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BOTANY

A Preliminary Pollen Study from a Fossil Bison Site in St. Paul, Minnesota[1]

The success of pollen analysis in the field of Pleistocene chronology is responsible for a tendency to associate pollen primarily with indicators of climate. The very important contributions of palynology to fields such as archeology and paleoecology are not so often emphasized.

One application of pollen analysis is the reconstruction of past plant communities for the purpose of extending ecological information about the forerunners of modern mammals. Adaptive radiation in most mammal groups began comparatively recently. The earliest geological examples of *Bison*, for example, appear in the late Pliocene of China (Skinner and Kaisen 1947), and representatives of the genus developed since that time have been found in a variety of habitats from Alaska to Mexico. Consequently we have no basis for assuming that environmental requirements of the prehistoric mammals were the same as those of the living forms. In this connection the longer history and apparent greater stability of modern plant species is extremely useful. Fossil material of angiosperm trees scarcely differentiable from those now growing about us has been found in the late Cretaceous and even in the Jurassic (Lawrence 1951), and we assume that their ecological demands have not altered greatly. This assumption underlies the present effort to describe conditions as they probably existed during the time of *Bison occidentalis* Lucas, from which our historic *Bison bison* is thought to have evolved.

Several northern Pleistocene bison (*B. occidentalis*) have been found in this area but few are reported in the literature, and generally no plant fossils have been mentioned in association with them.

[1]The author wishes to thank Dr. A. O. Dahl for providing equipment used in this study and for his help with the identification of pollen grains.

Skulls identified as *Bison occidentalis* by P. S. Taylor were discovered during excavation for a sewer in St. Paul in April 1955. The bones were found resting on a thin shell marl layer within an extensive peat bed. Peat samples were taken from the side of a trench at one foot intervals down to the marl layer which is 14 feet below the surface. The surface elevation is 795 feet above sea level. About six feet of road fill covers the old surface of the bog. The samples for this study begin about 1 foot below the presumed old bog surface.

A preglacial river channel extends from the mouth of Rice Creek near Fridley via Johanna, Josephine and McCarron Lakes, then along the valley of Trout Brook to the main Mississippi valley at Dayton's Bluff (Winchell 1875, Schwartz 1936, Schwartz and Thiel 1954, University of Minnesota Department of Geology 1956). The peat deposit is located within this valley near the intersection of Maryland and Mississippi Streets. Here the valley is cut down through the St. Peter Sandstone into the Shakopee formation to about 600 feet above sea level. An estimated 185 feet of glacial drift nearly fills the old channel. In this area and to the north the valley is crossed by terminal moraine and outwash deposits of the Patrician Cary glacier. From the southeast the gravel outwash terrace of the glacial Mississippi extends up the valley almost to Maryland Street. The surface soil of the area is a sandy loam.

METHODS

In general, the method given in Faegri and Iversen (1950) was followed in preparing the samples for analysis. The samples were acetolysed in addition to treatment with KOH, and it was found necessary to treat the lower two samples with HCl to remove calcium carbonate. A Leitz ortholux microscope was used for examining the slides, and identifications were made with the help of reference slides in addition to standard reference works (Faegri and Iversen 1950, Erdtman 1952, 1954, Wodehouse 1935, Sears 1930). Percentages are based on a total count of 200 pollen grains per sample.

DISCUSSION AND RESULTS

The work of Potter on bogs in northern Ohio, Darlington in West Virginia, Deevey in southern New England, Fuller in the Lake Michigan region, Lane in Iowa, McCullough in central New York and numerous others all record the following typical history: a belt of fir and spruce across the northern section of the United States from New England into the Central States area which followed the retreat of the glacier northward and was gradually replaced by more southerly types of vegetation until present day conditions were attained. All the studies indicate that fir and spruce were strongly predominant at the time of their maxima; together they formed 70 per cent or more of the total tree pollen (Dillon 1956). This picture is based on pollen frequencies and represents phytogeographic shifts. It is only an inference that climatic shifts are also involved, but it seems a reasonable hypothesis.

In spite of a wealth of literature on Pleistocene plant material, surprisingly little has been reported in Minnesota. There is, however, sufficient evidence to extend these generalizations to the Pleistocene flora of Minnesota. Spruce-fir predominance has been determined invariably at the presumed bases of all Pleistocene deposits sampled in Minnesota.

Winchell (1875) published the first account of plant remains of Pleistocene age in Minnesota, but the material is not specifically identified. No further Pleistocene plants were reported until the discovery of abundant fossil remains in Minneapolis at Loring Park in 1923 (Cooper and Foot 1932). That paper, the first to reconstruct a Pleistocene biotic community, reports spruce and associated plant and animal remains. Rosendahl (1948) identified spruce and other woods and a variety of other megascopic fossils, primarily seeds, cones, etc., from a number of deep wells throughout the state. Nielsen (1935) identified chips of tamarack and spruce wood and several types of pollen, showing that a northern coniferous plant cover was present in southeastern Minnesota during the Aftonian interglacial or early Kansan glacial period.

There are only a few papers which present detailed level-by-level accounts of Pleistocene fossil material from Minnesota, all of them based on pollen analysis.

Potzger's excellent paper (1953), "The History of Forests in the Quetico-Superior Country from Fossil Pollen Studies", and Erdtman and Rosendahl's (Erdtman 1954) pollen diagram from Itasca State Park are of limited usefulness for comparison here since they deal with bogs of the coniferous forest region. The Minnesota bogs studied by Voss (1934) are also mostly northern. Unfortunately the spectra from the two bogs in this area (Bald Eagle and Mission Creek) are both incomplete. Although they show the initial spruce-fir dominance, pollen was so scarce above that level that the samples were not included in the results.

Artist (1939), and Wilson and Potzger (1943), worked extensively on the lakes and bogs of the Anoka Sand Plain. They concur in an initial spruce-fir dominance followed by a brief but important pine dominance superceded in turn by a pine-oak association which persisted with fluctuations in importance of the two genera for a long time. Neither study revealed evidence for climatic change other than gradual post-glacial warming. This is at variance with the findings of Sears (1935), Potzger (1953), Deevey (1953) and others. In general, it is considered that post-glacial time almost universally and contemporaneously the world over consisted of periods of increasing warmth, warm maximum, and decreasing warmth, with fluctuations in moisture super-imposed on these temperature phases (Deevey 1953). There are important differences between the results of Artist and those of Wilson and Potzger with respect to the duration of the spruce period and the relative prominence of oak and pine. Wilson and Potzger attributed these discrepancies to differences in sampling techniques.

Thus, while there is unanimous agreement on the presence of northerly species and a gradual warming to the present, a consistent picture of post-glacial climatic alteration in Minnesota pollen zones is lacking. As Sears (1935) pointed out, "It is essential to reckon with the probability that climatic shifts, if any, have not operated uniformly nor persisted equally in all types of habitat."

The results of the Trout Brook data are summarized in Table 1 and Figure 1. For a number of reasons this profile is inadequate for any climatic correlation:

1. Notably absent from the sample is the spruce-fir association so prominent in all pollen profiles of Pleistocene deposits in this region. This is no doubt due to the fact that the lower deposits were not obtained.

TABLE 1.—*Percent of Total Pollen*

Species	Sample Depth Below Surface in Feet								
	1	2	4	5	6	7	8	9	9*
Pinus	53.5	24.9	13.7	16.9	23.5	20.5	23.7	9.8	11.2
Abies	2.5	3.1	0.0	0.0	0.0	0.0	2.3	0.5	2.4
Picea	5.5	0.9	0.0	0.0	0.0	0.0	0.7	0.7	3.2
Betula	1.0	1.3	0.3	0.9	1.5	0.5	1.7	3.5	2.0
Corylus	3.5	1.3	1.0	0.0	2.0	0.5	0.0	4.2	1.2
Alnus	0.5	0.4	1.7	2.7	0.5	1.0	2.0	1.2	2.4
Quercus	1.5	4.4	3.3	4.0	6.0	4.0	1.7	9.8	3.6
Ulmus	0.5	2.7	1.4	4.0	5.5	5.5	2.0	9.1	3.2
Tilia	1.0	0.4	1.0	0.9	0.5	0.5	0.3	1.0	3.6
Salix	1.0	0.0	2.0	0.4	0.5	1.5	0.3	0.5	2.8
Juglans	0.0	0.0	0.6	0.0	0.5	0.5	1.0	0.8	0.4
Carya	0.0	0.0	0.3	0.0	0.0	1.0	0.0	1.0	0.0
Fraxinus	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
Carpinus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Grass	7.0	6.2	6.0	5.3	7.0	21.5	27.0	14.2	14.0
Chenopod-Am.	4.5	8.0	4.0	5.8	7.0	4.5	4.6	4.5	10.8
Ambrosia	9.0	17.8	5.3	7.6	4.0	5.5	9.7	16.7	15.2
Composite	1.0	0.0	1.4	1.8	4.0	0.5	1.3	2.2	2.0
Artemesia	1.0	4.9	7.0	5.8	4.5	6.5	5.0	13.5	9.2
Typha	0.5	0.0	0.0	4.0	2.0	2.0	8.7	4.0	10.0
Cyperaceae	1.0	18.2	48.0	37.3	27.5	19.5	3.3	1.8	0.0
Plantago	0.0	3.1	1.0	0.0	1.0	0.0	1.3	0.3	0.4
Misc. & Unidentified	5.5	2.2	2.0	2.2	2.5	4.5	3.3	0.5	2.0

*Sample taken from inside bison skull at 9 foot level. Surface is the presumed upper level of old bog. The three foot sample has been omitted since pollen was badly corroded and extremely scarce.

2. The sample is also cut off at the top because the disturbed upper layer was not included. The lake appears to have filled in and presumably ceased recording pollen at some unknown time.

3. Since there is but a single location represented, there is the possibility that the sample does not represent the usual conditions for the area.

4. Minor fluctuations in the relative amounts of pine and deciduous genera occur which may reflect climatic variations. Since the fluctuations cannot be correlated with similar fluctuations in other profiles of the region, they may be attributed as easily to local

successional changes as to climatic influence. Aario, as reported by Artist (1939) considered only the appearance and disappearance of genera to be significant indicators of climatic change in such instances and placed little reliance on relative fluctuations.

The Trout Brook data, while shedding no light on post-Pleistocene climatic fluctuations, are adequate for reconstruction of the

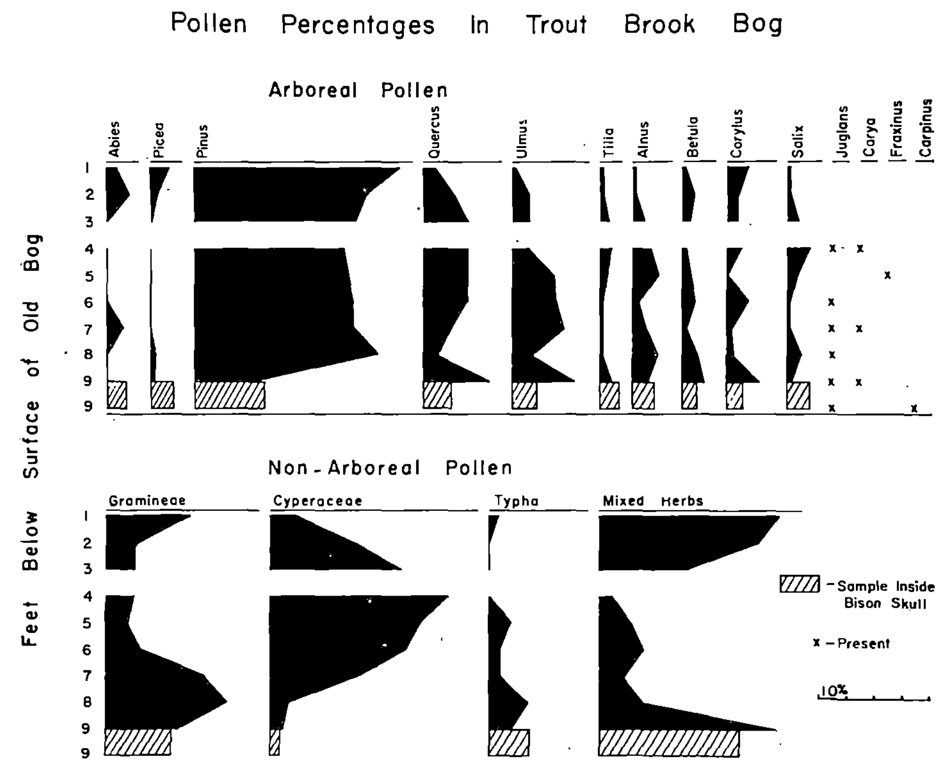

Fig. 1. The per cent of arboreal pollen has been calculated separately from the non-arboreal pollen. Without this separation the non-tree pollen obscured the relative proportions of tree pollen.

The three foot sample was omitted due to the extremely corroded condition of the pollen which allowed identification only of those grains most resistant to oxidation, e.g. Pine, *Ambrosia* and chenopod.

Refer to Table 1 for an enumeration of the mixed-herb category.

biotic community existing at this specific location at the time of *Bison occidentalis.*

With the exception of the topmost sample (probably anomalous because of extensive corrosion and oxidation) tree pollen never exceeds 40% of the total pollen (Table 1). Although the source of pollen found in peat may range from the bog itself to points over five miles distant, normally the greatest contribution is from nearby plants (Fuller 1935, Faegri and Iversen 1950). The 60 or more per cent non-tree pollen, then, is considered to represent chiefly the plants of the aquatic community and its borders.

Marl deposits are most favorably developed in warm shallow water over weed beds. The presence of seeds of *Najas* and several *Potamogeton* species and shells of *Valvata tricarinata,* all typically found in water not over 10 feet deep, suggest a shallow water environment. The pollen and seeds representing the aquatic community correspond to vegetation usually associated with a senescent lake in the last stages of sedimentary shoaling. The great expansion of *Cyperaceae* pollen with concurrent reduction in importance of (aquatic ?) grasses and cattail is consistent with sedge meadow vegetation. Numerous *Carex* and *Scirpus* seeds show the local abundance of sedge even more clearly than the pollen, since the fruits are less likely to be transported an appreciable distance.

The grass-chenopod-amaranth association, which increases relative to other non-tree pollen near the upper levels, has been given significance as a climatic indicator of a post-glacial xerothermic period in northern bogs (Sears 1935). In this instance its relative importance is probably governed by successional phases of the bog itself. A similar profile is interpreted by Wilson and Galloway (1937) as follows: composites were favored when the lake shore was bare and sandy. When the sphagnum (or sedge) mat developed they were excluded from the edge until the mat had matured. The rapid rise in per cent at the surface was due to human disturbance.

The significance of grass pollen, especially when abundant, has frequently been interpreted as indicative of reduced moisture and subsequent grassland invasion. Wilson and Galloway produce evidence that increasing abundance of grass pollen in recent times may also be due to invasion of grasses of the *Zizania aquatica* (wild rice) types with shallowing of the lake basin. Grass pollen in the present study was not specifically identified, although it is apparent that more than one species is present. Aquatic grasses are an important feature in marsh successions in this region, and there is a strong probability that they are major elements of the present diagram.

The tree pollen represented is dominantly pine with an admixture of oak and elm, with other deciduous species present in lesser amount.

In translating pollen analytical data into terms of vegetation, factors such as differential production, dispersal and destruction must be considered (Faegri and Iversen 1950). In general, pine is greatly over-represented relative to mixed-oak associations, whereas aspen is not well preserved or easily recognized in pollen analyses.

It seems likely, then, that the immediate locality of Trout Brook was not thickly forested; that pine, oak and elm were the major tree species present in the area, with the seeming domination of pine in the diagram undoubtedly due to the usual over-representation of pine pollen in fossil deposits.

The present vegetation is largely treeless with grasses, sedges and composites predominating. Clumps of cattail, some willow and alder shrub and a few elms are interspersed throughout the valley. Remnants of oak savannah persist on the morainic upland. There are no conifers in the immediate vicinity, but to the north fairly large stands are found near McCarron Lake, at Dale Street and County Road A, and on the hillslopes within morainic depressions in other nearby localities.

Trout Brook valley has been considerably disturbed by extensive railroad and highway development, artificial adjustment of water levels by the water department, and human occupation. A comparison with Butters' description (*in* Schwartz 1936)of the forest associations of the Minneapolis-St. Paul area as they existed before extensive metropolitan development, however, suggests that the types of vegetation have not changed radically from that early period.

There is nothing in the pollen diagram which suggests an environment appreciably different from conditions existing in the area at the present time. Pine may be more heavily represented in parts of the diagram than atmospheric collections would show today. The relatively greater production and resistance of pine pollen may account for this. Near the marl layer pine, oak and elm are present in almost equal amounts. The large quantities of oak, elm and basswood pollen found preclude the assignment of any portion of the diagram to the spruce-fir period and make it highly unlikely that the pine period is represented. It is interesting to note in this connection the discovery of bones of *Bison antiquus* in a post-Cary bog at Nye, Wisconsin (Eddy & Jenks 1935) commingled with wood of many hardwood species. *Bison antiquus* and *B. occidentalis* evidently lived contemporaneously, sharing part of a common range during very late Pleistocene (Skinner and Kaisen 1947).

Although direct correlation with profiles of other bogs is impossible because of differences in underlying drift, topography and latitude, some information can be inferred by comparison with them.

The few carbon dates available for the spruce and pine pollen zones in Minnesota suggest that these trees predominated in regions as far south as Anoka until the close of the Mankato glaciation about 8000 years ago. Wood from the late-Pleistocene community described by Cooper and Foot in Minneapolis has been dated at 11,790±200 years ago (Wright and Rubin 1956). The community described indicates a bog forest of tamarack and black spruce in the depressions and a climax forest of white spruce, *Abies, Pinus strobus* and some paper birch on the morainic uplands. The pine zone in the Quetico-Superior bogs is considered regionally simultaneous. The initiation of this zone following the sudden decline of spruce-fir has been carbon dated at 7,128±300 years ago (Potzger 1953). A sample from the pine pollen zone in Cedar Bog Lake has been dated at 7988±420 years ago (Wright and Rubin 1956). Since oak, elm and pine pollen at the level of the bison skulls in Trout Brook bog are present in about equal proportions, the assumption may be made that the zone represented is post glacial.

This interpretation corresponds well with the time when *Bison occidentalis* was thought to have been present in this region. Forbis (1956) found this bison spread over the central plains of North America up until about 6500 to 7000 years ago. Presumably they persisted somewhat later in this area since this bison followed the retreat of the ice and returning favorable climatic conditions into Alaska and the Yukon (Skinner and Kaisen 1947).

SUMMARY

The drift association shows that the Trout Brook deposit sampled is definitely at least as recent as Cary in age. The vegetation indicates that the zone in which *B. occidentalis* was found is also more recent than Two Creeks. Since evidence of spruce and pine zones is lacking, it is a reasonable surmise that *B. occidentalis* lived in an environment similar to that of the present in this area, probably more recently than about 8000 years ago.

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