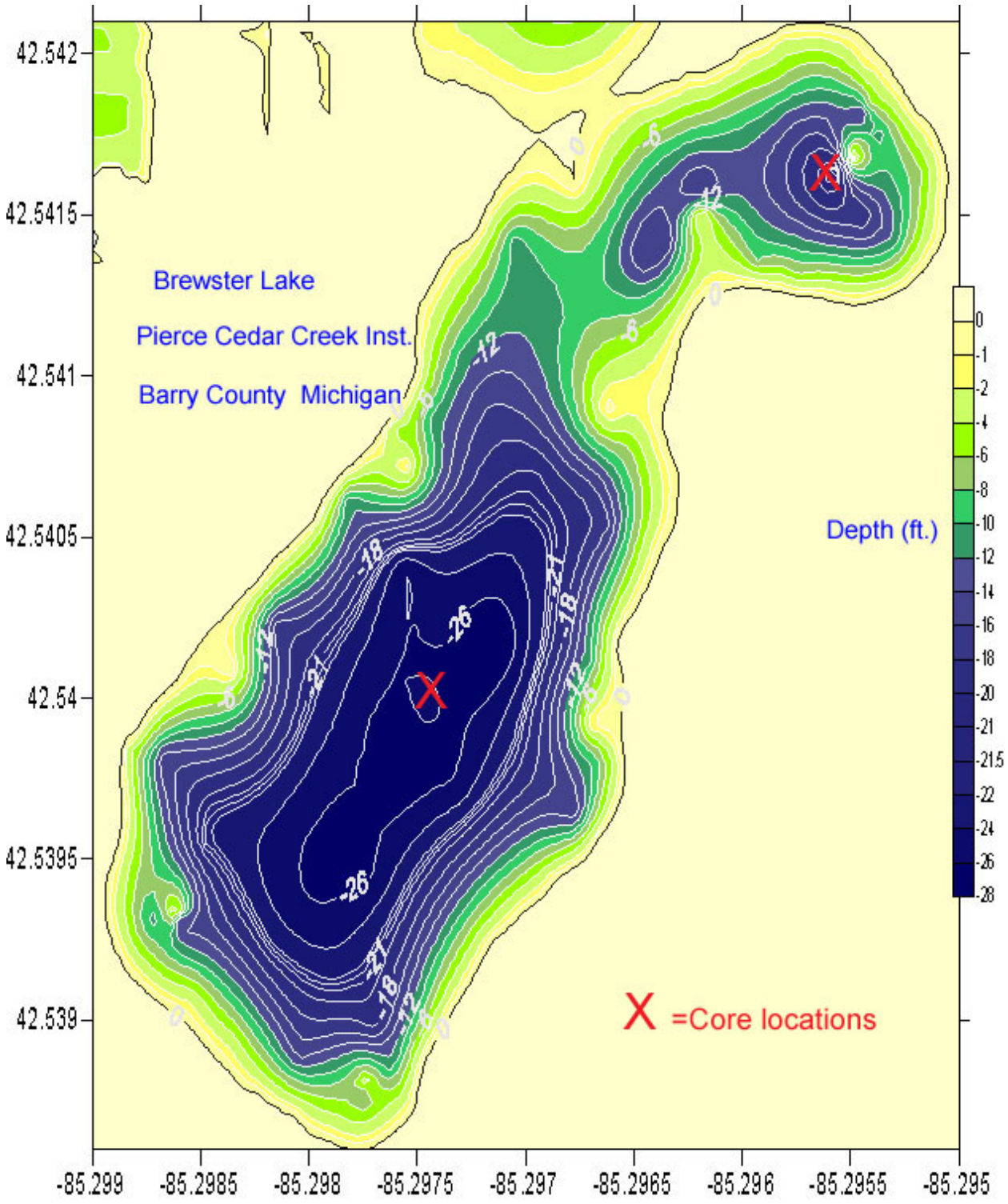

Figure 2. Bathymetric map of Brewster Lake showing the location of sediment core sampling locations (X).

Figure 3. Surficial sediment (0 to 6 Cm) from Brewster Lake core. Note interspersed plant material and mollusk shells.

Figure 4. Example of Abies sp. (Spruce, most likely White Spruce) pollen.

Figure 5. Example of Pinus sp. (Pine) pollen.

Figure 6. Example of Fagus sp. (Beech) pollen.

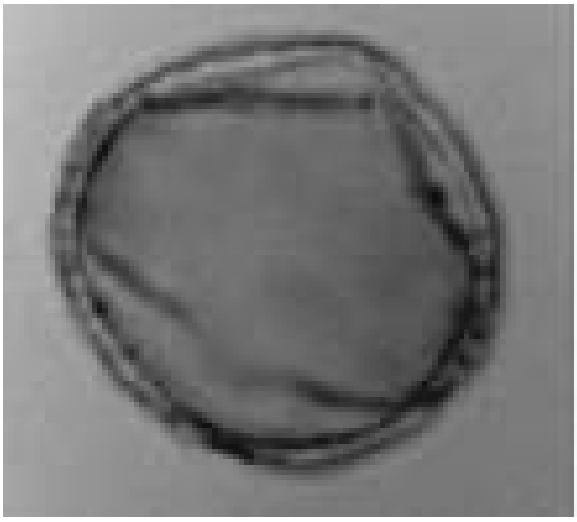

Figure 7. Example of Quercus sp. (Oak) pollen.

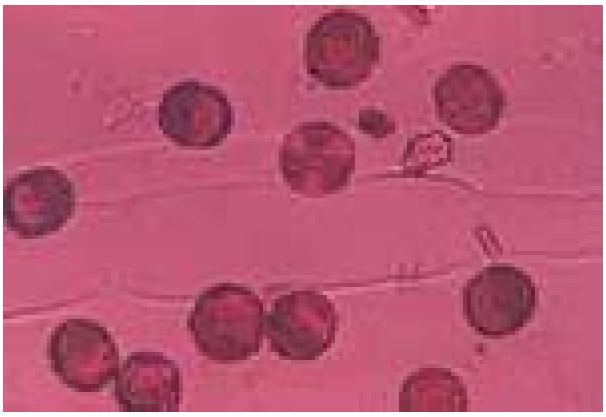

Figure 8. Example of Acer sp. (Maple) pollen.

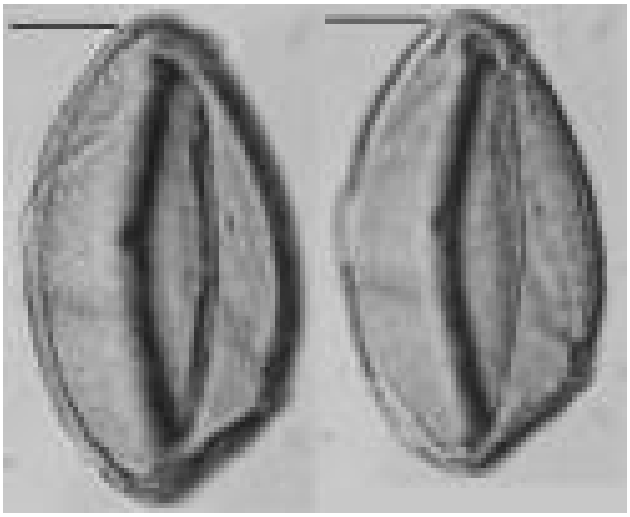

Figure 9. Example of Larix sp. (Larch) pollen

Table 1. Relative Percentages of Pollen Genera at Various Depths – North Core #1

North Basin
Core #1

	Genera %										
	Picea	Pinus	Betula	Abies	Fraxinus	Quercus	Fagus	Larix	Acer	Zea Mays	Misc. & UnID
Surface (0-6cm)	0	12	0	0	10	5	0	10	50	5	8
6-8cm	0	7	5	0	8	5	8	15	40	5	7
8-10cm	0	5	11	5	15	8	10	20	12	10	4
10-12cm	0	15	8	0	10	5	8	15	35	2	2
12-14cm	0	8	12	0	12	28	5	18	22	0	0
14-16cm	5	10	15	0	10	20	0	22	18	0	0
16-18cm	0	30	8	0	5	20	4	20	5	4	4
18-20cm	0	18	5	0	10	17	10	18	0	15	7
20-22cm	8	20	0	0	15	20	17	10	5	5	0
22-24cm	0	17	2	0	5	5	8	5	40	10	8
24-26cm	5	30	0	5	0	0	5	10	32	10	3
26-28cm	10	45	0	2	0	5	0	12	20	0	6
28-30cm	15	42	0	0	0	7	0	10	0	0	26
30-32cm	8	40	0	0	0	0	0	15	5	5	27
32-34cm	15	52	0	0	0	0	0	12	0	0	21
34-36cm	15	40	0	5	0	0	0	18	0	0	22
36-38cm	18	30	0	5	0	0	0	8	0	0	39
38-40cm	20	20	0	15	0	0	0	10	12	0	23
40-42cm	22	5	0	22	0	0	0	12	0	0	39
42-44cm	40	0	0	24	0	0	0	8	0	0	28
44-46cm	55	0	0	0	0	0	0	0	0	0	45
46-48cm	48	0	0	0	0	0	0	5	0	0	47
48-50cm	44	0	0	0	0	0	0	5	0	0	51

Table 2. Relative Percentages of Pollen Genera at Various Depths – Southwest Core #2

Southwest Basin Core #2	**Genera %**										
	Picea	Pinus	Betula	Abies	Fraxinus	Quercus	Fagus	Larix	Acer	Zea Mays	Misc. & UnID
Surface (0-6cm)	0	0	0	0	0	10	12	30	20	0	28
6-8cm	0	8	5	0	10	5	12	35	18	0	7
8-10cm	0	5	14	0	12	0	8	40	21	0	0
10-12cm	5	11	5	8	10	0	0	38	18	5	0
12-14cm	2	15	5	5	5	0	0	32	35	1	0
14-16	5	8	5	4	0	32	4	20	0	12	10
16-18cm	0	10	0	10	0	10	5	30	15	14	6
18-20cm	2	8	0	5	12	40	8	20	0	5	0
20-22cm	5	5	0	5	10	32	10	10	5	10	8
22-24cm	8	28	0	7	5	30	5	5	0	0	12
24-26cm	0	35	0	5	15	25	4	8	0	8	0
26-28cm	5	30	5	0	15	18	4	10	0	10	3
28-30cm	14	28	0	0	12	14	0	0	0	0	32
30-32cm	12	20	15	5	22	10	0	0	0	0	16
32-34cm	8	5	0	0	5	25	10	15	0	0	32
34-36cm	20	0	10	0	15	0	0	35	0	0	20
36-38cm	18	5	5	15	0	0	0	24	0	0	33
38-40cm	25	0	0	15	0	0	0	20	0	0	40
40-42cm	22	0	5	12	0	0	0	18	0	0	43
42-44cm	60	0	0	0	0	0	0	12	0	0	38
44-46cm	70	0	0	0	0	0	0	5	0	0	25
46-48cm	40	0	0	0	0	0	0	0	0	0	60
48-50cm	35	0	0	0	0	0	0	0	0	0	55

Fig.10. Percentages of Pollen Genera Identified at Various Samples Depths

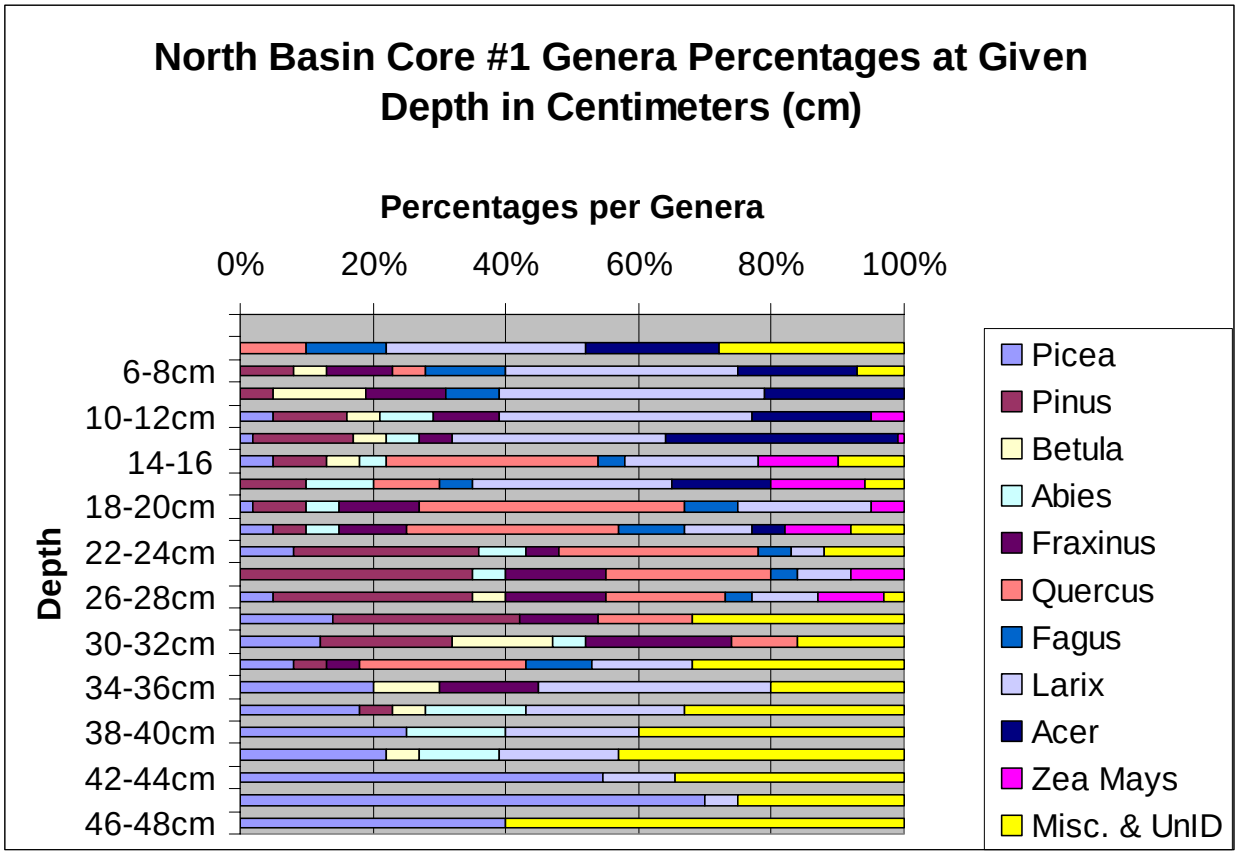

Fig. 11. Percentages of Pollen Genera Identified at Various Samples Depths