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A Reexamination of Late-Pleistocene Boreal Forest Reconstructions for the Southern High Plains

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Previous paleoecological research on the Southern High Plains resulted in development of a late Quaternary chronology of "pollen-analytical episodes" and the proposal that boreal forest existed in the region in the late Pleistocene. These interpretations are now considered untenable because (1) a number of the radiocarbon ages are questionable, (2) there are serious problems of differential pollen preservation and reproducibility of the pollen data, (3) there is an absence of supporting geological or paleontological data, and (4) the soils of the area contain none of the distinctive pedological characteristics produced by a boreal forest. Available data suggest that the region was primarily an open grassland or grassland with some nonconiferous trees through most of the Quaternary. © 1987 University of Washington.

INTRODUCTION

In the late 1950s and early 1960s considerable research was conducted into the late Quaternary, principally late Pleistocene, paleoecology of the Southern High Plains of northwestern Texas and eastern New Mexico (Wendorf, 1961a; Wendorf and Hester, 1975a). One of the most significant discoveries made, based on considerable pollen data, was the high content of pine and spruce pollen in some samples. This led to interpretations of pine and spruce woodlands or boreal forest on the Southern High Plains in the late Pleistocene (Hafsten, 1961, 1964; Wendorf, 1961b, 1970, 1975; Oldfield and Schoenwetter, 1975). These interpretations were initially controversial, but eventually accepted (Wendorf and Hester, 1975b; Wells, 1983) and are still widely cited (e.g., MacDonald, 1981; Stanford and Broilo, 1981; Barry, 1983; Jennings, 1983; Smith and Street-Perrott, 1983; Spaulding *et al.*, 1983; Watts, 1983; Wells, 1983; Axelrod, 1985; Bryant and Holloway, 1985; Gile, 1985; Greiser, 1985; Harris, 1985; Kutzbach and Wright, 1985).

A quarter century passed since these paleoecological data were collected and most of the interpretations made. This paper is a critical reexamination of the chronology of the proposed pollen-analytical episodes and the interpretations of boreal forest for the region, made in light of recent advances in palynology and radiocarbon dating and better understanding of the late Quaternary geology, soils, and paleontology of the Southern High Plains and following on some points raised by Holliday *et al.* (1985) and Holliday (1986).

Most of the pollen samples collected for the High Plains Paleoecology Project came either from sediments found in large basins containing ephemeral lakes or playas (late Pleistocene) or from sediments deposited in ephemeral drainages or draws (latest Pleistocene and Holocene). Hafsten (1961, 1964) conducted the initial pollen research in 1958 and defined a sequence of pollen "zones." Wendorf (1961b) used Hafsten's pollen data along with paleontological and geological data to define a sequence of late Quaternary "climatic intervals." Additional palynological research was carried out between 1961 and 1963 by Oldfield (1975) and Schoenwetter (1975), who pro-

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posed a series of late Quaternary pollen-analytical episodes. Oldfield and Schoenwetter (1975) then made some ecological reconstructions for each "episode." Wendorf (1970, 1975) further proposed some vegetation and climatic reconstructions for each episode (Table 1).

DATING

Twenty radiocarbon ages were used to date the pollen-analytical episodes of Oldfield and Schoenwetter (1975). Only four samples provided age control for the late Pleistocene sequence; the other 16 samples came from Holocene sections. Three of the late Pleistocene assays came from Rich Lake, in Terry County, Texas, and White Lake, in Bailey County, Texas. The samples for these ages are from freshwater carbonates and may be subject to the "hard water effect," which would produce inaccurate determinations (Fritz, 1984; Bradley, 1985). In the draw sites, sample I-246 (mistakenly cited as L-246 by Oldfield and Schoenwetter, 1975) was used to date the latest Pleistocene Crane Lake interval and Blackwater subpluvial. The date is now considered to be invalid because of uncertainties about the provenience of the sample, because of problems encountered in dating shell, and based on comparisons with more recently determined assays of wood samples (Holliday *et al.*, 1983). Therefore, there is little firm age control for the late Pleistocene pollen samples.

Relative dating and correlation of the late Pleistocene pollen samples were also based on correlations of lake stratigraphy from one basin to another. However, this is very difficult. Sediments deposited in the basins throughout the Quaternary are generally quite similar lithologically (olive to gray

TABLE 1. CHRONOLOGY AND INTERPRETATIONS OF POLLEN-ANALYTICAL EPISODES BY OLDFIELD AND SCHOENWETTER (1975) AND WENDORF (1975)

Age (yr B.P.)	Pollen-analytic episode	Vegetation	Climate
	Post-altithermal episodes[a]	Scattered pine?	Cooler?
	Sand Canyon postpluvial[a]	Grassland	Dry?
8,000	Unnamed subpluvial(s)(?)	Scattered pine?	Cooler?
9,000	Yellowhouse interval	Prairie	Drying
10,000	Lubbock subpluvial	Continuous pine woodland to mixed woodland and prairie	Cool–moist
	Scharbauer/White Lake[a] interval	Prairie	Dry?
11,000	Blackwater interval	Prairie and discontinuous pine and spruce(?) parkland	Cool–moist?
	Crane Lake interval[a]	Prairie	Dry?
12,000	Late Tahoka pluvial	Continuous pine and spruce woodland	Cool–wet
	Monahans/Vigo Park interval	Prairie and discontinuous pine and spruce woodland	Dry?
18,000	Early Tahoka pluvial	Continuous pine and spruce woodland	Cool–wet
ca. 27,000	Rich Lake interpluvial	Prairie or savanna	Cool–moist
ca. 32,000	Terry subpluvial	Prairie and discontinuous pine and spruce(?) woodland	Cool–wet
ca. 37,000	Arch Lake interpluvial	Prairie or savanna	Cool–moist
>37,000[b]	Brownfield oscillation	Prairie and discontinuous pine woodland (with oak?)	Cool–wet

[a] Not recognized by Wendorf (1975).

[b] Given as <35,000 B.C. by Wendorf (1975, Table 14-1); apparently a typographical error.

clays and lacustrine carbonates) (Reeves, 1976). Firm correlations must rely on good age control or index fossils.

POLLEN

The basis for reconstructing a boreal forest on the Southern High Plains was the relatively high abundance of pine and spruce pollen in some samples. New information on pollen preservation now leads to serious questioning of this interpretation. Differential pollen preservation can seriously affect the percentages of pollen types in samples (e.g., King *et al.,* 1975; Hall, 1981; Holloway, 1981). In particular, pine and spruce pollen tend to be much more resistant to deterioration than pollen from nonconifers (Hall, 1981; Holloway, 1981). In samples taken from Lubbock Lake in an attempt to duplicate the Lubbock subpluvial record, Hall (Holliday *et al.,* 1985; S. Hall, personal communication, 1986) found that all pollen grains are corroded or degraded and total pollen concentration is low. Bryant and Schoenwetter (1988) also note that pollen degradation was a problem encountered during some of the research for the High Plains Paleoecology Project.

Problems of pollen preservation are also indicated by difficulties in reproducing some of the pollen records at sites studied during the High Plains Paleoecology Project. At and near Lubbock Lake, one of the key sites for the latest Pleistocene and Holocene pollen record, at least seven palynologists have analyzed samples for pollen and the results have varied dramatically (Bryant and Schoenwetter, 1988). For example, Hafsten (1961) was unable to recover pollen from Lubbock Lake while Oldfield (1975) and Schoenwetter (1975) did. However, the pollen diagrams of Oldfield (1975) and Schoenwetter (1975) are noticeably dissimilar. The exact locations of all of this sampling is not known, but the general sampling area is known and the lithology and stratigraphy throughout this area is quite similar, suggesting that pollen analysis should produce comparable results. Although differences in extraction techniques could account for some variability, the lack of reproducibility by so many investigators suggests that poor pollen preservation has significantly affected the results of the Lubbock Lake studies. Furthermore, the dissimilarities between the pollen frequencies at the principal draw sites, Lubbock Lake, Plainview, and Blackwater Draw Locality 1 (the Clovis site), suggest that poor preservation of pollen grains may characterize the entire latest Pleistocene–early Holocene pollen sequence. This contention is reinforced by the lack of supporting geological or paleontological data from the draw sites for spruce–pine vegetation (e.g., Holliday, 1985a, 1985b; Johnson, 1986, 1987). As indicated, interpretation of the pollen data from Lubbock Lake and Plainview is further complicated because it has been impossible to determine exactly where, stratigraphically, most of the samples came from.

The poor pollen preservation in the draws also raises concern about the reliability of the pollen data from the older, lake basin samples. Both the draws and lakes basins have had fluctuating water levels and have accumulated calcareous sediment; pollen preservation tends to be poor under such conditions (Bryant and Holloway, 1983).

Long-distance airborne transport of pine and spruce pollen, often noted as a problem in palynological interpretations (e.g., Mack and Bryant, 1974; Mack *et al.,* 1978), may also be an important factor on the Southern High Plains. Pine and spruce occur in the mountains of New Mexico west (upwind) of the Southern High Plains and Pinyon pine occurs in isolated stands along the western escarpment of the region (Hafsten, 1961; Gross and Dick-Peddie, 1979). Expansion of these vegetation zones in the late Pleistocene would presumably increase the rain of pine and spruce pollen on the Southern High Plains.

SOILS

The surficial sediment of the Southern High Plains is an eolian mantle deposited episodically throughout the Quaternary and referred to as the Blackwater Draw Formation (Reeves, 1976; Holliday and Gustavson, 1987). The age for the end of deposition of this cover is uncertain, but it was probably at least several tens of thousands of years ago (early Wisconsinan or Wisconsinan maximum?) (Holliday and Gustavson, 1987), thus antedating the pollen-analytical episodes.

A boreal forest would impart distinctive pedologic characteristics to the soils formed in this parent material. Pine and spruce cover would produce "podzolized" soil profiles, characterized by (a) an eluvial (E) horizon, which is depleted of organic matter, clay, and free iron and aluminum; and (b) an illuvial (B) horizon with accumulations of clay, organic matter, and/or iron and aluminum (Jenny, 1980; Duchaufour, 1982; Birkeland, 1984) (Table 2a). The examples of podzolized profiles are for pine forests of the humid eastern United States. However, even Pinyon, which prefers to grow in dry climates and thin, rocky sediments (Brown, 1982) (notably different from the surfical cover of the High Plains) and occurs just west of the Southern High Plains, will produce soils that exhibit profiles with eluvial horizons (Folks, 1975).

Holocene pedogenesis could obscure or mask some podzolic features, but the E horizon position should still be considerably lower in organic matter, clay, iron and aluminum relative to the B horizon. The modern soils of the Southern High Plains are generally Paleustalfs, Paleustolls, and Calciustolls (Godfrey *et al.*, 1973; Aandahl, 1982); physical and chemical data from representative soil profiles (Table 2b) show that there is no evidence for podozolization during the genesis of these soils. In addition, the content of illuvial clay in the argillic horizons and carbonate content in the calcic horizons of the soils of the Blackwater Draw Formation are much greater than that found or expected in Holocene soils in the region (Holliday, 1985c; Holliday and Gustavson, 1987).

Between episodes of deposition of the Blackwater Draw Formation, there were long periods of landscape stability and pedogenesis; thus, the resulting Blackwater Draw Formation contains numerous buried soils, the oldest of which was covered 1.4 myr ago (Holliday and Gustavson, 1987). The buried soils are virtually identical to the surface soils, indicating in general terms that the late Quaternary vegetation of the Southern High Plains represents that of most of the Quaternary.

TABLE 2A. SELECTED PHYSICAL AND CHEMICAL DATA FOR SOME PODZOLIZED SOILS OF THE EASTERN UNITED STATES

Series: Location:	Becket fine sandy loam[a] Massachusetts			Matapeake fine sandy loam[b] Virginia			Cahaba fine sandy loam[b] Virginia		
	Horizon	% Clay	% Free Fe_2O_3	Horizon	% Clay	% Free Fe_2O_3	Horizon	% Clay	% Free Fe_2O_3
	A	3.8	1.08	A	6.0	0.56	Ap	5.1	0.30
	E	7.0	1.69	E	12.8	0.78	E	7.1	0.47
	BEt	10.6	3.99	BE	20.2	1.06	BE	19.0	0.99
	Bt	9.5	3.58	Bt	38.5	2.08	Bt	25.9	1.29
	C	8.9	3.15	BC	20.3	—	BC	20.4	0.90
				2C	7.1	0.64	C	23.3	0.58

[a] Jenny, 1980.
[b] Fiskell and Perkins, 1970.

TABLE 2B. SELECTED PHYSICAL AND CHEMICAL DATA FOR COMMON REGIONAL SOILS OF THE SOUTHERN HIGH PLAINS

Series:	Amarillo fine sandy loam[c]			Acuff sandy clay loam[d]			Pullman silty clay[e]		
	Horizon	% Clay	% Free Fe_2O_3	Horizon	% Clay	% Free Fe_2O_3	Horizon	% Clay	% Free Fe_2O_3
	A	20.0	0.30	Ap	22.4	0.7	Ap	34.7	0.8
	Bt1	26.2	0.39	Bt1	24.2	0.7	Bt1	44.3	0.9
	Bt2	20.7	0.31	Bt2	26.9	0.7	Bt2	42.0	0.8
	Bt3	22.0	0.34	Bt3	20.6	0.5	Bt3	38.4	0.9
				Bt4	23.0	0.3	Bt4	37.6	1.0
				Bt5	19.9	0.1	Bt5	41.9	0.4
							Bt6	38.8	0.5

[c] Mathers, 1963.
[d] SCS pedon 81TX-303-001.
[e] SCS pedon 79TX-381-003.

CONCLUSIONS

The High Plains Paleoecology Project of the late 1950s and early 1960s was a milestone in Quaternary studies in North America, providing a model of environmental change and a rich data base for many subsequent investigators. However, as the decades have passed since that research was completed, new data and advances in radiocarbon dating, palynology, geology, and pedology necessitate a critical reevaluation of the results of that research. Reeves (1976, p. 223) notes that "no stratigraphic, pedologic or paleontologic evidence exists that the Southern High Plains was ever heavily forested at any time during the Quaternary," but he does not elaborate.

The data presented in this paper show that the chronology of late Pleistocene pollen-analytical episodes is probably invalid and the associated terminology has outlived its usefulness. Moreover, the proposition that at various times in the late Pleistocene the Southern High Plains had a significant cover of pine and spruce is no longer acceptable. Vertebrate faunas from the Southern High Plains (Lundelius *et al.*, 1983; Johnson, 1986) and the pedologic data indicate that the late Pleistocene vegetation was either an open grassland or a grassland with some stands of nonconiferous trees, although pine may have been more extensive along the western escarpment of the region. This interpretation, combined with the record from the Blackwater Draw Formation, indicates that the Southern High Plains has been primarily a grassland, sometimes partially wooded, throughout most of the Quatenary. Clearly, considerable additional research into the Pleistocene vegetation and paleoecological history of the area is now called for.

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