Late Holocene Paleoecology of the Southern Plains

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Analyses of pollen and land snails from rockshelter sites in the Osage Hills of northeastern Oklahoma indicate that the period 2000–1000 yr B.P. was moister than today. During that time, colonies of the prairie vole Microtus ochrogaster were present in the Texas Panhandle. About 1000 yr B.P. the climate changed to dry conditions that have persisted to the present. Disjunct colonies of small mammals in Texas became extinct at the beginning of the dry episode, thereby establishing the composition of the modern fauna. The climatic model for the origin of the Panhandle Aspect (A.D. 1200–1500) is questioned on the grounds that the Southern Plains experienced a long period of dry climate commencing A.D. 950.

INTRODUCTION

The Southern Plains have long been of interest to geologists because of the abundance of Pleistocene vertebrate and molluscan faunas. Investigations of Holocene fossil remains, however, are meager, and the compilation of a late prehistoric climatic history has not been feasible. Recent excavations of archeologic sites have provided new opportunities for paleoecologic studies. Unfortunately, many Oklahoma and Texas rockshelters analyzed for pollen have proved essentially barren and, in the end, land snails have furnished much of what has been learned about past environmental conditions. The sites that have yielded the most information on past vegetation and molluscan faunas occur in the Cross Timbers region of the Osage Hills in northeastern Oklahoma.

VEGETATIONAL HISTORY

The modern vegetation in that part of the plains known as the Osage Hills is a tall-grass prairie separated into two parts by a wedge of scrubby oak forest, the Cross Timbers, which extends from Texas through Oklahoma and into southeastern Kansas (Fig. 1). The Cross Timbers is composed largely of post oak (Quercus stellata) and blackjack oak (Quercus marilandica). The Cross Timber oaks are separated from the main oak–hickory–pine upland forest of the western Ozarks by an oak–hickory–grassland savanna that includes post oak, blackjack oak, black oak (Quercus velutina), and black hickory (Carya texana). West of the Cross Timbers the upland vegetation is a tall-grass prairie with a sparse oak savanna (Rice and Penfound, 1959). Floodplain forests in the Osage Hills are dominated by American elm (Ulmus americana) and hackberry (Celtis occidentalis) with some green ash (Fraxinus pennsylvanica), black walnut (Juglans nigra), and pecan (Carya illinoensis) (Rice, 1965).

The Osage Hills forest has been greatly reduced since the 1950s. Many square miles of Cross Timber post oak and blackjack oak have been sprayed repeatedly to increase rangeland for cattle. Also, beginning in the 1890s, selective logging of walnut in the Osage Nation altered bottomland vegetation (Mathews, 1932). Overall, however, the Cross Timbers oak forest and other areas of Oklahoma have not been disturbed as much as in adjacent Texas and Kansas owing to Oklahoma's early history of Indian resettlement and late European arrival. In fact, comparison of Washington Irving's description of the Cross Timbers in 1832 with the Cross Timbers of today...
Pollen Analyses

Recent pollen studies of a number of archeologic sites in Oklahoma and Texas have resulted in only four late-prehistoric pollen records (Fig. 2). Pollen assemblages from other sites have been altered by progressive pollen deterioration (Hall, 1981) and are not cited here.

Big Hawk Shelter. Several rockshelter sites along Hominy Creek Valley in south Osage County were investigated for pollen and land snails. Big Hawk Shelter (Fig. 3) yielded one of the more important records of artifacts, vertebrate remains, and mollusks, including the earliest, best-dated pollen sequence in the region (Henry, 1978a). The diagram shows a dominance of oak, indicating the presence of an oak forest 1600 yr B.P. The lower half of the diagram, dating before about 1000 yr B.P., contains a moderate amount of hickory pollen which indicates that the Cross Timbers oak forest included a larger component of hickory than it does today. A number of Carya species occur in both upland and bottomland sites today. Modern surface pollen transects across Hominy Creek and Birch Creek valleys both show that when present, hickory is more abundant in upland sites (Fig. 4). After about 1000 yr B.P., hickory pollen declined and oak increased in abundance. The increase in grass (Gramineae) and chenopod (Chenopodium-type) pollen in the upper 15 cm of the rockshelter deposit may reflect historic
clearing of oaks and subsequent expansion of grasses and chenopods.

Cut Finger Cave. This small site, only 25 m east of Big Hawk Shelter, contains a shorter sedimentary record. The small amount of oak pollen shows little resemblance to oak-dominated Big Hawk, even though the two sequences overlap in time.

Painted Shelter. Painted Shelter is on Birch Creek in eastern Osage County in the heart of the Cross Timbers. The pollen diagram shows the unchanging presence of oak since 1450 yr B.P.; the upper part of the section is not dated. Other tree taxa, including hickory, are minor components of the pollen spectra.

Little Caney River Valley. The Little Caney River flows south from Kansas into Washington County, Oklahoma, along the eastern margin of the Cross Timbers. A composite diagram of one modern and eight prehistoric pollen spectra shows a trend toward decreased grass pollen and increased tree pollen (oak and hickory), the change occurring about 1000 yr B.P. Today, the Little Caney Valley is wooded and the uplands are a tall-grass prairie with outliers of Cross Timber oaks. All of the pollen samples in the composite diagram are from floodplain sites. The change in the pollen record about 1000 yr B.P. from grass-dominated to increased tree vegetation is thought to be related to water-table position. Grasses thrive on floodplains with
HOMINY CREEK BIRCH CREEK

A B C D E F G H I J K L

Quercus
Corylus
Ulmus
Juglans
Fraxinus
Celtis
Populus
Salix
Betula
Ailus
Corylus
Juniperus
Pinus
Picea
Rhus
Gromelone

Ambrorsia type
Aster type
Liquidiflorae
Artemisia
Chenopodion type
Umbellifera
Coryphylaceae
Polygonaceae
Lilaceae
Plantago
Cyperaceae
Ephedra trifurca type
Tern spores - undiff
unknown
indeterminable pollen sum

pollen concentration (grains per gram)

spike counts

16,000
4,000
800

Fig. 4. Modern pollen spectra from surface material collected in transects down north sides of Hominy Creek and Birch Creek valleys. Hominy Creek surface stations about 60 m apart; A–D are from upland oak forest; E is from wooded slope adjacent Big Hawk Shelter, and F–H are from a cleared, low terrace above the stream channel. Birch Creek surface stations J–L are from upland oak forest and are about 300 m apart; I is on wooded terrace above the stream channel; transect is about 3 km SE of Painted Shelter (Fig. 1). Oak, hickory, and walnut pollen frequencies are greater in uplands; elm and hackberry pollen is more abundant in bottomlands. Presence of pine, spruce, and Ephedra pollen grains is a result of long-distance transport. The average pollen concentration of 12 surface samples is 43,000 grains/g of dry surface duff (each sample represents 20 pinches of surficial material).

a high water table, while roots of most trees cannot tolerate saturated soils. The Little Caney pollen diagram is viewed as a vegetation response to water-table position: a high water table prior to 1000 yr B.P. promoted grasses and excluded trees; a lowered water table post-1000 yr B.P. permitted the extension of trees onto the floodplain where they occur today. The alluvial stratigraphy of the valley supports this interpretation. During the interval of grass abundance, an azonal A-horizon soil, the Copan paleosol, developed on the floodplain. Floodplain incision, resulting in termination of Copan paleosol accumulation, accompanied the lowering of the water table (Hall, 1977b).

Washita River Valley. Three cores, one 5.2 m and two 7.3 m long, have been taken from the alluvial valley fill of the Washita River in western Oklahoma and analyzed for pollen (Bond, 1967). The resulting pollen diagrams show a single sequence of pollen succession: a lower zone of tree pollen (pine, oak, hickory, walnut, basswood–elm), followed by a zone of non-arboreal pollen (composites, chenopods, grasses); the tree pollen–nonarboreal pollen cycle is repeated in the upper half of the cores. The alluvium from which these cores were taken is probably less than 3000 yr old. Wood from 15-m depth near the pollen core sites is dated 3850 ± 110 yr B.P. (Goss et al., 1972). The cores, however, are undated. I hesitate to make a strict interpretation of vegetation change from these core records. The pollen succession is unlike any other known late Holocene sequence from the Southern Plains. The lack of radiocarbon dates, the potential for an unconformity in the alluvial record, the effect of fluctuating water table on the floodplain vegetation, and the cut-and-fill history of the meandering Washita River channel introduce great uncertainty into the interpretation of the Washita pollen diagrams.

Southwestern Kansas. Two unpublished pollen diagrams comes from studies of cores
from the mixed prairie (Küchler, 1974) of southwestern Kansas. Both diagrams, neither reproduced here, show changes in late Holocene vegetation. An undated 2.0-m core from Sedge Marsh at Meade County State Park shows abundant grasses, composites, and sedges (Cyperaceae), with smaller amounts of pine pollen which, along with spruce (Picea) and fir (Abies), constitute a background pollen influx from the Rocky Mountains (Kapp, 1962). The abundance of willow (Salix) in the lower half of the diagram may be related to higher water table, more open water, the history of sediment filling, or a combination of all these factors.

The second unpublished diagram is from a 5.6-m core taken at Big Basin, a solution collapse basin in Clark County (Shumard, 1974). The lower spectra, compared with the upper, are marked by high composites and low chenopods and grasses. In a transition zone dated 535 ± 130 yr B.P. at 3.2-m depth, composites decrease and chenopods and grasses increase in abundance. Pine-pollen frequencies also increase slightly but consistently at and above the dated horizon. None of these pollen fluctuations are recorded at Sedge Marsh in nearby Meade County. Other uninvestigated sinkhole depressions and bottomland marshes occur in the Great Plains, a region from which we have almost no Holocene paleoecologic information.

Central Texas bogs. Six spring-fed bogs in central and east Texas have been investigated for pollen. Three of the bogs have been dated by radiocarbon. Bryant (1977) provides a good review of these bog studies, concluding that the late Holocene vegetation of central Texas was unchanging. As far as can be determined, however, the bogs do not contain a preserved pollen record spanning the past 2000 yr.

Pine-Pollen Rise

Pine is ubiquitous in pollen spectra from the Plains. In the southwestern Plains, pinyon pine grains (Pinus edulis) are wind drifted eastward from New Mexico; in the southeastern Plains, grains of short-leaf (P. echinata) and loblolly pine (P. taeda) are wind drifted from Texas and eastern Oklahoma. Several pollen diagrams from the Plains show an increase in pine pollen in levels variously dated between 500 and 1050 yr B.P. (Henry et al., 1979). The rise in pine frequency probably reflects a late-prehistoric increase in abundance of short-leaf pine in eastern Oklahoma. A pollen diagram from Ferndale Bog located in the oak–pine forest (Duck and Fletcher, 1943) of southeastern Oklahoma shows two large increases in pine, one about 1800 yr B.P. and another about 600 yr B.P. (Albert, 1981). The exact nature and cause of the change in pine remain to be determined. Regardless, the pine-pollen rise may serve as a horizon marker in the southeastern Plains.

PAST MOLLUSCAN FAUNAS

Numerous land snails and freshwater mussels have been analyzed from four rockshelters in Hominy Creek and Birch Creek valleys in the Osage Hills. The sites containing abundant mollusks are the same sites in the Oklahoma Cross Timbers discussed previously that have been investigated for pollen.

Freshwater Mussels

The unionacean mussels, harvested from streams and brought to the rockshelters by prehistoric man, are indices to permanence and velocity of stream flow, water depth, and bottom sediment (gravel, sand, or mud). Metcalf (1977a, b, 1980) has studied the bivalves recovered from Big Hawk Shelter, Cut Finger Cave, and Sunny Shelter, as well as the regional modern faunas. He found that, in general, prehistoric faunas had a greater number of species and differed in species composition from those in the area today. At Big Hawk Shelter in Hominy Creek Valley, 689 single valves of 13 species were recovered from rockshelter sediments dated 420 to 1750 yr B.P. The
distribution of species in the rockshelter through time appears fairly even; a greater concentration of valves at medial depth in the site is probably due to increased annual occupancy or greater utilization of mussel resources. There does not appear to be a correspondence between the mussel record from Big Hawk and changes in the land-snail fauna (discussed below) or the pollen sequence. The overall fauna from Big Hawk suggests that the Hominy Creek channel bottom had more gravel and less sand in the past and that it had a more permanent water flow with less suspended silt than today (Metcalf, 1977a). The differences between the modern fauna in Hominy Creek and the prehistoric fauna from Big Hawk Shelter are attributed to recent channel cutting, stream drying in the 1930s and 1950s, and pollution from oil fields (Metcalf, 1980).

\textbf{Land Snails}

The challenge of paleoecologic interpretation of snail faunas dating from the past 2000 yr is very different from the comparison of glacial and nonglacial faunules. With the latter, the widespread displacement of species documents major changes in climate. In contrast, late-prehistoric rockshelters in the Osage Hills generally contain the same species throughout (Fig. 5).

Sediments in the Cross Timber rockshelters are both colluvial and eolian in origin. The snail assemblages include shells washed from adjacent hillslopes and individuals attracted to the shelters by debris from intermittent occupation by prehistoric man. At Big Hawk Shelter, concentrations of snail shells correspond level by level to the densities of nontool flint flakes (Hall, 1980). If differential habitation of the shelter by certain snails had occurred, paleoecological interpretations based on relative frequencies could be in error. When low-density and high-density shell assemblages are compared, however, one species or group of species is neither over- nor under-represented. Also, the simultaneous faunal changes in the rockshelter sequences are too similar to be attributed to influences from man’s presence.

\textbf{Big Hawk Shelter.} The land-snail record from Big Hawk is the best one from the Southern Plains. Excavations in 1976 resulted in 1459 shells (Hall, 1977a); during the 1977 field season, an additional 12,841 shells were recovered. Shell counts by species and at 10-cm intervals from the 1977 excavations are given elsewhere (Hall, 1980).

The principal trend in the Big Hawk snail diagram is the increase in abundance of the striped forest snail (Anguisspira alternata) from the base upward, peaking at 1540 ± 85 yr B.P. (SMU-380), and declining in abundance through the top of the sequence. A. alternata is found most commonly in wooded floodplains but can also occur in moist places on wooded hillslopes (Leopard, 1959). A minor but paleoecologically important component of the Big Hawk fauna is Triodopsis cragini, a dry habitat indicator discussed in more detail in the section on Sunny Shelter where it is one of the dominant species. The appearance of T. cragini when the moist-habitat species A. alternata begins to decline suggests that a period of moister environmental conditions was reversing.

\textbf{Environmental preferences of Plains snails, including the 16 terrestrial species}
from Big Hawk Shelter, are summarized in papers by Leonard (1959) and Metcalf (1962). From Metcalf's work, I have compiled five terrestrial habitat categories that apply to the Osage Hills, including Hominy Creek: (1) moist wooded floodplains, (2) dry wooded slopes, (3) moist prairies with hillside seeps, (4) dry prairies with rocky hillsides, and (5) dry post oak-blackjack oak uplands. The Big Hawk fauna is listed in Table 1 according to habitat preference; Metcalf did not find snails in dry oak uplands, so that category is omitted. Some species are found in more than one habitat category. Gastrocopta armifera, for example, is found in moist wooded floodplains and dry prairie sites although more abundant at dry stations (Metcalf, 1962).
TABLE 1. HABITAT ASSOCIATIONS, BIG HAWK SHELTER LAND-SNAIL FAUNA

<table>
<thead>
<tr>
<th>Species</th>
<th>Moist wooded hillside and floodplains</th>
<th>Dry wooded hillside</th>
<th>Moist prairies and hillside seeps</th>
<th>Dry prairies, rocky hillside</th>
<th>Habitat associations</th>
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</thead>
<tbody>
<tr>
<td>Anguispira alternata</td>
<td>X</td>
<td></td>
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<td></td>
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<tr>
<td>Strobilops labyrinthica</td>
<td>X</td>
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<tr>
<td>Gastrocopta corticaria</td>
<td>X</td>
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<tr>
<td>Mesodon t. thyroides</td>
<td>X</td>
<td></td>
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<td>A</td>
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<tr>
<td>Stenotrema leai aliciae</td>
<td>X</td>
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<tr>
<td>Euconulus sp.</td>
<td>X</td>
<td></td>
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<tr>
<td>Succinea sp.</td>
<td>X</td>
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<tr>
<td>Polygyra d. dorfeuilliana</td>
<td>X</td>
<td></td>
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<td></td>
<td>B</td>
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<tr>
<td>Triodopsis cragini</td>
<td>X</td>
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<tr>
<td>Helicodiscus parallelus</td>
<td>X</td>
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<tr>
<td>Zonitoides arboresus</td>
<td>X</td>
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<tr>
<td>Gastrocopta contracta</td>
<td>X</td>
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<td>C</td>
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<tr>
<td>Vallonia parvula</td>
<td>X</td>
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<tr>
<td>Nesovitrea indentata</td>
<td>X</td>
<td></td>
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<td></td>
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<tr>
<td>Hawaiiia minuscula</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>D</td>
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<tr>
<td>Gastrocopta armiferana</td>
<td>X</td>
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</tbody>
</table>

Relative frequencies of shell counts grouped by habitat associations from Table 1 show that moist-habitat species dominate the overall Big Hawk Shelter fauna (Fig. 6). However, a decreasing abundance of moist wooded floodplain individuals (habitat association A), paralleling the relative frequency profile of *A. alternata,* suggests a gradual decrease in availability of moist wooded microhabitats. When habitat associations A and C (moist wooded and moist prairie) are plotted together, the peak

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Fig. 6. Habitat-associations diagram of Big Hawk Shelter land snails. Species included in associations A–D are listed in Table 1; relative frequencies of these species are shown in Figure 5. Each level represents a 10-cm interval, from 0 to 10 cm at the top to 120- to 130-cm depth at the base. Low shell counts from the basal two levels may account for the irregular frequencies there.
shown by A. alternata is flattened but resumes a marked decline in moist-habitat abundance at a level dated 895 ± 50 yr B.P. (SMU-371). The decrease in moist habitats is mirrored by an increase in dry wooded habitat individuals (association B). Furthermore, the combined shell frequencies in associations A and C flatten the basal portion of the profile, suggesting that an abundance of moist habitats was in existence by 1750 ± 70 yr B.P. (SMU-521), persisting at Big Hawk until 990 yr ago.

Copperhead Cave. The snail succession at Copperhead Cave, a site on Hominy Creek about 8 km east of Big Hawk Shelter, is a composite of two separate but overlapping stratigraphic sequences; the upper section is undated. The intervals of depth indicated in the snail diagram (Fig. 5) are composite stratigraphic thicknesses and are not depth from ground surface (Henry, 1978b). The snail fauna is dominated by A. alternata, but in the upper part of the sequence, postdated 805 ± 60 yr B.P. (SMU-696), abundance decreases as at Big Hawk. The discrepancy in chronology may be due to incorrect correlation of the two separate stratigraphic sections. Discontinuous vertical ranges of low-abundance species in Copperhead Cave are probably related to small sample size. At Big Hawk, similar discontinuous ranges became continuous and profiles smoothed out when the second field season excavations increased the number of shells ninefold.

Cedar Creek Shelter. Cedar Creek Shelter lies immediately adjacent to Copperhead Cave and has a nearly identical land-snail fauna dominated by A. alternata. A sharp decline in A. alternata abundance begins with an interval dated 1010 ± 50 yr B.P. (SMU-495), and indicates a shift away from moister conditions at that time.

Sunny Shelter. Sunny Shelter occurs on Birch Creek and contains a fauna that differs from the rockshelter faunas on Hominy Creek owing to the location of Sunny Shelter in a comparatively drier wooded upland setting. The fauna is dominated by moist-habitat species Helicodiscus parallelus. At an interval with an interpolated age of 1075 yr B.P., H. parallelus decreases in abundance coinciding with increased frequencies of the dry-habitat species T. cragini. T. cragini is restricted in modern distribution to a narrow band from East Texas and western Louisiana northward through eastern Oklahoma and western Arkansas and ending in the corners of southeastern Kansas and southwestern Missouri (Fig. 7). In Kansas it occurs in dry upland oak forests (Leonard, 1959); T. cragini occurs today under rocks around Sunny Shelter, and it is one of the most drought-resistant polygyrids in Oklahoma (Branson, 1962).

The somewhat irregular profiles of snail frequency at Sunny Shelter are probably due to small sample size. Shell counts from Copperhead Cave and Cedar Creek Shelter are given in Hall (1978); shell data from Sunny Shelter appear in Hall (1977c).

PAST VERTEBRATE DISTRIBUTIONS

In addition to providing important pollen and land-snail records, the rockshelters from Hominy Creek and Birch Creek valleys have produced large collections of vertebrate remains (Butler, 1978; Henry et al., 1979). Over 60,000 bone pieces were

![Fig. 7. Modern distribution of Triodopsis cragini.](image-url)
recovered from Big Hawk Shelter alone. However, rigorous identifications and paleoecologic inferences, especially of rodents which can provide valuable insights on past environments (Semken, 1980), have not been made.

The Texas Panhandle and the Prairie Vole

The prairie vole *Microtus ochrogaster* is found in open, generally dry prairie habitats in the central and northern Plains (Fig. 8). Today the prairie vole does not occur in Texas. Specimens from southeastern Texas were collected prior to 1900 but the vole has not been seen there since, although it is still present in prairie habitats in southwestern Louisiana (Davis, 1974). During late Pleistocene the prairie vole probably ranged throughout Texas and adjacent New Mexico (Lundelius, 1967).

Archeological excavations in the Texas Panhandle have resulted in the unexpected recovery of prairie vole remains from three late prehistoric sites: Canyon Country Club Cave and Blue Spring Shelter in Randall County, and Deadman Shelter in Swisher County. At all three sites, *M. ochrogaster* occurs in strata with artifacts that predate the Panhandle Aspect, a prehistoric culture dating from A.D. 1200 to 1500, the significance of which is discussed below. The time span for the dated strata containing *M. ochrogaster* is 840–1650 yr B.P. (Table 2; Hughes, 1978). The identifications of *M. ochrogaster* at the Panhandle sites are not entirely certain; teeth of *M. ochrogaster* cannot be distinguished from those of the pine vole *Pitymys pinetorum* except for the lower third molar (Patton, 1963; Schultz and Rawn, 1978). Owing to the difficulty of separating *M. ochrogaster* and *P. pinetorum*, Graham (1976) refers to doubtful specimens as *M. ochrogaster*|*pinetorum*.

Fig. 8. Present and past distribution of the prairie vole *Microtus ochrogaster*. Modern range modified from E. R. Hall (1981); open triangles are historic outliers discussed by Armstrong (1972) and Findley et al. (1975). Black circles are late-Holocene prairie-vole records (see Table 2); numbered open circles are late-Pleistocene and early-Holocene records: (1) Howells Ridge Cave (Harris, 1977), (2) Dry Cave (Harris, 1977), (3) Blackwater Draw, Brown Sand Wedge (Slaughter, 1975; Harris, 1977), (4) Schulze Cave (Dalquest et al., 1969), (5) Lubbock Lake Site (Johnson, 1974), (6) Howard Ranch local fauna (Dalquest, 1965), (7) Robert local fauna (Schultz, 1967), and (8) Friesenhahn Cave (Graham, 1976).
In the case of the Texas Panhandle, however, the paleoenvironmental implications are the same, whether the remains are of prairie vole or pine vole; both species live farther east (E. R. Hall, 1981) and require moister habitats than are generally available in the Panhandle today.

The late-prehistoric Texas Panhandle records of *M. ochrogaster* (or *M. ochrogaster/pinetorum*) may represent a relict population from more widespread Pleistocene distribution. The late-Holocene sites containing the faunal material occur along the margins of the Palo Duro and Tule canyons that are cut deeply into the High Plains caprock escarpment, providing a microhabitat not generally found in the Plains. The isolated relict colonies could probably respond quickly to increased moisture availability, expanding their range in the canyons along the escarpment and increasing the opportunity for their incorporation in rockshelter deposits. Alternatively, the records may represent a brief late-Holocene invasion of the Panhandle by a westward expansion of the main population that today is only 280 km east of the Panhandle sites.

The presence of *M. ochrogaster* in the Texas Panhandle 840–1650 yr B.P. is regarded as evidence for conditions moister than those of today (Duffield, 1970; Schultz and Rawn, 1978; Hughes, 1978). *M. ochrogaster* is the only species recorded from the Panhandle sites, however, that prefers moister habitats. Other small mammals that could be expected as relicts or possible westward immigrants along with the prairie vole, such as *Blarina brevicauda*, *Synaptomyx cooperi*, *Oryzomys palustris*, and *Scalopus aquaticus*, are not found at the Panhandle sites.

Prairie-vole populations are sensitive to extremes in climate and succumb to prolonged drought (Dice, 1922). During the 1930s, for example, the prairie-vole population of western Kansas became extinct during six years of exceptionally dry weather (Choate and Williams, 1978). The prairie vole’s absence from the Panhandle today and its presence in the past, however, does not necessarily mean that the Panhandle climate during the late Holocene was moister than today’s climate. The late-Holocene colonies could have been wiped out by a 1930s-style drought sometime after 840 yr B.P., thus eliminating the possibility of prairie-vole recolonization upon the return to less dry conditions.

If the change in climate to drier conditions about 1000 yr B.P. documented in northeastern Oklahoma applies to the rest of the Southern Plains, it may have contributed to the extinction of the prairie vole in the Panhandle and to the elimination of other isolated enclaves of small mammals (Table 2). Some forms, however, persisted for a long time. *P. pinetorum* survived until recently at Longhorn Cavern in central Texas, and the recent range restriction of *Geomys bursarius* may be explained by recent denudation of the thick soil cover needed for burrows (Semken, 1961). In a review of Texas vertebrate faunas, Lundelius (1967) concluded that, in general, the modern mammalian faunal composition was reached about A.D. 1000 (950 yr B.P.). Whether or not the change to drier conditions 1000 yr B.P. could have played a role in mammalian range shifts cannot be determined with certainty until additional dated local faunas from other areas in the Southern Plains are available for comparison.

**Bison Populations and Climate**

At the mention of the Plains, one thinks of great herds of bison. However, Dillehay (1974) has shown in a review of faunal remains from Southern Plains archeologic sites that populations have fluctuated greatly in the past and, indeed, bison may have been absent during the period A.D. 500–1200 (1450 to 750 yr B.P.). The absence of bison correlates partly with the period of moister conditions, seemingly contradicting the bison’s fondness for abundant green grass (Frison, 1978). At the time of Dille-
<table>
<thead>
<tr>
<th>Species/Site</th>
<th>Age (yr B.F.)</th>
<th>Distance from Modern Range (km)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microtus ochrogaster</td>
<td></td>
<td></td>
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<tr>
<td>Canyon Country Club Cave</td>
<td>Level 4; 1650–1270</td>
<td>280</td>
<td>Duffield, 1970; Hughes, 1978</td>
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<tr>
<td>Blue Spring Shelter</td>
<td>840–1135</td>
<td>280</td>
<td>Hughes, 1978</td>
</tr>
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<td>Miller’s Cave</td>
<td>Brown clay unit; 3000</td>
<td>460</td>
<td>Patton, 1963; Lundelius, 1967</td>
</tr>
<tr>
<td>Pitymys pinetorum</td>
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<td></td>
<td></td>
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<tr>
<td>Longhorn Cavern</td>
<td>&lt;200</td>
<td>300</td>
<td>Semken, 1961</td>
</tr>
<tr>
<td>Rattlesnake Cave</td>
<td>&lt;200</td>
<td>150</td>
<td>Semken, 1967</td>
</tr>
<tr>
<td>Kyle site</td>
<td>Two levels; 980–1390, 390–673</td>
<td>210</td>
<td>Lundelius, 1967</td>
</tr>
<tr>
<td>Geomys bursarius</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Longhorn Cavern</td>
<td>&lt;200</td>
<td>65</td>
<td>Semken, 1961; Lundelius, 1967</td>
</tr>
<tr>
<td>Rattlesnake Cave</td>
<td>&lt;200</td>
<td>120</td>
<td>Semken, 1967; Lundelius, 1967</td>
</tr>
<tr>
<td>Pratt Cave</td>
<td>&lt;2090</td>
<td>160</td>
<td>Lundelius, 1979</td>
</tr>
<tr>
<td>Kyle site</td>
<td>Two levels; 980–1390, 390–673</td>
<td>Locally extinct</td>
<td>Lundelius, 1967</td>
</tr>
<tr>
<td>Barton Road site</td>
<td>Cultural and noncultural units</td>
<td>Locally extinct</td>
<td>Lundelius, 1967</td>
</tr>
<tr>
<td>Onychomys leucogaster</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dye Creek</td>
<td>1350</td>
<td>150</td>
<td>Dalquest and Hibbard, 1965</td>
</tr>
<tr>
<td>Kyle site</td>
<td>Two levels; 390–670, 980–1390</td>
<td>160</td>
<td>Lundelius, 1967</td>
</tr>
<tr>
<td>Pratt Cave</td>
<td>2090–2560</td>
<td>40</td>
<td>Lundelius, 1979</td>
</tr>
</tbody>
</table>
hay’s review, however, there were no dated sites from the High Plains during the bison-absence period (the Duncan-Wilson shelter shown by Dillehay, Fig. 5, in southwestern Oklahoma is actually located 160 km to the northeast in Caddo County). More recently, Deadman Shelter, from which *M. ochrogaster* is reported, has produced remains of bison from levels dated 1830–1200 yr B.P. (Schultz and Rawn, 1978). A review of sites from north-central Texas shows that bison were present in small numbers throughout the past 2000 yr (Lynott, 1979). The moist period 2000–1000 yr B.P. should have resulted in generally increased availability of green grass in the Plains. When additional sites dating from this period are excavated, they may contain bison.

### PAST CLIMATE AND THE PANHANDLE ASPECT

The pollen and land-snail studies from northeastern Oklahoma provide the first well-dated record of late-Holocene paleoecology from the Southern Plains, and it would be remiss not to compare the results to the often-cited climatic reconstructions of Bryson *et al.* (1970). A series of globally synchronous episodes of postglacial climatic changes has been proposed, based on compilations of radiocarbon dates largely from pollen sequences in northwestern Europe and northeastern United States (Bryson and Wendland, 1967; Wendland and Bryson, 1974). Wright (1976) criticizes the climatic subdivisions, observing that Holocene vegetation shifts are gradual and lack the abruptness implied by rigid episodic divisions. The Oklahoma pollen and land-snail records show gradual changes, and the transition from moist to dry conditions at the several sites investigated ranges from 1130 to 800 yr B.P. (Table 3), although a single time horizon for the change is best placed at 1000 yr B.P. The entire moist period (2000–1000 yr B.P.) corresponds roughly but not precisely to the “Scandic” (1680–1260 yr B.P.) and
TABLE 3. CHRONOLOGY OF PAST ENVIRONMENTAL CHANGE

<table>
<thead>
<tr>
<th>Site</th>
<th>Moist period (yr B.P.)</th>
<th>Transition (yr B.P.)</th>
<th>Dry period (yr B.P.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollen records</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Big Hawk Shelter</td>
<td>1620+−1130</td>
<td>1130−900</td>
<td>900−420−</td>
</tr>
<tr>
<td>Little Caney Valley</td>
<td>1980+−1100</td>
<td>1100−800</td>
<td>800−present</td>
</tr>
<tr>
<td>Land-snail records</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Big Hawk Shelter</td>
<td>1750+−990</td>
<td>990</td>
<td>990−420−</td>
</tr>
<tr>
<td>Copperhead Cave</td>
<td>1440+−800−</td>
<td>Post-800</td>
<td>Post-800−present?</td>
</tr>
<tr>
<td>Cedar Creek Shelter</td>
<td>1540+−1010</td>
<td>1010</td>
<td>1010−(700)</td>
</tr>
<tr>
<td>Sunny Shelter</td>
<td>1175+−1075</td>
<td>1075</td>
<td>1075−720−</td>
</tr>
</tbody>
</table>

"See discussion of stratigraphy in text.

"neo-Atlantic" (1260−800 yr B.P.) periods of Wendland and Bryson (1974).

Attempts to correlate the northeastern Oklahoma sequence with the climatic episodes, however, must take into account the following limitations in the data. The Oklahoma pollen and snail records after 400 and prior to 1700 yr B.P. are sparse. Also, the well-documented Big Hawk Shelter record has an uncertainty of resolution that applies as well to the other rockshelters. Big Hawk was excavated in 10-cm intervals, each interval now known to represent about 140 yr. This means that climatic changes cannot be resolved within a range less than 140 yr and that climatic events of less than 140-yr duration would either not show up at all in the pollen or land-snail record or would appear as a minor profile fluctuation that would probably be interpreted as data noise. Thus, the pollen and land-snail sequences reported here from northeastern Oklahoma are not sufficiently sensitive to document short-term climatic shifts, such as 100- to 200-yr duration, that could nevertheless have great impact on the culture and subsistence of prehistoric groups in the Plains. Even though the northeastern Oklahoma records show a lack of precision, they indicate a shift to drier climate 1000 yr B.P. which is not considered to be synchronous with the Bryson et al. (1970) climatic episodes.

The global climatic episodes have been applied by Bryson et al. (1970) to explain the development of the Panhandle Aspect. The Panhandle Aspect, located in the Texas Panhandle and adjacent Oklahoma, is a prehistoric culture dated A.D. 1200–1500 and characterized by stone houses, bison tibia digging-stick tips, manos and metates, and notched bone rasps (Lintz, 1978). Bryson and others have proposed that a group of people migrated to the Panhandle area in A.D. 1200 from western Iowa and eastern Nebraska where they are known as the Upper Republican culture. The Upper Republican, dated A.D. 1050–1350, is characterized by square earth lodges, pottery elbow pipes, and collared rim pottery (Lintz, 1978). The migration model is based on relative chronologies (the Panhandle Aspect postdates the Upper Republican) as well as reconstructed air masses and mean frontal zones. According to the model, if the westerlies had increased in the Plains during the 12th century, as has been suggested for Western Europe at that time, July rainfall in the Iowa–Nebraska area would have been diminished and rainfall in most of the Southern Plains would have been increased (Bryson et al., 1970). The model states that the Upper Republican group would have left the central plains because of drought and migrated south to the Texas Panhandle where the climate was moister, the people there developing a culture now known as the Panhandle Aspect.

The migration model is not without criticism on archaeological grounds. The absence of transitional sites in Kansas (Wedel, 1968), the lack of similarity of
skulls from Panhandle Aspect and Upper Republican populations (McWilliams and Johnson, 1979), and the fact that the Panhandle area was occupied earlier by Plains Woodland people suggest that the Panhandle Aspect culture may have been a local development and not necessarily a result of Upper Republican migration from the north (Lintz, 1978).

The pollen and land-snail sequence from northeastern Oklahoma indicates that the late-Holocene climate did indeed change in the Southern Plains, but the climate became drier, not moister, and the change occurred well before the 12th century. Thus the climatic model for the origin of the Panhandle Aspect is strongly questioned.

PALEOECOLOGY

The pollen and land-snail sequences from northeastern Oklahoma indicate that the Southern Plains were moist between about 2000 and 1000 yr B.P. (Table 3). The evidence for moist climate includes (a) comparatively high frequencies of hickory pollen at Big Hawk Shelter, (b) a high water table at Little Caney River Valley indicated by high frequencies of grass pollen, (c) abundance of A. alternata at Big Hawk, Copperhead, and Cedar Creek sites, (d) abundance of moist-habitat snails at Big Hawk Shelter, and, possibly, (e) the presence of the prairie vole M. ochrogaster in the Texas Panhandle. About 1000 yr B.P. the climate changed, resulting in dry conditions that probably have persisted. The onset of drier conditions is documented by changes in the above records in addition to the appearance and increase in abundance of T. cragini at Big Hawk and Sunny shelters.

ACKNOWLEDGMENTS

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Semken, H. A., Jr. (1967). Mammalian remains from Rattlesnake Cave, Kinney County, Texas. Pearce-Sellards Series 7, Texas Memorial Museum, University of Texas, Austin.


