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A >130,000-YEAR-LONG POLLEN RECORD FROM PITTSBURG BASIN, ILLINOIS[1]

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ABSTRACT

Pittsburg Basin contains a sediment record extending from the present back to the end of the Late Illinoian glacial period, when central Illinois was covered with *Picea*/*Pinus* forest. During the last interglacial period, a temperate deciduous forest more diverse than Holocene *Quercus*/*Carya* forest replaced the Illinoian late-glacial boreal forest. Prairie pollen types and the charcoal/pollen ratio, indicating fire frequency, temporarily increased. Then forest, with high *Juniperus* percentages, became dominant once more, as the charcoal/pollen ratio dropped. After the last interglacial period, the charcoal/pollen ratio increased again and prairie and wetland surrounded Pittsburg Basin through the entire Wisconsinan glacial period. The area was still prairie in the Late Wisconsinan period, but with some *Picea* and *Pinus*. During the current interglacial period, the region has been a mixture of prairie and *Quercus*/*Carya* forest.

In the last interglacial period, Pittsburg Basin was surrounded by vegetation different from that which has surrounded it during the current interglacial period. Rather than indicating substantial differences in climate between analogous phases of different glacial/interglacial cycles, this variation may be due to changes in fire frequency, which could be caused by small changes in climate or human activity or differences in soil.

Keywords: palynology, charcoal, last interglacial period, Illinoian glacial period, prairie/forest border

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INTRODUCTION

Little is known of early Wisconsinan and pre-Wisconsinan environments in North America east of the Rocky Mountains. In most areas, Wisconsinan glaciers have eroded or buried older peat and lake sediments wherever fossil pollen and other indicators of past environmental conditions might otherwise be found.

In contrast, the Pleistocene record in western and southeastern Europe now includes pollen records that extend back from the present through the last interglacial age and even earlier. These have been correlated with each other, with long marine oxygen-isotope records of global ice volume, and with oxygen-isotope records of precipitation from ice cores from Antarctica. These records generally agree that the last interglacial age was slightly warmer than the Holocene and that it was immediately succeeded by two relatively long and warm interstadial periods early in the last glacial age. Uranium-thorium dates from coral terraces indicate high sea levels (and therefore minimal global ice levels) between 130,000 and 120,000 years ago at the time of the last interglacial age, and two lesser peaks beginning 105,000 and 83,300 years ago, marking the two interstadial periods (Gallup *et al.*, 1994).

Much of what is known of the last interglacial age and the early Wisconsinan in midwestern North America comes from the study of the Sangamon soil. The Sangamon soil is better developed, with a more clay-rich and heavily oxidized B-horizon, than Holocene soils from the same areas (Boardman, 1983). Ruhe (1974) classified the Sangamon soil from Indiana to eastern Nebraska as an ultisol, whose Holocene equivalent is restricted to the forested area south of Indiana. The above evidence implies that, during the period in which the Sangamon soil developed, forest extended farther west into areas that were prairie during the Holocene and that the climate was warmer and wetter. Alternatively, the Sangamon soil may have had longer to develop than the Holocene soil under similar conditions. Curry and Pavich (1997) estimated that the Sangamon soil formed between approximately 155,000 and 55,000 years ago, whereas the Holocene soil only began to form after the glaciers left northern Illinois about 14,000 years ago (Johnson *et al.*, 1997). Unless the second hypothesis can be disproved, the Sangamon soil provides no direct evidence for warmer or wetter climate.

Pittsburg Basin contains a pollen record extending from the present back into the late Illinoian (penultimate) glacial period (Grüger, 1972a). It is the longest nearly continuous pollen record in North America east of the Rocky Mountains. Grüger's (1972a) analysis showed several features that differentiate the Pittsburg Basin record from the long pollen records of Europe. At Pittsburg Basin there are striking differences between the vegetation of the last interglacial period and of the Holocene, and between that of the late Illinoian and the Late Wisconsinan. In some of the last-interglacial sediments, Grüger (1972a) observed high percentages of what he interpreted to be *Taxodium distichum* pollen, although Pittsburg Basin is over 200 km north of *T. distichum*'s modern range limits. There was no indication of interstadial periods in the early part of the last glacial period, unlike the marine record and other long pollen records. Also, *Picea* percentages at Pittsburg Basin in the Late Wisconsinan samples are low compared to those in other midwestern assemblages of that age.

In 1994, new cores were obtained from Pittsburg Basin in order to answer questions raised about the differences between more recent studies of the last glacial/interglacial cycle and Grüger's (1972a) interpretations. Charcoal analysis, modern analog analysis, and new information about prairie vegetation could be used to assist in the interpretation of pollen data. Geiss and Banerjee (1997, 1999) discuss the magnetic stratigraphy of the 1994 Pittsburg Basin cores.

SITE

A continuous record from the Illinoian glacial age to the present was sought from a lake basin on Illinoian till southwest of the terminal moraine of the Late Wisconsinan ice sheet. Pittsburg Basin contained a circular lake 680 m in diameter, 9 km southwest of Vandalia in Fayette County, south-central Illinois (38°N, 89°W, 162 m elev.). It was drained in 1926 for agricultural purposes. It was one of a string of small lakes bounded by ridges of sandy outwash (Jacobs and Lineback, 1969). The pre-homesteading vegetation of the region consisted of species-poor *Quercus*-*Carya* forest along the streams, with prairie on the uplands (Fig. 1).

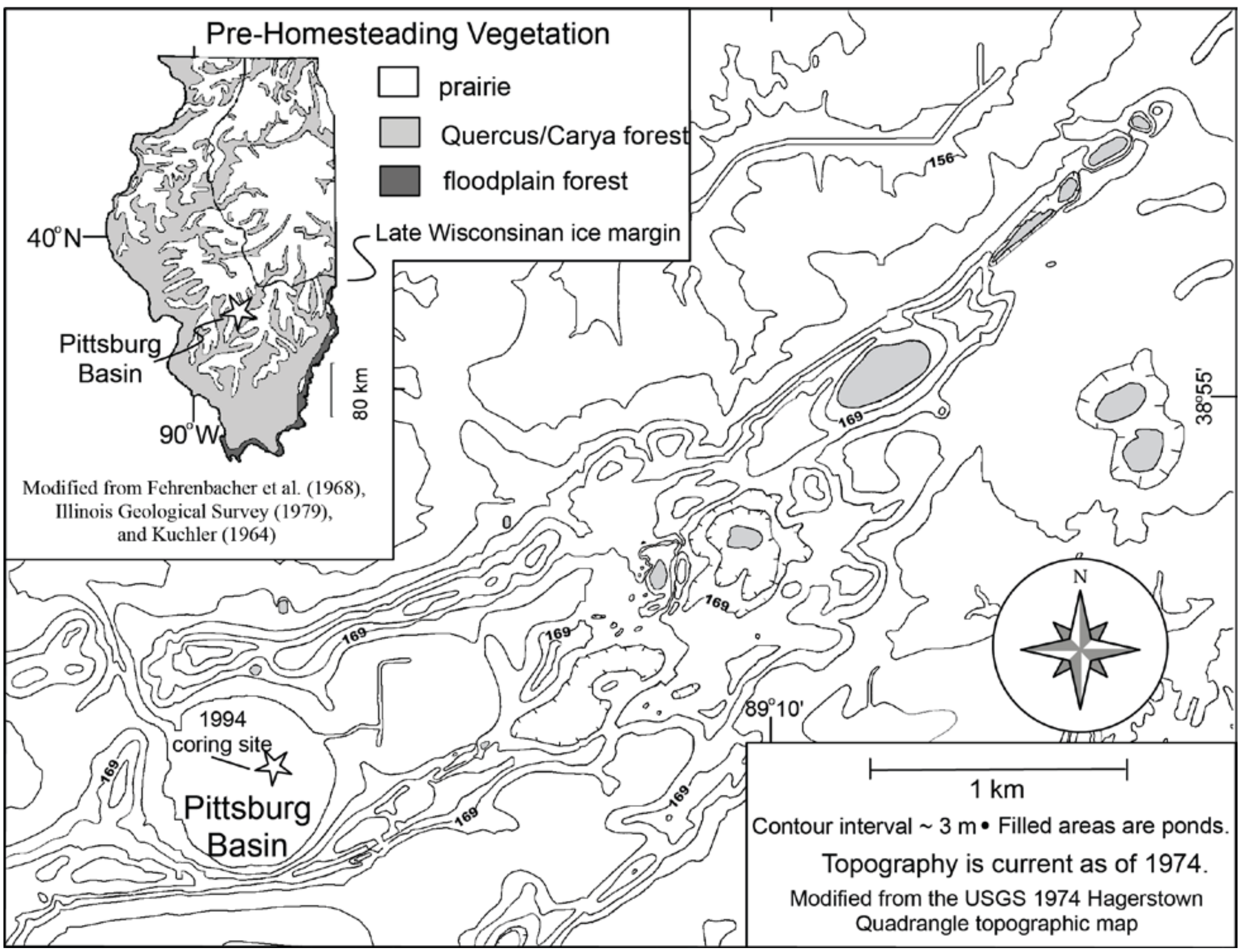

Figure 1: Pittsburg Basin Site Map

METHODS

The analyses described in this paper were made on sediment from several cores taken from within a few meters of one another near the center of Pittsburg Basin in August, 1994, and correlated by visible stratigraphic markers (H. Wright and E. Ito, unpub.). Cores 5C, 5D, and 5G were taken with a modified Livingstone corer (Wright, 1967) driven by a Giddings drill rig. All drives were extruded in the field and wrapped in plastic and aluminum foil. They were brought back to University of Minnesota Limnological Research Center Core Lab and stored at 4^{o} C. Organic matter and calcium carbonate percentages in the sediment were measured by loss-on-ignition (Dean, 1974).

Samples were taken with a 0.5 cm^3 brass tube and prepared for pollen analysis according to the method described by Faegri and Iversen (1975) as modified by Linda Shane (unpublished). A known volume of calibrated *Eucalyptus* pollen suspension was added to each sample so that the concentration of pollen grains could be calculated. Pollen and spores were counted under a light microscope at 400X magnification. At least 300 identified terrestrial grains and spores were counted per sample (the average was 475 grains).

Microscopic fossil charcoal was counted on the pollen slides according to the point-count method of Clark (1982). During pollen processing, macroscopic charcoal fragments (those that did not go through the 180-μm sieve during pollen preparation) were removed from the sample and discarded so only fine charcoal particles were counted. Charcoal was distinguished from opaque minerals by its shape and the presence of cell structure.

The pollen sequence was divided into zones containing similar assemblages for the purpose of description, with psimpoll, a computer program (Bennett, 1994), which uses algorithms from Birks and Gordon (1985). Zonation was based on relative frequencies of pollen taxa that constituted 5% or more of the main sum for at least one sample. Zone boundaries initially defined by eye agreed with those selected by the program using optimal (non-binary) splitting of the information content of the data.

I compared the pollen samples from Pittsburg Basin to the M70 dataset, 520 samples of modern pollen from 47 US states and Canadian provinces provided by the North American Pollen Database (Grimm, 1996) to search for modern analogs for the fossil assemblages from Pittsburg Basin. Another computer program, dissim32.exe (R. Calcote and S. Sugita, unpublished), was used to calculate a dissimilarity coefficient between each modern and each fossil assemblage. The coefficient used was the squared-chord distance between pollen assemblages i and j, equal to

$$d_{ij} = \Sigma_k (p_{ik}^{1/2} - p_{jk}^{1/2})^2$$

in which p_{ik} is the proportion of pollen type k in assemblage i and p_{jk} is the proportion of the same pollen type in assemblage j. According to a study by Overpeck *et al.* (1985), samples from the same vegetation formation have a squared chord distance no greater than 0.15.

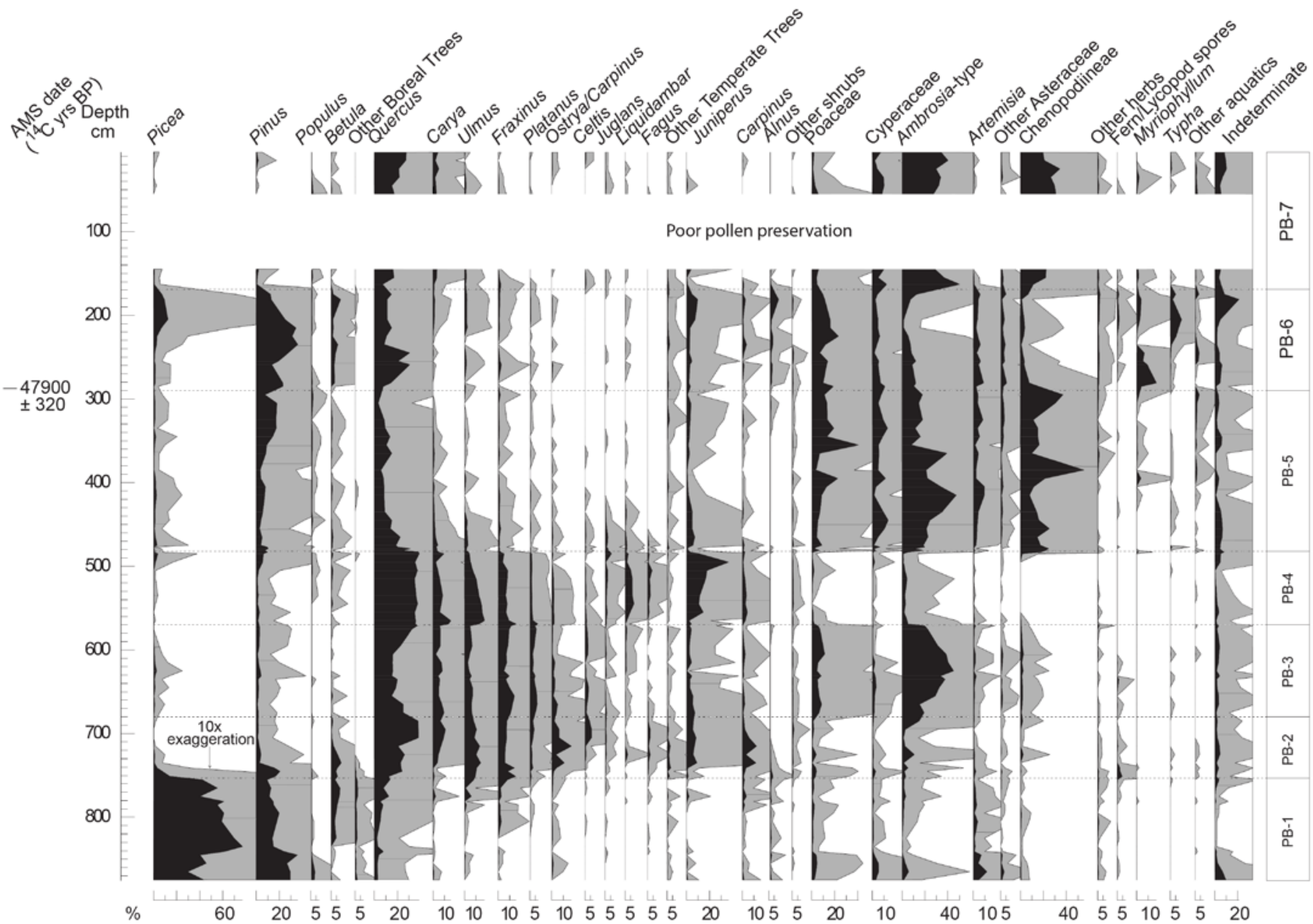

Figure 2: Pollen Percentages from Pittsburg Basin Core 94-5C/D/G

RESULTS

The pollen percentages were divided into seven zones (Fig. 2). Figure 3 shows the pollen concentration by volume for each taxon at each level. Types that do not exceed 2.5% of the identified terrestrial pollen total are lumped together in Figure 2 and are not shown in Figure 3.

The pollen of *Picea* and *Pinus* dominates zone PB-1. Prairie-vegetation types (Poaceae, Cyperaceae, *Ambrosia*-type, *Artemisia*, and other Asteraceae) occur at low percentages in the lower part of the zone, as do *Betula*, *Quercus*, *Ulmus*, and *Fraxinus* in the upper part.

The base of PB-2 is marked by an abrupt decrease of *Picea* and, higher in the zone, of *Pinus*. These are replaced by increases in *Quercus*, *Carya*, *Ulmus*, *Fraxinus*, *Ostrya*/*Carpinus*, and *Corylus*. Small amounts of *Platanus*, *Celtis*, *Juglans*, and *Liquidambar* occur by mid-zone, along with traces of Poaceae, Cyperaceae, *Artemisia*, and Chenopodiineae. Some *Ambrosia*-type pollen also occurs in this zone, and its concentration increases throughout zone PB-2. *Quercus* concentrations decrease at the top of the zone.

Percentages of tree taxa decline (except for the traces of *Picea* and *Pinus*) in PB-3, although none disappears completely. *Ambrosia*-type increases to 40% in mid-zone and then declines (although the concentration does not change in this zone). The percentage of *Quercus* begins to increase above mid-zone. The percentages of Poaceae, Cyperaceae, *Artemisia*, other Asteraceae, and Chenopodiineae are also higher in this zone than in PB-2 or PB-4, but total pollen concentrations are lower.

High percentages and concentrations of *Quercus* pollen mark PB-4. *Ambrosia* concentrations and percentages drop abruptly at the base of PB-4. The percentages and concentrations of *Carya*, *Ulmus,* and *Fraxinus* increase gradually and peak early in this zone and then decline. *Ostrya/Carpinus*-type, *Platanus*, *Celtis*, and *Corylus* behave similarly but have smaller values than during PB-2, whereas *Liquidambar*, *Juglans*, and *Fagus* pollen are present at higher percentages than in PB-2. *Juniperus* pollen is present in greater abundances (absolute and relative) than in PB-2, and it increases to a peak at the end of the zone. The percentage of *Pinus* also rises at the top of the zone.

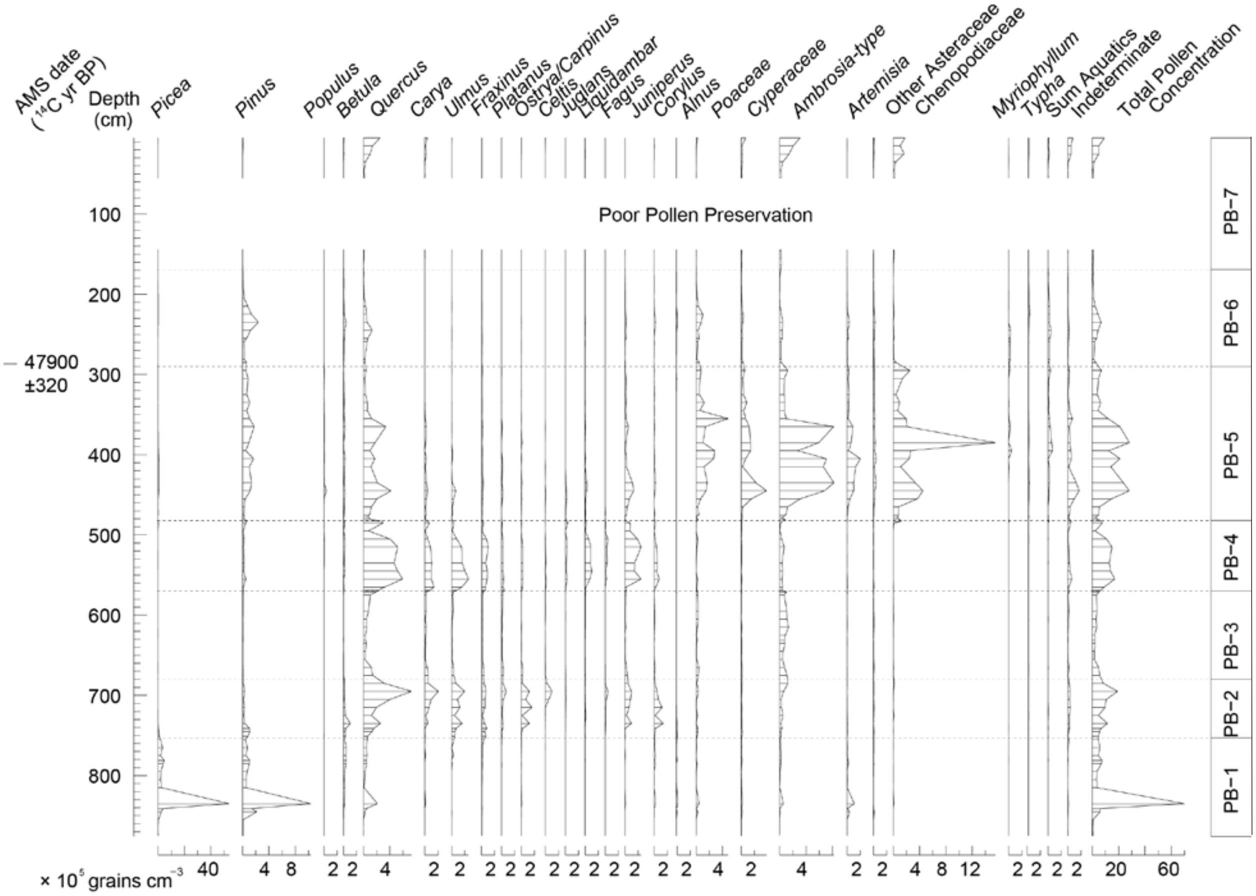

Figure 3: Pollen Concentrations from Pittsburg Basin Core 94-5C/D/G

At the base of PB-5, percentages of all tree taxa decrease gradually. For all pollen types except those mentioned below, concentrations decrease to very low levels, but intermittent grains are found throughout the zone. *Juniperus* and *Picea* recover but are still a low percentage of the total pollen. *Pinus* and *Quercus* are also present throughout the zone. *Pinus* has higher concentrations in PB-5 than in PB-4, but *Quercus* and *Juniperus* have lower concentrations. Percentages and, to a greater extent, concentrations of Poaceae, Cyperaceae, *Ambrosia*-type, Chenopodiineae, *Artemisia*, and other Asteraceae types increase sharply at the beginning of the zone, and remain high. Concentrations of aquatic pollen types are at their peak in PB-5.

In zone PB-6, percentages and concentrations of Chenopodiineae and *Ambrosia*-type decline and the percentages of Poaceae remain high. The concentrations of *Ambrosia*-type and Poaceae decline in the upper part of the zone. Percentages of *Quercus*, then *Pinus*, and finally *Picea* peak and decline. The concentrations of these tree pollen types all peak in mid-zone. *Betula*, *Juniperus, Corylus*, and *Alnus* also occur. Aquatic taxa, particularly *Myriophyllum* (early in PB-6) and *Typha* (in mid-zone), have significant amounts of pollen in this zone.

At the base of PB-7, *Picea* and *Pinus* percentages decline to negligible amounts. *Quercus* percentages remain unchanged, and *Carya* increases to a low level. Percentages of Poaceae, *Artemisia*, other Asteraceae, and the aquatics decline, while those of *Ambrosia*-type, Cyperaceae, and Chenopodiineae increase. Pollen is poorly preserved in the middle of zone PB-7, so the counts for the levels from 65 to 135 cm (which have an average of 32% indeterminate grains per level) are not included in the diagram or in any of the statistical analyses.

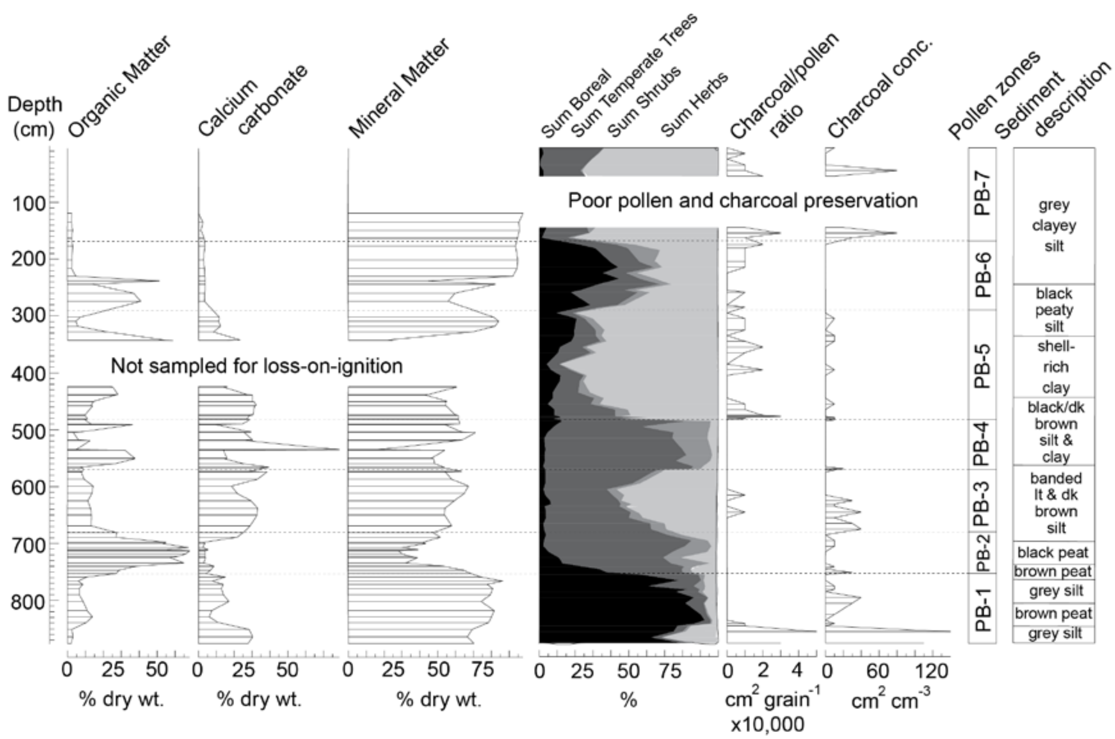

Figure 4: Summary of Stratigraphic Data from Pittsburg Basin Core 94-5C/D/G

Scirpus seeds from 287 cm gave an AMS date of 47,900 ± 320 ^{14}C yr BP (University of Arizona #AA21053), which should be interpreted as a minimum age of at least 40,000 years. More recent levels of the 1994 core contain insufficient macrofossils and charcoal for dating.

Loss-on-ignition (Fig. 4) reveals that organic-matter varies from 2% to 68%. Most levels of the two deciduous-forest zones (PB-2 and PB-4) contain over 30% organic matter. Peaks of over 30% calcium carbonate appear in the lower levels of PB-1 from 850 to 875 cm, in PB-3 from 625 to 675 cm, in PB-4 from 570 to 600 cm, and in PB-5 from 440 to 540 cm. Below 400 cm, mineral matter ranges from 50 to 70% of the sediment dry weight. Above 400 cm, mineral matter is generally 80-90% of dry weight.

The charcoal/pollen ratio is the best overall measure for fire frequency throughout this record because it should not be affected by changes in the sedimentation rate (Fig. 4). The greatest amounts of charcoal relative to pollen are in pollen zones PB-1, PB-5, and PB-7, though the last may be partly due to preservation bias, as charcoal was probably better preserved than pollen. Charcoal/pollen ratios are intermediate in PB-3 and PB-6. The lowest charcoal/pollen ratios are in pollen zones PB-2 and PB-4. Lithology is also shown on Figure 4.

In the Pittsburg Basin 1994 core, there are good modern analogs (squared-chord distance < 0.15) only for samples from PB-1 (835-781 cm) and from upper PB-5 and PB-6 (405-175 cm). The depths of the eleven fossil samples that have good modern analogs and the locations of those analogs are given in Table 1 and Figure 5. The best analog for many samples in PB-1 is Riley Lake, Ontario, which is dominated by *Picea* today and is located on the southern shore of Hudson Bay, just south of the tree line approximately 1600 km north of Pittsburg Basin (McAndrews *et al.*, 1982). The best modern analogs for PB-5 samples are Cottonwood Lake, Minnesota (Almquist-Jacobson *et al.*, 1992), and Clear Lake, Iowa (Baker *et al*., 1992). Clear Lake is situated in tall-grass prairie, with some trees growing at the lake margin. The best modern analogs for samples in PB-6 are Cottonwood Lake, South Dakota, and Upper Graven Lake, in west-central Minnesota in a prairie enclave, with stands of *Quercus macrocarpa* and *Populus tremuloides* near the lake from which the modern sample was taken.

Depth (cm)	Analog	Squared Chord Distance	Lat. (N)	Long. (W)
835	Riley Lake, Ontario	0.130	54° 18' 20"	84° 33' 30"
825	Riley Lake, Ontario	0.090	54° 18' 20"	84° 33' 30"
781	Riley Lake, Ontario	0.120	54° 18' 20"	84° 33' 30"
405	Cottonwood Lake, MN	0.131	45° 45' 40"	96° 01' 00"
365	Clear Lake, Iowa	0.133	43° 09' 00"	93° 21' 00"
345	Upper Graven Lake, MN	0.148	46° 11' 04"	95° 18' 25"
325	Upper Graven Lake, MN	0.135	46° 11' 04"	95° 18' 25"
305	Cottonwood Lake, SD	0.135	45° 30' 00"	97° 19' 48"
295	Cottonwood Lake, SD	0.112	45° 30' 00"	97° 19' 48"
281	Upper Graven Lake, MN	0.145	46° 11' 04"	95° 18' 25"
255	Upper Graven Lake, MN	0.116	46° 11' 04"	95° 18' 25"

Table 1: Best Modern Analogs For Pittsburg Basin Pollen Samples

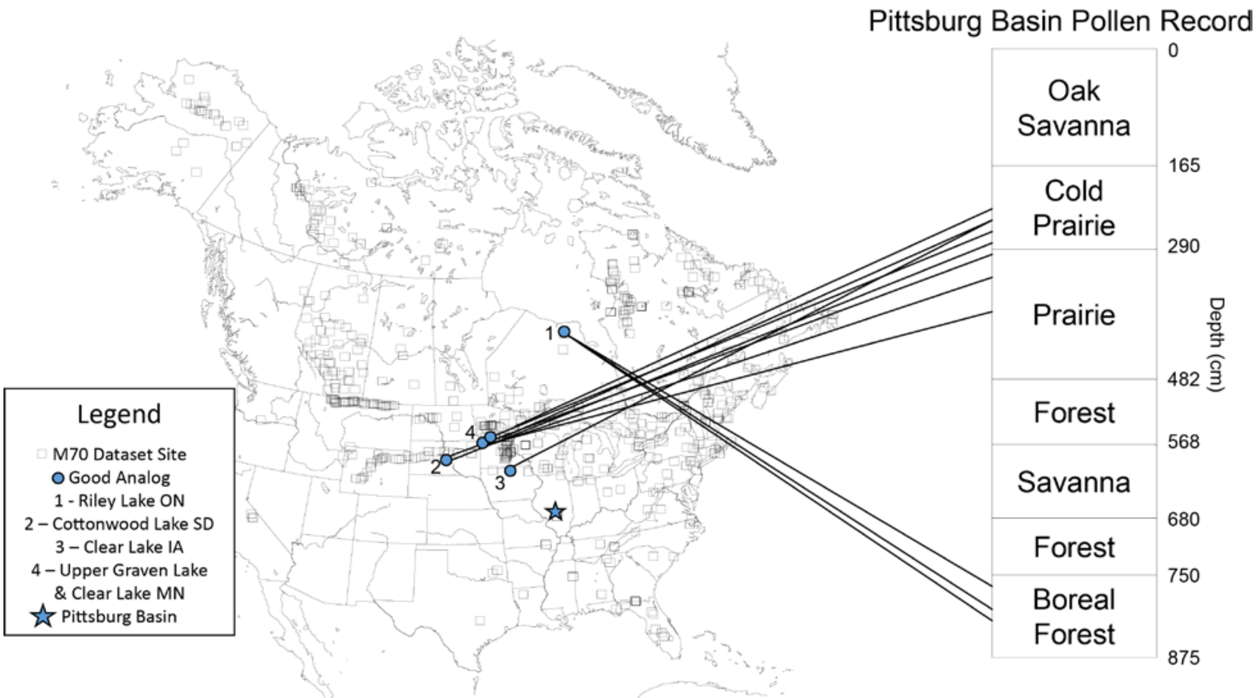

Figure 5: Good Modern Analogs for Pittsburg Basin Pollen Assemblages

DISCUSSION

Pollen zone PB-1 is assigned to the end of the late-Illinoian glacial period by definition, not by correlation, because the PB-1 pollen assemblages were extracted from type Illinoian sediments, which consist of outwash from the retreating late-Illinoian glacier. The *Picea-Pinus* forest assemblage indicates a cold, boreal climate. Fire frequency was high early in this period, but decreased towards the end.

Zones PB-2, PB-3, and PB-4 represent a period at least as warm and as wet as the present in central Illinois, presumably the last interglacial. Zones PB-2 and PB-4 are dominated by temperate deciduous forest, but more diverse in composition than the Holocene *Quercus-Carya* forests in Illinois. The last-interglacial forest contained trees that currently do not grow so far west, e.g. *Fagus*, or that are now rare in Illinois, such as *Liquidambar*. Hardwoods such as *Ulmus*, *Fraxinus*, *Ostrya*, and others that are now minor components of Illinois forests were more common. Prairie near Pittsburg Basin contributed the small amounts of prairie pollen to the assemblages of PB-2 and PB-4. However, the charcoal/pollen ratio for these levels is virtually zero, so fires were small or rare. A third biome is represented in the pollen assemblages, a savanna, intermediate between prairie and forest, with *Quercus* and *Juniperus*.

Taxodium-type pollen is rare in the 1994 core, and no other floodplain forest types (*Nyssa* and *Gleditsia*) are in the last-interglacial assemblages except for low percentages that can be accounted for by long-distance transport. The *Juniperus* curve from this study follows the same pattern as the *Taxodium*-type curve of Grüger (1972a), who rejected the possible presence of *Juniperus* pollen on the grounds that all *Juniperus* species grow only in dry, open places. But *Juniperus virginiana* occurs at the prairie-forest boundary as part of the savanna vegetation in areas protected from burning (Blewett, 1986). *Juniperus virginiana* is a shade-intolerant upland shrub that grows at the edges of woods near Pittsburg Basin today, whereas *Taxodium distichum* is a tree now restricted to floodplain forests in the southeastern US, 200 km and more south of Pittsburg Basin. Many *Taxodium*-type grains have a papilla. Almost none of the fossil Taxodiaceae-Cuprussaceae-Taxaceae-type (the group that includes both *Taxodium* and *Juniperus* pollen) grains that I examined from core PB-75 or PB-94-5D has a papilla. So there is no indication in the 1994 record of southern floodplain forest extending into central Illinois.

PB-3 was deposited during a mid-interglacial prairie period, similar to that observed in the mid-Holocene in Iowa (Baker *et al.*, 1992). Prairie covered a greater proportion of the region contributing pollen to Pittsburg Basin than during PB-2 and PB-4, but forest was still present. Percentages of hardwood pollen types decreased only slightly, and types from trees that usually produce relatively little pollen are still almost continuously present throughout PB-3. Regional fire frequency was higher when this zone was deposited than during the forest periods on either side of it.

PB-2 has slightly higher percentages of *Ostrya*, *Celtis*, and *Corylus* than PB-4, which has somewhat higher percentages of *Juglans*, *Liquidambar*, and *Fagus* and much higher percentages of *Juniperus*. This slight disparity between the pollen assemblages in PB-2 and PB-4, respectively the beginning and the end of the last interglacial period, may be due to higher mean annual temperature or precipitation for PB-4 or to changes in seasonal variation in temperature or moisture availability. Another possible explanation is that progressive soil development during the last interglacial might have favored a slightly different set of tree taxa during PB-4 than during PB-2. Assuming no hiatus between PB-1 and PB-2, the trees in PB-2 became established in soil that had developed under closed *Picea* forest, which typically consists of an acidic litter layer with very little organic soil beneath it. Early in PB-2, that acidic litter layer would have been broken down and neutralized under the deciduous forest. Assuming a developmental sequence typical of soils on glacial deposits in the midwestern U.S., early in the last interglacial period before PB-3 was deposited, alfisols, characteristic of modern temperate deciduous forests, would have been widespread in central Illinois. During PB-3, the parts of the landscape dominated by prairie would have developed mollisols, which are richer in organic matter than alfisols and have a greater capacity to retain water and nutrients. Mollisols could have been fully developed in just over 500 years, according to the rates of organic-matter accumulation calculated by Dahlman and Kucera (1965). When trees invaded the prairie at the beginning of the second forest period (PB-4), taxa that prefer wetter, more fertile soils may have been favored.

The lack of modern analogs for the last-interglacial levels may be due to the small number of assemblages from the rich deciduous forests of the southeastern US in the M70 set of surface pollen assemblages. But this seems unlikely, as the last-interglacial forest was near the edge of a vast prairie, unlike those in the southeastern U.S. The pollen of a number of tree taxa typical of the southeast, such as *Taxodium*, *Castanea*, and *Nyssa*, is missing completely. Another problem is likely to be the small number of potential modern analogs in Illinois in the

North American Pollen Database's M70 dataset.

Zone PB-5 probably represents the early part of the last (Wisconsinan) glacial period. The climate was drier than previously, but the pollen gives no indication that it was colder. The modern analogs for PB-5 (and PB-6) are tall-grass prairie areas, not tundra. The lake itself was partly replaced by marsh. Grüger (1972a) found substantial numbers of Cyperaceae (*Scirpus*) and Chenopodiineae (*Chenopodium rubrum*) macrofossils in the levels of the 1969 core that correlate with PB-5. Most of the trees were eliminated and the entire region became prairie. The charcoal/pollen ratio is much higher in zone PB-5 than in any of the preceding zones, indicating that fires were more common in the region than they had been at any previous time.

Total pollen concentration decreases between 380 cm and 345 cm. The increased percentage of mineral matter in the sediment above 340 cm implies an increase in clastic input into the lake, which would dilute pollen influx, resulting in low pollen concentrations in PB-6 and the upper levels of PB-5. The higher percentages of indeterminable grains in PB-5, PB-6, and PB-7 indicate that oxidation, possibly caused by changes in the water level after agricultural drainage, has also decreased pollen concentrations in those zones.

Interstadial signals, usually two of them, especially in European pollen sequences, occur at the beginning of the last glacial period in almost every other long record, but there is no indication of any amelioration of climate at Pittsburg Basin during this period. However, the sites with long records indicate interstadial episodes early in the last glacial period are not as far inland as Pittsburg Basin. Behre (1989) observed that the signal of the early last-glacial interstadial periods grows weaker as one examines European records from farther inland. Alternatively, the climate in central Illinois may have become warmer, but not wetter, or at least not wet enough to decrease fire frequency and allow trees to return, and the changes are not visible in the pollen record.

The climate when zone PB-6 was deposited appears to have been slightly colder than that for PB-5. The modern analogs are found slightly farther north than those for PB-5 are. PB-6 includes the Late Wisconsinan glacial maximum, as indicated by correlation with Grüger's (1972a) record, with many radiocarbon dates at those levels. According to the AMS date from 287 cm, the base of PB-6 is older than 40,000 ^{14}C yr BP. Assuming that the onset of loess deposition in the Midwest was a response to the cooling represented by this zone, the base is about 50,000 years old (Curry and Follmer, 1992). Increased soil moisture, resulting from the cooler climate and reduced evaporation, caused the frequency of fire to decrease slightly and allowed *Quercus* to expand in the area.

Pinus and *Picea* replaced *Quercus* as the climate continued to cool. However, high percentages of prairie types indicate that the area around Pittsburg Basin was still mostly prairie. Most late-glacial records from central Illinois (*i.e.* Grüger, 1972b; Zhu and Baker, 1995) have levels with over 40% *Picea* dating from the Late Wisconsinan, but Pittsburg Basin shows prairie throughout. The other records with high *Picea* concentrations have substantial percentages of shade-intolerant prairie types in the same levels, particularly *Artemisia* and Chenopodiineae, presumably from plants growing in prairie patches between fire-intolerant *Picea* stands. Pittsburg Basin may have been part of one such patch.

Myriophyllum pollen peaks imply that the lake was disturbed during PB-6. In modern lakes, human disturbance of the sediments often causes *Myriophyllum spicatum* populations to increase in density (Smith and Barko, 1990). The pollen in PB-6 almost certainly came from the North American native *Myriophyllum exalbescens*, which closely resembles *M. spicatum* and may be a subspecies of *M. spicatum* (Aiken *et al.*, 1979). Disturbance could have taken a variety of forms in a late-glacial lake, including changes in lake level or erosion of the shore.

Zone PB-7 was deposited during the Holocene interglacial period. *Quercus*, *Carya*, and prairie taxa dominate the pollen assemblages and the landscape. There is no evidence of a settlement horizon (an *Ambrosia* peak and a reduction in *Quercus* and *Carya*), but the top 30 cm of Pittsburg Basin was plowed, mixing the pollen in the sediment. Poor pollen preservation and some degradation of charcoal characterizes mid-PB-7. Surface soil began to form when the lake was drained in 1926. The result is a gap in the 1994 pollen record from 135 to 65 cm. Durable and easily recognized pollen types such as Chenopodiineae and *Ambrosia* were more likely to be identified in those levels than other types. Grüger (1972a) also noted poor pollen preservation in the uppermost levels, even though his samples had been taken 25 years earlier. However, the transition from PB-6 to PB-7 does indicate a change in vegetation and climate from boreal to temperate. *Quercus*, *Carya*, and prairie plants were present, although the relative densities of the plant types that produced the pollen probably cannot be determined. Deterioration of the pollen record in PB-7 is probably one reason why no modern analog was found for any of the samples in PB-7.

The two late-glacial periods are characterized by different vegetation, as are the two interglacial periods. Local variation in fire frequency is thought to have maintained the mosaic of prairie and savanna vegetation that was typical of central Illinois before homesteading (Grimm, 1984; Daubenmire, 1936). Fire frequency seems to be higher in PB-6 and in PB-7 than during the corresponding zones of the previous glacial/interglacial cycle. Changes in soil drainage or climate resulting in droughts every few years or an increase in ignition probability (because of human settlement in the Americas at the end of the last glacial period) could have pushed the prairie/forest border a few km to the east. Vegetation around Pittsburg Basin, which was near the edge of the prairie/forest border before homesteading, would have been dramatically affected.

PB-1 and PB-6 do not reflect a major difference in regional vegetation (which implies a difference in climate) between the late Illinoian and the late Wisconsinan glacial periods. They show movement (perhaps only a few km) of the boundary between two ecosystems: boreal forest and northern prairie, which themselves have changed little if at all. This movement could be due to a number of factors, including small differences in climate. The same argument could be made for PB-2-4 and PB-7, of the last interglacial and Holocene interglacial periods, but in that case, there are also changes in the forest elements of the assemblages. The last-interglacial forests are more diverse; because hardwood types other than *Quercus* and *Carya* have higher percentages. Since the deciduous forests themselves rarely burn, changes in frequency and extent of fires are not enough to explain the difference. Presumably central Illinois was slightly warmer and wetter during the last interglacial period than during the current one, but without modern analogs for the last-interglacial assemblages, it is hard to be more definite.

REGIONAL AND GLOBAL CORRELATIONS

Three other pollen sequences that include last-interglacial assemblages have been obtained from central Illinois (fig. 6). The assemblages and sequences of the other records are similar to the 1994 record from Pittsburg Basin. *Taxodium* pollen is not reported at any of the other three sites, but neither are there high levels of *Juniperus* pollen in the levels correlated with PB-4 (Zhu and Baker, 1995; King and Saunders, 1986).

The last-interglacial sediments at Hopwood Farm are associated with vertebrate remains. Electron-spin-resonance dates obtained from some of these fossils indicate that this assemblage was deposited in a time interval that includes marine stage 5e (Curry and Follmer, 1992). One date cited, from a *Casteroides ohioensis* tooth, is between 92,000 $\pm$ 2,000 and 137,000 $\pm$ 35,000 years before present; another from a *Mammut americanum* tooth is between 75,000 $\pm$ 9,000 and 137,000 $\pm$ 17,000 years before present. One of the most significant finds was the remains of a giant tortoise, *Geochelone crassicuata*, that lived during the last-interglacial prairie period (H3a), which indicates that winters must have been mild, never below freezing, because giant tortoises can neither migrate nor burrow.

Heterocypris punctata, a subtropical ostracode, occurs intermittently in last-interglacial sediments from Raymond Basin (Fig. 4; Curry *et. al.*, 1997). It is also intolerant of prolonged freezing conditions, indicating that the upper part of RB-3 and the middle of RB-4 were deposited when winters in central Illinois were warmer than present.

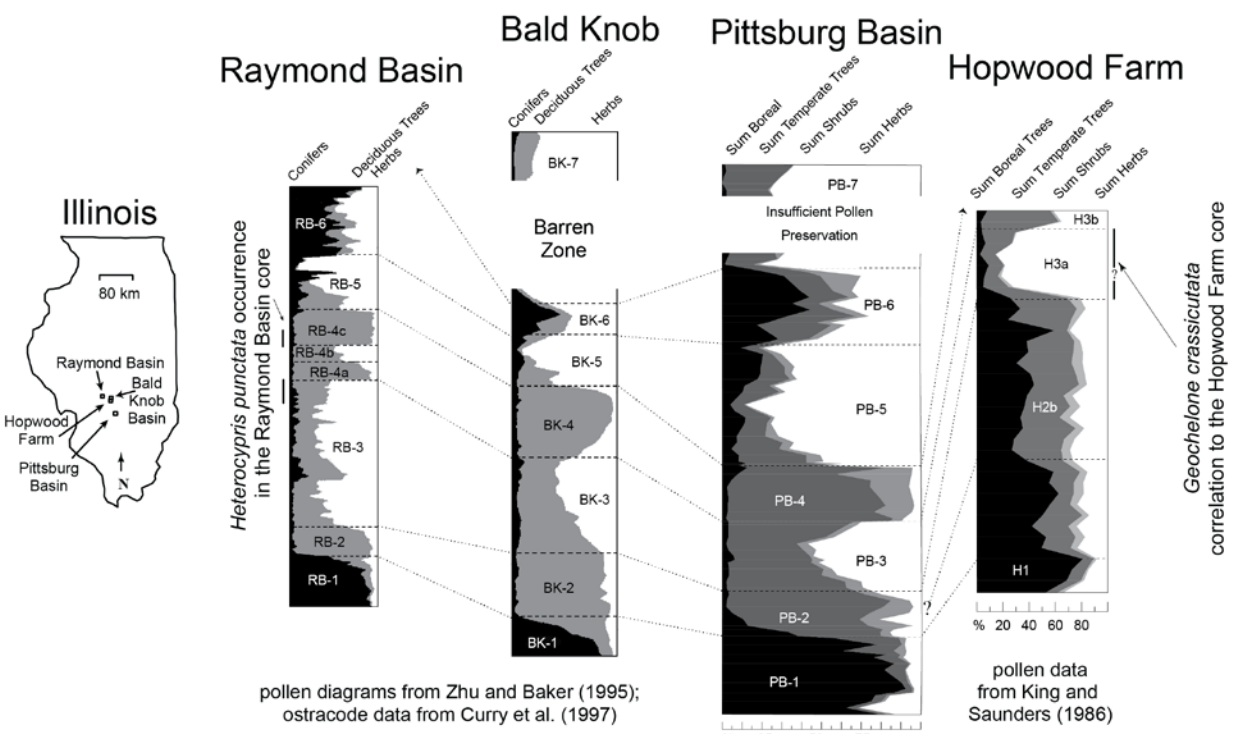

Figure 6: Correlation of the 1994 Pittsburg Basin Record with other last-interglacial Records from south-central Illinois

The proposed chronology for the Pittsburg Basin pollen-assemblage zones according to the regional and global climate records is given in Figure 7. I correlate the last-interglacial zones at Pittsburg Basin (PB-2, PB-3, and PB-4) with marine substage 5e (130,000 to 120,000 years ago). PB-3 and PB-4 are correlated with faunal remains indicating warmer winters than present. Pairs of terrestrial pollen records and near-shore marine $\delta^{18}O$ records correlated by pollen stratigraphy have been taken from the coasts of Norway (Mangerud, 1979), northern Spain/France (Turon, 1984), and the northwestern U.S. (Heusser and Heusser, 1990). In all of these records, a dramatic change in vegetation indicating a drier climate coincides with or swiftly follows the transition between marine substages 5e and 5d.

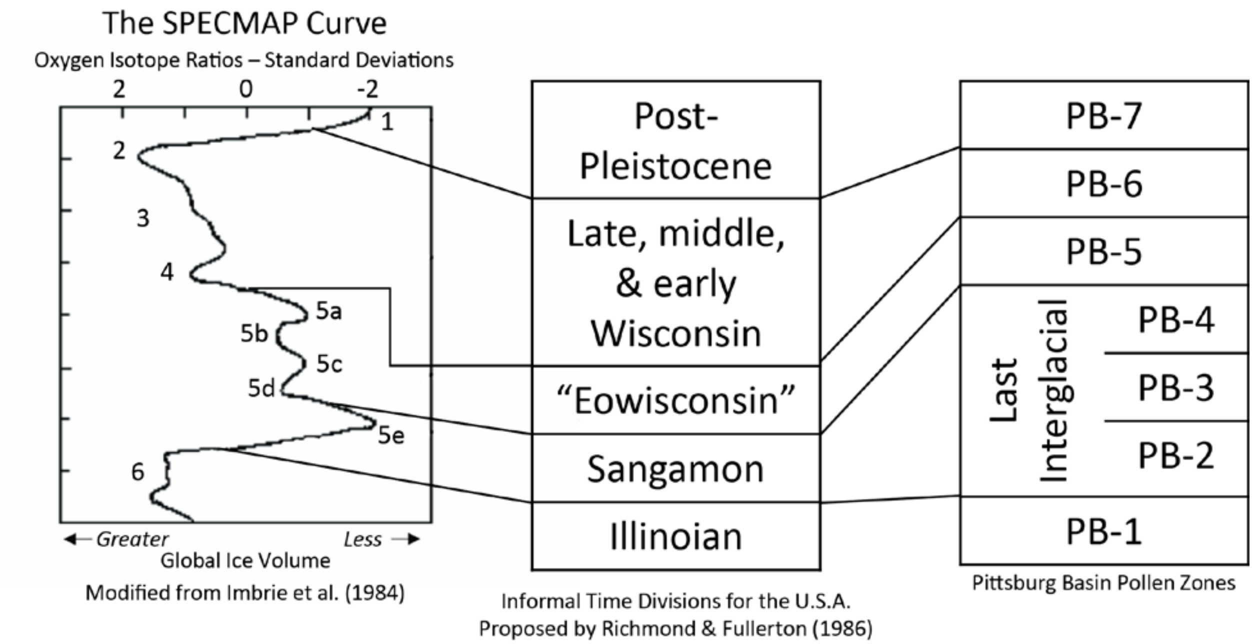

Figure 7: Correlation of the 1994 Pittsburg Basin Record with Midwestern U.S. Stratigraphy and the SPECMAP record

Zhu and Baker (1995) correlate the top of RB-4b, the end of the last interglacial period, with the end of marine stage 5a, about 72,000 years ago. Curry and Baker (2000) estimate that the top of RB-4b is about 90,000 years old. Both estimates assign RB-4 and, by correlation, PB-4, to a period found to be colder than present in Europe and in the northwestern U.S. However, RB-4 contains occasional *Heterocypris punctata* fossils indicating warm winters, and both PB-4 and RB-4 contain tree pollen indicating an environment similar to the previous deciduous-forest period (represented by RB-2 and PB-2). Zhu and Baker (1995) and Curry and Baker (2000) both assign that first deciduous-forest period to the beginning of the last interglacial period. Because of the lack of accurate dates for most continental records over 40,000 years old, there is no evidence to indicate that the climate in the midwestern U.S. was markedly different after 120,000 years ago than before. However, based on correlation with records closer to the oceans, the last interglacial at Pittsburg Basin (PB-2, PB-3, and PB-4) is believed to be contemporaneous with marine substage 5e.

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