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Late Pleistocene and Early Holocene Vertebrates and Paleoenvironments on the Southern High Plains, U.S.A.

Les vertébrés et paléoenvironnements du Pléistocène supérieur et de l'Holocène inférieur dans les hautes plaines du Sud, États-Unis

Wirbeltieoe und Paleoumgebung im späten Pleistozän und frühen Holozän in den Hochebenen des Südens, U.S.A.

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Article abstract

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LATE PLEISTOCENE AND EARLY HOLOCENE VERTEBRATES AND PALEOENVIRONMENTS ON THE SOUTHERN HIGH PLAINS, U.S.A.*

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ABSTRACT Only a few vertebrate faunas are known for the Southern High Plains from the late Pleistocene and early Holocene. This review focuses on vertebrate local faunas from two major localities on opposite sides of the region but in the same drainage system that provide proxy data for paleoenvironmental reconstructions from *ca.* 11,600 to 8600 yr BP. Both localities are archaeological sites within deeply stratified, radiocarbon-dated deposits. Four distinct, successive vertebrate local faunas are known for Lubbock Lake covering the period 11,100 to 8600 yr BP. Two distinct, successive vertebrate local faunas come from Blackwater Draw Locality #1 for the period 11,600 to 10,500 yr BP. All of the local faunas are disharmonious but the extent of disharmony and diversity varies. Faunal elements from the Northern Plains and Southeast are the most notable. The late Pleistocene local faunas indicate mild winters which did not maintain freezing conditions and cool summers with a more effective moisture regime, reduced annual temperature fluctuation, and less seasonality. The beginnings of a warming trend, greater seasonality, and increased annual temperature fluctuation denote the early Holocene. The latest local fauna marks the last of the pluvial-related ones and heralds the end of pluvial conditions beginning around 8500 yr BP. The successive local faunas illustrate the complexity of disharmony occurring in unglaciated regimes *during deglaciation of North America.*

RÉSUMÉ *Les vertébrés et paléoenvironnements du Pléistocène supérieur et de l'Holocène inférieur dans les hautes plaines du Sud, États-Unis.* On ne connaît que quelques faunes de vertébrés datant du Pléistocène supérieur et de l'Holocène inférieur dans les plaines du Sud. Le présent article étudie les faunes locales de vertébrés relevées dans deux sites importants, Lubbock Lake et Blackwater Draw Locality #1, se trouvant aux deux extrémités de la région. Ils font néanmoins partie du même bassin hydrographique et fournissent des données indirectes permettant de reconstituer les paléoenvironnements de 11 600 à 8600 BP environ. Les deux sites se trouvent dans des dépôts fortement stratifiés et datés au radiocarbone. À Lubbock Lake, quatre faunes locales distinctes se sont succédé de 11 100 à 8600 BP; au Blackwater Draw Locality #1, deux faunes locales se sont succédé de 11 600 à 10 500 BP. Les faunes locales comptent toutes des éléments étrangers au milieu, mais dont l'importance varie. Les éléments fauniques des plaines du nord et du sud-est sont les plus remarquables. La nature des faunes locales du Pléistocène supérieur révèle l'existence d'hivers doux sans gel soutenu et d'étés frais et humides, de faibles fluctuations des températures annuelles et des changements saisonniers peu marqués. Celle de l'Holocène inférieur révèle un début de réchauffement, des changements saisonniers plus marqués et une plus grande fluctuation des températures annuelles. Les faunes locales les plus récentes vivaient à une époque pluviale et annoncent, vers 8500 BP, la fin de cette époque. Les faunes locales successives reflètent la complexité du milieu, caractéristique des régimes non glaciaires en Amérique du Nord au cours de la déglaciation.

ZUSAMMENFASSUNG *Wirbeltiere und Paleoumgebung im späten Pleistozän und frühen Holozän in den Hochebenen des Südens, U.S.A.* Nur wenige Wirbeltier-Faunas sind in den Hochebenen des Südens aus dem späten Pleistozän und dem frühen Holozän bekannt. Dieser Artikel studiert die lokalen Wirbeltier-Faunas von zwei Haupt-Fundstellen, die sich an entgegengesetzten Seiten der Gegend befinden, jedoch zum selben Drainage-System gehören und indirekte Daten für die Rekonstruktion der Paleo-Umgebungen für die Zeit von ungefähr 11 600 bis 8600 v.u.Z. vermitteln. Beide Fundstellen sind archäologische Plätze, die sich in tief geschichteten, Radiokarbon-datierten Ablagerungen befinden. Für Lubbok-Lake sind vier verschiedene, aufeinander folgende lokale Wirbeltier-Faunas bekannt, in der Zeitspanne von 11 100 bis 8600 Jahren v.u.Z. Zwei verschiedene lokale Wirbeltier-Faunas sind in der Zeit von 11 600 bis 10 500 Jahren v.u.Z. in Blackwater Draw Locality #1 aufeinandergefolgt. All diese lokalen Faunas sind disharmonisch, aber das Ausmaß der Disharmonie und Diversität variiert. Die Fauna-Elemente von den Ebenen des Nordens und Südostens sind am bemerkenswertesten. Die lokalen Faunas des späten Pleistozän weisen auf milde Winter ohne anhaltenden Frost und kühle Sommer mit effektiveren Feuchtigkeitsverhältnissen, reduzierter Jährlicher Temperaturschwankung und geringeren *Unterschieden zwischen den Jahreszeiten.* Das frühe Holozän weist eine Tendenz zur Erwärmung, grössere Jahreszeitenunterschiede und größere Jährliche Temperaturschwankungen auf. Die jüngste lokale Fauna ist die letzte vom Pluvial bestimmte und kündigt das Ende der Pluvial Zeit an, das ungefähr 8,500 Jahre v.u.Z. beginnt. Die aufeinander folgenden lokalen Faunas illustrieren die Komplexität der Disharmonie, die während der nichtglazialen Zeiten auftritt, in der Zeit der Enteisung von Nordamerika.

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INTRODUCTION

The Southern High Plains (or Llano Estacado), the southermost portion of the High Plains physiographic section, is a broad plateau covering about 130,000 km^2 in northwest Texas and eastern New Mexico (Fig. 1). The Southern High Plains is defined by escarpments along the east, north, and west sides but merges with the Edwards Plateau of Central Texas along the southern edge (HAWLEY *et al.*, 1976; HOLLIDAY, 1982, 1985a). The regional climate is dry, midlatitude, and semidesert (STRAHLER and STRAHLER, 1983). Although considerable interannual variation occurs (NOAA, 1982a, 1982b), the average annual precipitation ranges from 46.8 cm in the eastern portion (Lubbock, Texas) to 42.3 cm on the western side (Clovis, New Mexico).

Fluvial and aeolian sediments of the Ogallala Formation (Miocene-Pliocene) form the local bedrock. An extensive deposit of aeolian sediments, the Blackwater Formation (Pleistocene), covers the bedrock units and created the regional level topography. This surface was modified by the formation of thousands of ephemeral lake basins (locally known as playas), major dune fields, and a number of northwest to southeast trending ephemeral drainages (draws) which are tributaries of the Red, Brazos, and Colorado rivers (HAWLEY *et al.*, 1976; HOLLIDAY, 1982, 1985a).

Only a few vertebrate faunas are known for the region from the late Pleistocene and early Holocene (EVANS and MEADE, 1945; LUNDELIUS *et al.*, 1983; SEMKEN, 1983). The focus of this paper is on vertebrate faunas from 11,600 to 8600 yr BP that provide proxy data for paleoenvironmental reconstructions. The most significant faunas come from one locality on the eastern side of the Southern High Plains, that of Lubbock Lake (Fig. 1). Lubbock Lake (41LU1) has a detailed and extensive vertebrate record that ranges in time from the latest Pleistocene through the historic (JOHNSON, 1976) within a deeply stratified and well-dated context (HOLLIDAY, 1985a; HOLLIDAY *et al.*, 1983, 1985). The only other major vertebrate fauna (LUNDELIUS, 1972; HUGHES, 1984) known for the region comes from Blackwater Draw Locality #1, a deeply stratified locality on the western side of the Southern High Plains (Fig. 1). Other significant vertebrate faunas are unknown although a few localities have produced limited assemblages, primarily of extinct bison (*Bison antiquus*).

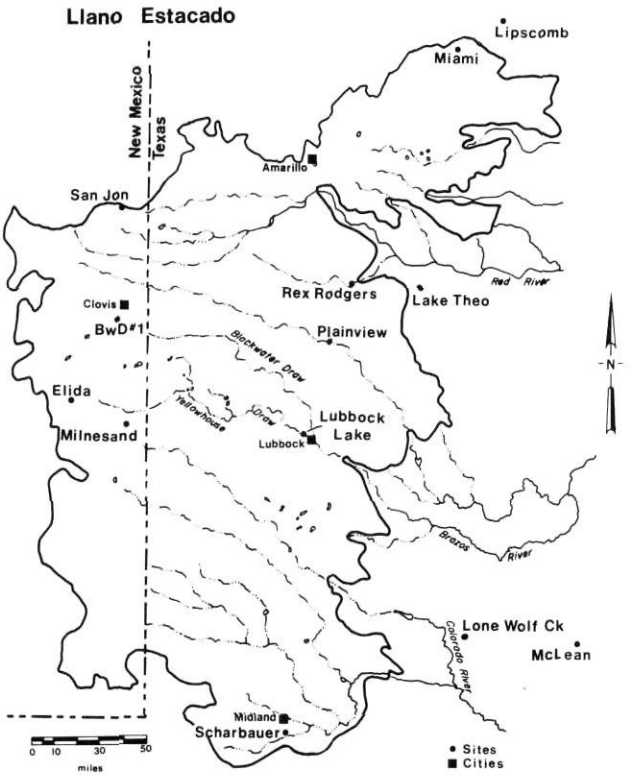

FIGURE 1. Map of the Southern High Plains (Llano Estacado) locating Lubbock Lake and Blackwater Draw Locality #1 which produced late Pleistocene and early Holocene vertebrate local faunas, and other Paleoindian sites in the region.

Carte des hautes plaines du Sud (Llano Estacado) qui montre la localisation du Lubbock Lake et de Blackwater Draw Locality #1, qui ont révélé l'existence de faunes locales de vertébrés du Pléistocène supérieur et de l'Holocène inférieur, et d'autres sites paléoindiens.

THE LOCALITIES

Both Lubbock Lake (JOHNSON, 1976) and Blackwater Draw Locality #1 (Fig. 1) (HESTER, 1972) are archaeological sites within stratified deposits. Extensive vertebrate recovery with intensive microvertebrate sampling has been a major methodological focus at Lubbock Lake (JOHNSON, 1976, 1983), producing four major local faunas within a 2500 year period (11,100-8600 yr BP). Such a program was not a primary objective at Blackwater Draw Locality #1 (HESTER, 1972). Nevertheless, the archaeological recovery work produced a diversified local fauna from the latest Pleistocene (11,600-11,000 yr BP) associated with the Clovis culture (LUNDELIUS, 1972; HUGHES, 1984) and a limited local fauna from the earliest Holocene (*ca.* 10,500 yr BP) associated with the Folsom culture (HUGHES, 1984). Another local fauna (11,600-10,500 yr BP) described from the site (SLAUGHTER, 1975) is time-transgressive. The geologic unit from which it comes (Unit C) encompasses a period that represents successive geologic events and signifies major geologic, climatic, and hydrologic changes. Therefore, this local fauna is pertinent only to the local situation.

Lubbock Lake (LL) is situated in valley fill in an entrenched meander of Yellowhouse Draw (Fig. 2) which is an ephemeral tributary of the Brazos River (Fig. 1). The draw still was incising in the latest Pleistocene, but aggradation began about 11,000 yr BP and the draw has been filling intermittently throughout the Holocene (HOLLIDAY, 1982, 1983, 1985a). Lubbock Lake is an extensive complex site with a virtually complete cultural, faunal, and floral record within a sequence of sediments and soils up to 8 m thick that span at least the past 11,500 years (JOHNSON, 1976, 1983; HOLLIDAY, 1982, 1983, 1985a; HOLLIDAY *et al.*, 1983, 1985).

Five basic geologic units (numbered oldest to youngest) and five named soils formed in the deposits were identified

FIGURE 2. Aerial view of the basin section of the Lubbock Lake Landmark showing a large meander and the walls of the draw.

Vue aérienne du bassin lacustre de Lubbock Lake qui montre un large méandre et les murs du couloir de drainage.

in the late Quaternary valley fill (HOLLIDAY, 1982, 1985a). The ages of the substrata, soils, and cultural features are well-controlled by over 115 radiocarbon determinations (HOLLIDAY *et al.*, 1983, 1985).

Stratum 1 consists of sand and gravel (substratum 1A), crossbedded sands (substratum 1B), and on overlying clay drape (substratum 1C). Stratum 1 represents a meandering stream deposit with point bar sediments (1A) and overbank deposits (1B and 1C). Fluvial activity ceased at about 11,000 yr BP (HOLLIDAY, 1982, 1985a). The main cultural occupation from the Clovis period is dated to 11,100 yr BP (JOHNSON and HOLLIDAY, 1985; JOHNSON, 1983).

Stratum 2, a lacustrine deposit, conformably overlies stratum 1. Substratum 2A contains beds of pure diatomite with interbedded peaty muds. Substratum 2B consists of a homogeneous sapropelic mud deposit. The Firstview Soil formed in the upper part of 2B. Stratum 2 represents a sequence from open to marshy ponds to a slowly aggrading bog with little to no standing water. Soil development marks a stable land surface with little deposition or erosion occurring (HOLLIDAY, 1982, 1985a). The Firstview Soil began forming about 8500 yr BP (HOLLIDAY 1982, 1985a).

Substratum 2A contains the Folsom cultural material dating between 10,800 to 10,300 yr BP. Plainview materials are found in lower 2B at the 2B-2A contact and date 10,000 yr BP. Upper 2B contains the Firstview occupation dating around 8600 yr BP (HOLLIDAY *et al.*, 1983, 1985).

Blackwater Draw Locality #1 (BWD #1) is situated in fill in a small basin tributary to Blackwater Draw, another ephemeral tributary of the Brazos River (Fig. 1). Blackwater Draw and Yellowhouse Draw join about 6 km downstream from Lubbock Lake to form Yellowhouse Canyon. Blackwater Draw Locality #1 is another extensive complex site and shares with Lubbock Lake a similar geologic and cultural history, particularly the latest Pleistocene to middle Holocene record (HAYNES, 1975; HOLLIDAY, 1985a, 1985b).

Seven geologic units and several unnamed soils formed in the deposits are recognized in the late Quaternary basin fill (HAYNES, 1975; HOLLIDAY, 1985b). Several radiocarbon determinations are available from the various strata and soils (HESTER, 1972; HAYNES, 1975; HOLLIDAY, 1985b).

The geologic units of interest are Unit B and Unit D (also known as stratum 1 and stratum 2 respectively, SELLARDS, 1952). Unit B is composed of spring sediments. This fluvial activity ceased about 11,000 yr BP (HAYNES, 1975). The Clovis occupation which yielded the vertebrate fauna under review has three radiocarbon determinations on carbonized plant remains: 11,630 ± 400 yr BP (A 491); 11,170 ± 360 yr BP (A 481); 11,040 ± 500 yr BP (A 490) (HESTER, 1972). This unit, at least the upper part, appears equivalent to stratum 1 at Lubbock Lake.

Unit D, a lacustrine deposit, unconformably overlies Unit B wherever they are found juxtaposed in the stratigraphic section. Unit D consists of laminated (poorly developed) diatomite and peaty muds representing ponding of the spring waters. This unit contains Folsom cultural material. The Folsom occupation which yielded the vertebrate fauna under review has two radiocarbon determinations on carbonized plant remains: 10,490 ± 200 yr BP (A 492); 10,170 ± 250 yr BP (A 488). Elsewhere in the site, this unit yielded determinations on carbonized plant remains of 10,250 ± 320 yr BP (A 379-380) and 10,490 ± 900 yr BP (A 386) (HESTER, 1972). This unit is equivalent to substratum 2A at Lubbock Lake.

VERTEBRATE LOCAL FAUNAS

In determining geographic faunal elements, the region closest to the two archaeological sites and the Southern High Plains or the region of greatest sympatric overlap was considered. Although an animal may have a widespread distribution (such as *Ondatra zibethicus*), it was viewed as part of a suite of animals that characterized a particular region. An assumption was made of a modern framework in which to contrast changes in the past. While modern conditions are not necessarily the norm, they provide a fixed reference point.

All of the local faunas are disharmonious (SEMKEN, 1974, 1983) but the extent of disharmony and diversity varies. Disharmony generally decreases through time as extra-regional faunal influences wane. The overall diversity of the faunas decreases from the late Pleistocene to early Holocene because of extinction and shifting ranges (Table I, II, III). However, within extant forms, diversity remains consistently high. The local faunas primarily reflect pluvial conditions within grasslands and riparian habitats.

Grasslands is used as a general term because the specific character of the vegetation varied throughout the period under discussion but grasses dominated. As used in this discussion, parkland is a grassland interrupted occasionally by small stands of trees. Savannah is an uninterrupted grasslands with scattered trees. A scrub-grasslands is a prairie with brush and rare trees (BRYANT and SHAFER, 1977:6).

Among the 76 taxa of the Lubbock Lake Clovis local fauna (Table I), 18% are extinct forms and 26% no longer range

TABLE I

Lubbock Lake Paleoindian vertebrate local faunas

Clovis local fauna (11,100 yr. BP)	Folsom local fauna (10,800-10,300 yr. BP)	Plainview local fauna (10,000 yr. BP)	Firstview local fauna (8,600 yr. BP)
+ *Lepisosteus* sp.	*Ictalurus* (cf. *Ameiurus*)	*Ictalurus* sp.	*Ictalurus* sp.
+ *Carpiodes cyprinus*	+ *Morone chrysops*	*Ictalurus* (cf. *Ameiurus*)	*Ambystoma trigrinum*
Ictalurus (cf. *Ameiurus*) sp.	+ *Lepomis gulosus*	*Ambystoma tigrinum*	*Rana catesbeiana*
Ictalurus melas	*Percina* sp.	*Bufo* sp.	*Rana pipiens*
Ictalurus punctatus	*Rana catesbeiana*	*Rana catesbeiana*	*Chelydra serpentina*
Lepomis cyanellus	*Rana pipiens*	*Rana pipiens*	*Kinosternon flavescens*
Ambystoma tigrinum	*Kinosternon flavescens*	*Chelydra serpentina*	*Chrysemys scripta*
Scaphiopus bombifrons OR *S. hammondi*	*Chrysemys scripta*	*Kinosternon flavescens*	*Terrapene ornata*
Acris crepitans	*Elaphe* OR *Pituophis*	*Chrysemys scripta*	*Phrynosoma cornutum*
Bufo cognatus	+ *Thamnophis* cf. *sirtalis*	*Terrapene ornata*	*Eumeces obsoletus*
≠ *Bufo woodhousei bexarensis*	*Anas crecca carolinensis*	*Eumeces obsoletus*	+ *Thamnophis* cf. *sirtalis*
Rana catesbeiana	*Circus cyaneus*	+ *Coluber constrictor*	*Anas platyrhynchos*
+ *Rana palustris*	*Rallus limicola*	*Lampropeltis getulus*	*Anas acuta*
Rana pipiens	*Fulica americana*	+ *Nerodia* cf. *cyclopion* OR *N.* cf. *rhombifera*	*Anas crecca carolinensis*
Chelydra serpentina	*Chordeiles* cf. *minor*	+ *Sonora semiannulata*	*Anas cyanoptera*
Kinosternon flavescens	*Colaptes auratus*	*Thamnophis marcianus*	*Tympanuchus cupido* OR *Centrocercus urophasianus*
≠ *Geochelone wilsoni*	cf. *Eremophila alpestris*	*Thamnophis proximus*	*Tympanuchus cupido* OR *"Pedioecetes" phasianellus*
≠ *Geochelone* sp.	*Mimus polyglottis*	+ *Thamnophis* cf. *sirtalis*	+ *Rallus* cf. *longirostris*
Chrysemys scripta	*Notiosorex crawfordi*	+ *Tropidoclonion lineatum*	*Porzana carolina*
≠ *Terrapene carolina puttnami*	*Lepus californicus*	+ *Agkistrodon contortrix*	+ cf. *Laterallus exilis*
+ *Trionyx* sp.	*Spermophilus tridecemlineatus*	*Podiceps* cf. *nigricollis*	*Agelaius phoeniceus*
+ *Carphophis amoenus*	*Cynomys ludovicianus*	*Podilymbus* cf. *podiceps*	*Molothrus* cf. *ater*
Elaphe guttata	*Geomys bursarius*	*Anas platyrhynchos*	*Sylvilagus* cf. *audubonii*
+ *Gyalopion canum*	*Perognathus* cf. *hispidus*	*Anas strepera* OR *A. acuta*	*Lepus californicus*
Heterodon nasicus	*Sigmodon hispidus*	*Anas clypeata*	*Spermophilus tridecemlineatus*
Lampropeltis triangulum	+ *Microtus pennsylvanicus*	*Anas crecca carolinensis*	*Spermophilus mexicanus*
Nerodia sp.	+ *Microtus ochrogaster*	+ *Gallinula chloropus*	*Cynomys ludovicianus*
+ *Salvadora* sp.	+ *Ondatra zibethicus*	*Fulica americana*	*Geomys bursarius*
+ *Sonora semiannulata*	*Canis latrans*	+ *Charadrius montanus*	*Dipodomys ordii*
+ *Thamnophis* cf. *sirtalis*	*Canis lupus*	*Notiosorex crawfordi*	*Onychomys leucogaster*
+ *Tropidoclonion lineatum*	≠ *Capromeryx* sp.	*Sylvilagus* sp.	*Sigmodon hispidus*
+ *Virginia* cf. *striatula*	≠ *Bison antiquus*	*Lepus californicus*	*Neotoma* cf. *micropus*
Crotalus atrox		*Spermophilus tridecemlineatus*	*Neotoma* cf. *albigula*
Branta canadensis		*Spermophilus mexicanus*	+ *Microtus pennsylvanicus*
Anser caerulescens		*Cynomys ludovicianus*	+ *Microtus* cf. *ochrogaster*
Anas platyrhynchos		*Geomys bursarius*	+ *Ondatra zibethicus*
Anas acuta		*Dipodomys ordii*	*Canis latrans*
Anas cf. *clypeata*		*Reithrodontomys montanus*	*Canis lupus*
Anas crecca carolinensis		*Onychomys leucogaster*	*Taxidea taxus*
Meleagris sp.		*Sigmodon hispidus*	*Felis* cf. *rufus*
Rallus limicola		*Neotoma* cf. *micropus*	*Odocoileus* sp.
Fulica americana		+ *Microtus pennsylvanicus*	*Antilocapra americana*
Athene cf. *cunicularia*		+ *Microtus ochrogaster*	≠ *Bison antiquus*
+ *Corvus corax*		+ *Ondatra zibethicus*	
cf. *Agelaius phoniceus*		+ *Synaptomys cooperi*	
cf. *Pooecetes gramineus*		*Canis lupus*	
+ *Blarina* sp.		*Odocoileus* sp.	
≠ *Holmesina septentrionalis*		*Antilocapra americana*	
Lepus californicus		≠ *Bison antiquus*	
+ *Spermophilus richardsonii*			
Spermophilus tridecemlineatus			
Spermophilus mexicanus			
Cynomys ludovicianus			
+ *Thomomys bottae*			
Geomys bursarius			
Reithrodontomys montanus			
+ *Peromyscus* cf. *eremicus*			
Onychomys leucogaster			
Neotoma cf. *micropus*			
+ *Microtus pennsylvanicus*			
+ *Microtus ochrogaster*			
+ *Ondatra zibethicus*			
Canis latrans			
Canis lupus			
+ *Vulpes macrotis*			
≠ *Arctodus simus*			
≠ *Mammuthus columbi*			
≠ *Equus mexicanus*			
≠ *Equus francisci*			
≠ *Platygonus compressus*			
≠ *Camelops hesternus*			
≠ *Hemiauchenia* sp.			
≠ *Capromeryx* sp.			
≠ *Bison antiquus*			

into the area. A little over half (56%) the fauna is from within its modern range. Therefore, 44% of that assemblage is unknown to the modern community structure.

Among the extant fauna, three areas of sympatry occur. Faunal elements come from the Northern, Southeast (Louisana), and Trans-Pecos (south) areas. The Northern forms are separated into a northwestern group represented by *Microtus pennsylvanicus, M. ochrogaster, Ondatra zibethicus*, and *Spermophilus richardsonii*; and a northeastern group containing *Carpiodes cyprinus* and *Carphophis amoenus*. Southeastern forms include *Blarina* sp., *Lepisosteus* sp., *Terrapene carolina puttnami, Trionyx* sp., *Rana palustris, Thamnophis* cf. *sirtalis, Tropidoclonion lineatum* and *Virginia* cf. *striatula*. Trans-Pecos forms are represented by *Vulpes macrotis, Peromyscus* cf. *eremicus, Thomomys bottae, Salvadora* sp., *Sonora semiannulata, Gyalopion canum*, and *Corvus corax*.

The Northern Plains is the area of sympatry for the northern element: the northwest group is central Colorado; for the northeastern, eastern Kansas. While the Southeastern area of sympatry is western Louisiana, the snakes in particular represent an extension of the central Brazos River riparian biome into its upper drainage system in the draw. The Trans-Pecos faunal element may be associated more with the annual rainfall pattern and effective moisture than general aridity.

The fauna is a highly diversified one with all classes of vertebrates represented. It reflects both riparian and grassland (parkland) communities representing a good environmental cross section of the draw (Fig. 3). The occurrence of *Arctodus* and *Holmesina* this late in the geologic record is unusual and marks the youngest age-controlled occurrence and first well-established association with man (JOHNSON and HOLLIDAY, 1985).

This rich and varied fauna is complemented by the Blackwater Draw Locality #1 Clovis local fauna (Table II) (LUNDELIUS, 1972; HUGHES, 1984; WINANS, 1985; REA *et al.*, ms.) At least 11 additional species occur at this locality that are not known from Lubbock Lake. However, the fauna is skewed toward larger, extinct forms. Among the 29 taxa, 45% are extinct forms while an equal 45% are from within their modern range. Only 10% are forms which no longer range into the area. The disproportionately high percentage of extinct forms, while reflecting the diversity of the time, also is a result of the lack of microrecovery techniques and orientation towards large bone recovery. This skewed view is ameliorated through a regional view of the combined local faunas (Table III). Of the 85 taxa, 21% are extinct forms, 25% no longer range into the area, and 59% are from within their modern range. These figures are nearly identical to those from the LL Clovis local fauna, indicating a probable reasonable faunal assemblage and makeup for the region during that time.

The faunal influences in the BWD#1 Clovis local fauna are not as strongly expressed as in the LL Clovis local fauna. While three areas of sympatry occur, the animals representing these areas are minimal. Faunal elements are from the northwest group of the Northern Plains (*Microtus pennsylvanicus, Ondatra zibethicus*), Southeast (*Terrapene carolina puttnami*), and southwest (*Vulpes velox*). However, these forms are sig-

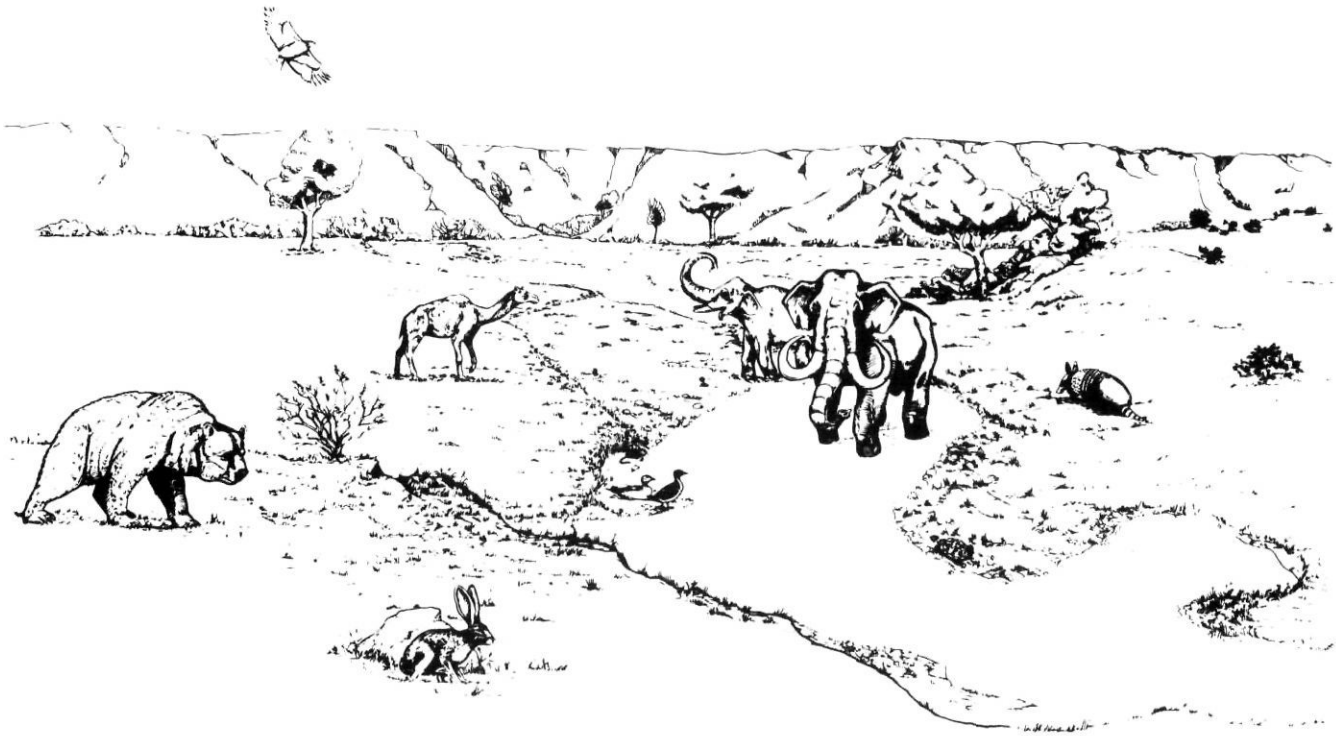

FIGURE 3. Artist's drawing of the paleoenvirons and fauna of the Southern High Plains draws during Clovis times (11,600-11,000 yr BP).

Dessin du paléomilieu et de la faune qui existaient à l'époque de Clovis (11 600 à 11 000 BP) dans les hautes plaines du Sud.

TABLE II

Blackwater Draw Locality #1 vertebrate local faunas

BWD #1 Clovis local fauna (11,600-11,000 yr BP)	BWD #1 Folson local fauna (*ca.* 10,500 yr BP)
Rana sp.	*Geomys bursarius*
≠ *Terrapene carolina puttnami*	cf. *Neotoma*
Branta canadensis	+ *Ondatra zibethicus*
Cathartes aura	*Canis latrans*
Buteo regalis	≠ *Bison antiquus*
cf. *Haliaeetus*	
Falco columbarias	
≠ *Paramylodon harloni*	
Lepus californicus	
Cynomys ludovicianus	
+ *Microtus pennsylvanicus*	
+ *Ondatra zibethicus*	
≠ *Canis dirus*	
Canis latrans	
Canis lupus	
+ *Vulpes velox*	
Urocyon cinereoargenteus	
≠ *Smilodon californicus*	
≠ *Mammuthus columbi*	
≠ *Equus francisci*	
≠ *Equus mexicanus*	
≠ *Platygonus* sp.	
≠ *Camelops hesternus*	
≠ *Hemiauchenia macrocephala*	
Odocoileus virginianus	
Antilocapra americana	
≠ *Capromeryx* sp.	
≠ *Bison antiquus*	

\+ no longer occurs in the areas
≠ extinct

nificant in that they indicate the extent of the northern and southeastern elements across the Southern High Plains.

The fauna primarily is a grasslands (parkland) one dominated by herd herbivores and the carnivores that preyed upon them or scavenged their remains. Although the fauna mainly is a mammalian one, great diversity occurs within the herbivores and carnivores. This diversity reflects a complex trophic situation and availability of niches brought about by the superimposed, compressed ecological zones (SEMKEN, 1983; LUNDELIUS *et al.*, 1983). Most of the birds are large birds of prey or scavengers which reflect the general makeup of the assemblage. However, this skewed view of the avifauna, particulary in comparison to that from Lubbock Lake, undoubtedly reflects sampling bias towards recovery of larger elements.

The Lubbock Lake Folsom local fauna (Table I) lacks the diversity of extinct forms seen in the two Clovis local faunas. A major changeover in the vertebrate fauna occurred at 11,000 yr BP and the reduction in diversity reflects a major ecologic shift. The only extinct forms are *Bison antiquus* and *Capromeryx* which also are the only large herd herbivores recovered. Carnivore diversity concomitantly was reduced.

Among the 30 taxa recovered, 7% are extinct forms and 23% no longer range into the area. Almost three-fourths (70%) of the fauna is from within its modern range. Only 30% of the assemblage is unknown to the modern community structure in comparison to the 44% of the preceding period, reflecting a 33% reduction in the extent of diversity and a concomitant reduction in disharmony.

Riparian and grassland communities continue to dominate the local fauna (Fig. 4) which is influenced by both northern and southeastern forms. The Trans-Pecos element is not seen in the local fauna. The Northern Plains forms are represented by the continuation of *Microtus pennsylvanicus, M. ochrogaster*, and *Ondatra zibethicus*. The southeastern area of sympatry shifted from Louisiana to eastern Texas and is represented by *Lepomis gulosus, Morone chrysops, Thamnophis* cf. *sirtalis*, and *Tropidoclonian lineatum*. These forms represent a continuation of faunal elements from the central Brazos River riparian biome.

The Blackwater Draw Locality #1 Folsom local fauna (Table II) is limited in scope due to recovery techniques and more restricted excavations in Unit D (HESTER, 1972; HUGHES, 1984; HAYNES, 1975). Because of the very limited nature of this local fauna, it provides little in the way of a regionwide view of the faunal assemblage or communities at the time (Table III). Nevertheless, at least one additional form (*cf. Neotoma* sp.) is represented at BWD#1 that was not recovered from Lubbock Lake. Given the character of the local fauna, its absence at Lubbock Lake appears a sampling error. Its presence in the fauna provides additional data on the grasslands environs. Despite the meager appearance of the BWD#1 Folsom local fauna, the occurrence of *Ondatra zibethicus* indicates the continued region-wide northern faunal element.

The Lubbock Lake Plainview local fauna (Table I) is somewhat anomalous because it reflects a maintenance in the extent of disharmony (29%) over the preceding period (30%), rather than an expected continued decrease. Based on proxy data from the fauna and geology (HOLLIDAY, 1983, 1985a), climate conditions and the environs were similar, although perhaps the winters were cooler by 10,000 yr BP. A concomitant slight increase occurs in the proportion of fauna from within its modern range (71%). In comparing the LL Clovis, LL Folsom, and LL Plainview local faunas, eight pairs of animals occur in the LL Clovis and LL Plainview that are absent in the LL Folsom local fauna (Table IV)). Even if these animals are added to the LL Folsom local fauna, its extent of disharmony changes little (29%) and the LL Plainview local fauna maintains the status quo. The LL Plainview local fauna (Fig. 4) may reflect a stable adjustment of the faunal communities during the earliest Holocene rather than the view generally provided by the discontinuous, disjunct, and not so well-dated fossil record.

Sample bias, in the form of the smaller size of excavation area opened, also is a problem, particularly in comparing the two local faunas for extent and constituency. The LL Plainview local fauna contains about one-third more identified species

TABLE III

Combined Lubbock Lake and Blackwater Draw Locality #1 local faunas showing changes through time

Animal	Clovis	Folsom	Plain-view	First-view
+ *Lepisosteus* sp. (garfish)	X			
+ *Carpiodes cyprinus* (quillback)	X			
Ictalurus melas (black bullhead)	X			
Ictalurus punctatus (channel catfish)	X			
Ictalurus (cf. *Ameiurus*) sp. (bullhead)	X	X	X	
+ *Morone chrysops* (white bass)		X		
+ *Lepomis gulosus* (warmouth)		X		
Lepomus cyanellus (green sunfish)	X			
Lepomis sp. (sunfish)		X		
Percina sp. (logperches & blackside darter)		X		
Ambystoma tigrinum (tiger salamander)	X	X	X	
Scaphiopus bombifrons (plains spadefoot toad) OR *S. hammondi* (western spadefoot toad)	X			
Bufo cognatus (plains toad)	X			
≠ *Bufo woodhousei bexarensis* (Friesenhahn Cave toad)	X			
Bufo sp. (toad)	X		X	
Acris crepitans (cricket frog)	X			
Rana catesbeiana (bullfrog)	X	X	X	X
Rana pipiens (leopard frog)	X	X	X	X
+ *Rana palustris* (pickerel frog)	X			
Chelydra serpentina (snapping turtle)	X		X	X
Kinosternon flavescens (yellow mud turtle)	X	X	X	X
≠ *Geochelone wilsoni* (extinct Wilson's tortoise)	X			
≠ *Geochelone* sp. (extinct tortoise)	X			
Chrysemys scripta (pond slider)	X	X	X	X
≠ *Terrapene carolina putnami* (extinct Carolina box turtle)	X			
Terrapene ornata (ornate box turtle)			X	X
+ *Trionyx* sp. (soft turtle)	X			
Phrynosoma cornutum (Texas horned lizard)				X
Eumeces obsoletus (Great Plains skink)			X	X
+ *Coluber constrictor* (racer)			X	
+ *Carphophis amoenus* (worm snake)	X			
+ *Elaphe guttata* (corn snake)	X			
+ *Gyalopion canum* (western hook-nosed snake)	X			
Heterodon nasicus (western hog-nosed snake)	X			
Lampropeltis getulus (comon king snake)			X	
Lampropeltis triangulum (milk snake)	X			
+ *Nerodia* cf. *cyclopion* (green water snake) OR *N.* cf. *rhombifera* (diamondback water snake)			X	
Nerodia erythrogaster (red-bellied water snake)				X
Nerodia sp. (water snake)	X			
Elaphe or *Pituophis* sp. (rat, worm, or bullsnake)		X		
+ *Salvadora* sp. (patch-nosed snake)	X			
+ *Sonora semiannulata* (ground snake)	X		X	
Thamnophis cf. *marcianus* (checkered garter snake)			X	
Thamnophis proximus (ribbon snake)			X	
+ *Thamnophis* cf. *sirtalis* (common garter snake)	X	X	X	X
+ *Tropidoclonion lineatum* (lined snake)	X		X	
+ *Virginia* cf. *striatula* (rough earth snake)	X			
+ *Agkistrodon contortix* (copperhead)			X	
Crotalus atrox (western diamondback rattlesnake)	X			
Podiceps cf. *nigricollis* (eared grebe)			X	
Podilymbus cf. *podiceps* (pied-billed grebe)			X	
cf. *Cathartes aura* (turkey vulture)	X			
Branta canadensis (Canada goose)	X			
Anser caerulescens (snow goose)	X	X		

Animal	Clovis	Folsom	Plain-view	First-view
Anas platyrhynchos (mallard)			X	X
Anas strepera OR *A. acuta* (gadwall or pintail)	X	X	X	X
Anas acuta (pintail)	X			X
Anas cf. *clypeata* (northern shoveler)	X		X	
Anas crecca carolinensis (American green-winged teal)	X	X	X	X
Anas cyanoptera OR *A. discors* (cinnamon or blue-wirged teal)				X
Anas cf. *cyanoptera* (cinnamon teal)				X
Anas sp. (teal)	X	X	X	X
cf. *Oxyura jamaicensis* (ruddy duck)	X			
Circus cyaneus (American marsh harrier or hawk)		X		
Buteo regalis (ferruginous hawk)	X			
cf. *Haliaeetus* (eagle)	X			
Falco columbarias (merlin, pigeon hawk)	X			
+ *Tympanuchus cupido* (prairie chicken) OR *Centrocercus urophasianus* (sage grouse)				X
+ *Tympanuchus cupido* (prairie chicken) OR *"Pedioecetes" phasianellus* (sharp-tailed grouse)				X
+ *Meleagris* sp. (turkey)	X			
+ *Rallus limicola* (Virginia rail)	X	X		
Rallus cf. *longirostris* (clapper rail)				X
Porzana carolina (sora)				X
+ cf. *Laterallus exilis* (gray-breasted crake)				X
Gallinula chloropus (common gallinule)			X	
Fulica americana (American coot)			X	
+ *Charadrius montanus* (montain plover)			X	
Athene cf. *cunicularia* (burrowing owl)	X			
Chordeiles cf. *minor* (common nighthawk)		X		
Colaptes auratus (northern flicker)		X		
cf. *Eremophila alpestris* (horn lark)		X		
+ *Corvus corax* (common raven)	X			
Mimus polyglottis (northern [common] mockingbird)		X		
Agelaius phoeniceus (red-winged blackbird)				X
cf. *Agelaius phoeniceus* (red-winged blackbird)	X			
Molothrus cf. *ater* (brown-headed cowbird)				X
cf. *Pooecetes gramineus* (vesper sparrow)	X			
+ *Blarina* sp. (shrew)	X			
Notiosorex crawfordi (desert shrew)		X	X	
≠ *Paramylodon harlani* (big-tongued sloth)	X			
≠ *Holmesina septentrionalis* (extinct giant armadillo)	X			
Sylvilagus cf. *audubonii* (Audubon cottontail)				X
Sylvilagus sp. (cottontail)			X	X
Lepus californicus (blacktail jackrabbit)	X	X	X	X
+ *Spermophilus richardsonii* (Richardson's ground squirrel)	X			
Spermophilus tridecemlineatus (thirteen-lined ground squirrel)	X	X	X	X
Spermophilus mexicanus (Mexican ground squirrel)	X		X	X
Cynomys ludovicianus (blacktail prairie dog)	X	X	X	X
+ *Thomomys bottae* (valley pocket gopher)	X			
Geomys bursarius (plains pocket gopher)	X	X	X	X
Perognathus cf. *hispidus* (hispid pocket mouse)		X		
Perognathus sp. (pocket mouse)	X			
Dipodomys ordii (Ord's kangaroo rat)			X	X
Reithrodontomys montanus (plains harvest mouse)	X		X	
+ *Peromyscus* cf. *eremicus* (cactus mouse)	X			
Peromyscus sp. (white-footed and pygmy mice)			X	
Onychomys leucogaster (northern grasshopper mouse)	X		X	X
Sigmodon hispidus (hispid cotton rat)		X	X	X
Neotoma cf. *micropus* (southern plains wood rat)	X		X	X
Neotoma cf. *albigula* (white-throated wood rat)				X
cf. *Neotoma* sp. (wood rat)		X		
+ *Microtus pennsylvanicus* (meadow vole)	X	X	X	

Animal	Clovis	Folsom	Plainview	Firstview
+ *Microtus ochrogaster* (prairie vole)	X	X	X	X
+ *Ondatra zibethicus* (muskrat)	X	X	X	X
+ *Synaptomys cooperi* (southern bog lemming)			X	
Canis dirus (dire wolf)	X			
Canis latrans (coyote)	X	X		X
Canis lupus (gray wolf)	X	X	X	X
+ *Vulpes macrotis* (kit fox)	X			
+ *Vulpes velox* (swift fox)	X			
Urocyon cinereoargenteus (gray fox)	X			
≠ *Arctodus simus* (short-faced bear)	X			
Taxidea taxus (badger)				X
≠ *Smilodon californicus* (New World sabertooth cat)	X			
Felis cf. rufus (bobcat)				X
≠ *Mammuthus columbi* (Columbian mammoth)	X			
≠ *Equus francisci* (extinct small stilt-legged horse)	X			
≠ *Equus mexicanus* (extinct stout-legged horse)	X			
≠ *Platygonus compressus* (extinct peccary)	X			
≠ *Platygonus* sp. (extinct peccary)	X			
≠ *Camelops hesternus* (extinct camel)	X			
≠ *Hemiaucheina macrocephala* (extinct llama)	X			
≠ *Hemiaucheina* sp. (extinct llama)	X			
Odocoileus virginianus (white-tailed deer)			X	X
Odocoileus sp. (deer)	X			
Antilocapra americana (pronghorn antelope)	X		X	X
≠ *Capromeryx* sp. (extinct antelope)	X	X		
≠ *Bison antiquus* (extinct bison)	X	X	X	X

≠ extinct
\+ no longer occurring in the region

FIGURE 4. Artist's drawing of the paleoenvirons and fauna of the Southern High Plains draws during Folsom through Plainview times (11,000-10,000 yr BP).

Dessin du paléomilieu et de la faune qui existaient à l'époque de Folsom jusqu'à celle de Plainview (11 000 à 10 000 BP) dans les hautes plaines du Sud.

TABLE IV

Pairs of animals occurring in common between the Lubbock Lake Clovis, Folsom, and Plainview local faunas

LL Clovis local fauna	LL Folsom local fauna	LL Plainview local fauna
Ambystoma tigrinum		*Ambystoma tigrinum*
Chelydra serpentina		*Chelydra serpentina*
Nerodia sp.		*Nerodia* sp.
Tropidoclonion lineatum		*Tropidoclonion lineatum*
Thamnophis cf. *sirtalis*	*Thamnophis* cf. *sirtalis*	*Thamnophis* cf. *sirtalis*
Sonora semiannualata		*Sonora semiannulata*
Fulica americana	*Fulica americana*	*Fulica americana*
Cynomys ludovicianus	*Cynomys ludovicianus*	*Cynomys ludovicianus*
Spermophilus tridecemlineatus	*Spermophilus tridecemlineatus*	*Spermophilus tridecemlineatus*
Spermophilus mexicanus		*Spermophilus mexicanus*
Geomys bursarius	*Geomys bursarius*	*Geomys bursarius*
Lepus californicus	*Lepus californicus*	*Lepus californicus*
Microtus pennsylvanicus	*Microtus pennsylvanicus*	*Microtus pennsylvanicus*
Microtus ochrogaster	*Microtus ochrogaster*	*Microtus ochrogaster*
Ondata zibethicus	*Ondatra zibethicus*	*Ondatra zibethicus*
Canis latrans	*Canis latrans*	
Canis lupus	*Canis lupus*	*Canis lupus*
Bison antiquus	*Bison antiquus*	*Bison antiquus*

than the LL Folsom local fauna yet about the same as the LL Firstview local fauna (Tables I, III). Continuity is provided in the form of 11 sets of animals which occur in all three local faunas (Table IV). Of the additional six species which are absent in the LL Folsom local fauna (Table IV), four are species whose modern ranges include the Southern High Plains. It seems unreasonable that these animals would vacate the draws while others of similar habitat parameters remained, and then reestablish themselves. Furthermore, the other two species are snakes which no longer range into the Southern High Plains. Their occurrence in the LL Plainview local fauna appears more reasonable as relict forms rather than re-entry into the region. If that was the case, then, a residual Trans-Pecos faunal element (*Sonora semiannulata*) persisted for at least 1000 years after the Clovis local fauna.

Another example of sampling bias despite a large area of excavation opened is the paucity of mammalian carnivores in the LL Plainview local fauna. *Canis latrans* is ubiquitous and appears in the other local faunas. The Southern High Plains was well within its modern range (DAVIS, 1974; FINDLEY *et al.*, 1975). Why *Synaptomys cooperi* is not present during the Clovis period when it would be most reasonably expected but is present during Plainview times may also be related to sampling bias.

Among the extant species in the LL Plainview fauna, two major areas of faunal influence occur. The northern element again is split into two areas of sympatry, northwest out of the mountain-plains ecotonal area of Colorado and northeast off the open plains. This split reflects the continued major influence from the Northern Plains. The Northern Plains forms include *Coluber constrictor*, *Charadrius montanus*, *Synaptomys cooperi*, *Microtus pennsylvanicus*, *M. ochrogaster*, and *Ondatra zibethicus*. The southeastern influence shifted closer to Lubbock, with the area of sympatry in northcentral Texas. The snakes, in particular, reflect the continued presence of faunal elements of the central Brazos River riparian biome. The southeastern forms include *Nerodia cyclopion/rhombifera*, *Thamnophis* cf. *sirtalis*, *Tropidoclonion lineatum*, *Agkistrodon contortix*, and *Gallinula chloropus*.

The Lubbock Lake Firstview local fauna (Table I) has 44 taxa, 2% of which are extinct (*Bison antiquus*) and 14% no longer range into the area. The fauna is well towards being a modern one (84%) and marks a sharp decrease in the extent of disharmony over the LL Plainview local fauna (50% reduction). The main faunal element is the Northern Plains with the continued presence of *Microtus pennsylvanicus, M. ochrogaster*, and *Ondatra zibethicus*. The southeastern influence is minor, represented by *Thamnophis* cf. *sirtalis* and *Rallus* cf. *longirostris*. *Thamnophis* cf. *sirtalis* appears as a relict form, a residual of the previous faunal elements of the central Brazos River riparian biome. The grasslands community dominates but with a riparian community associated with freshwater marshes (Fig. 5).

Rallus longirostris is an anomaly in the LL Firstview local fauna in that this bird is a coastal saltwater marsh rail (OBERHOLSER and KINCAID, 1974). All paleoenvironmental data point to the waterway setting at this time as a freshwater marsh (JOHNSON, 1976, 1983; HOLLIDAY, 1982, 1983, 1985a; PIERCE, 1975). Although known to be driven inland into freshwater marshes during coastal storms (OBERHOLSER and KINCAID, 1974: 295), such an explanation is not feasible given the great distance to coastal waters from Lubbock. The significance of this rail is unknown.

Another anomaly is the occurrence of *Laterallus* cf. *exilis*. Although this crake is a freshwater marsh bird, its modern range is Central and South America. The only other known

FIGURE 5. Artist's drawing of the paleoenvirons and fauna of the Southern High Plains draws during Firstview times (8600 yr BP).

Dessin du paléomilieu et de la faune qui existaient à l'époque de Firstview (8600 BP) dans les hautes plaines du Sud.

U.S. occurrence is in the middle Pleistocene of Florida (OLSON, 1974; REA *et al.*, ms).

PALEOENVIRONMENTAL CONDITIONS

During the Clovis period, the environs of the draws were a parkland with stands of hackberry and other deciduous trees (paleobotanical evidence) along the stream and valley floor and large expanses of well-drained grasslands grading into wet meadows. A low gradient, sometimes muddy, stream with emergent vegetation meandered through the draws. Spring water flowed through the small tributary into Blackwater Draw proper. Abundant plants, including sedge beds, grew along the banks of the streams. The open grassland vegetation was a mixed grass prairie. Mild winters which did not maintain freezing conditions and cool summers provided a more equitable and ameliorated climate than today, with a more effective moisture regime, reduced annual temperature fluctuation, and less seasonality.

The beginnings of a warming trend, greater seasonality, and increased annual temperature fluctuation denote the early Holocene (post-11,000 yr BP). The 1000 year span of Folsom and Plainview local faunas (11,000 to 10,000 yr BP) appears a stable one of very gradual changes (Fig. 4). During this span, a series of clear ponds with weedy growth were in the valley axes. The valley floor and margins were a savannah. The extent of the open grasslands in the draws increased at the expense of the parkland. The mixed grasslands habitat became dominant in the draw environs, with probable scattered deciduous trees on the draw slopes and around the ponds. Wet meadow grasses and sedge beds around the ponds graded into the better-drained mixed grasslands along the valley floor. Milder winters persisted but with increasingly sustained freezing temperatures. Summers were warming. These conditions reflect a less equitable climate than in the preceding period but one still more ameliorated than today.

The draw setting by Firstview times (8600 yr BP) appears that of a scrub-grasslands with rare deciduous trees and occasional brushy areas (Fig. 5). The valley axis was a wet meadow-freshwater marshland with emergent vegetation and continued sedge beds that graded into a better-drained valley floor and margin of mixed grass prairie. The marshland was a boggy area of shallow water resources. The fauna is almost a modern one and reflects a trend toward modern climatic conditions. Seasonality is more strongly expressed with greater temperature fluctuations and probable decrease in rainfall, effective moisture, or rainfall pattern change.

CONCLUSIONS

The Lubbock Lake vertebrate record serves as a model of environmental change for the Southern High Plains during the end of the Pleistocene and early Holocene. Although making such correlations throughout a region can be misleading, the risks are fewer for the Southern High Plains because of the flat topography, low environmental gradients, and uniform regional geology. Similarities in late Quaternary stratigraphic and environmental records are documented for several localities (SELLARDS, 1952; HAYNES, 1975; HOLLIDAY, 1983, 1985b). In addition, Blackwater Draw Locality #1 (LUNDELIUS, 1972; HUGHES, 1984) provides subsidiary, collaborative data, albeit limited, from the opposite side of the Southern High Plains but within the same drainage system.

The local faunas reflect pluvial conditions over a *ca.* 3000 year span. Obvious faunal and climatic conditions change

during that time but overall, indications are of a milder, wetter environment from more equitable climates than that of the modern one. Factors responsible for these conditions appear to be lowered and less fluctuating annual temperatures (indicating less seasonal response) and greater availability of moisture in the form of surface waters and rainfall. Both rainfall amount and pattern appear significant. While the average annual amount of rainfall appears much greater than that of modern conditions, a change in the time of year of most rainfall also would alter the effective moisture pattern. Winter rains with dry, albeit cool, summers may explain the Trans-Pecos influence. Such a rainfall pattern may have begun to shift in the early Holocene, as a factor in the warming and drying trend, toward the modern pattern of summer rains (HARAGAN, 1976, 1983).

The late Pleistocene is characterized by a major climatic change. On the Southern High Plains, that major change comes quite distinctly around 11,000 yr BP. The Folsom local fauna is quite different from the preceding Clovis local fauna and indicates both climatically and environmentally different conditions that denote the beginning of the early Holocene. This changeover appears as a distinctive boundary and marks the end of the Pleistocene biota in the region at 11,000 yr BP. This abrupt changeover also occurs in the geologic record and hydrologic system of the draws.

Another equally major shift occurs around 8500 yr BP marking the end of wet and moist conditions and an increased warming and drying trend that ultimately culminates in the Altithermal (JOHNSON and HOLLIDAY, 1986; HOLLIDAY, 1985a). The LL Firstview local fauna (8600 yr BP) marks the last of the pluvially-related faunas. However, it reflects a more modern community than the previous faunas and heralds the end of pluvial conditions. Annual average temperatures continue to rise and available moisture decreases. Deposition ceases and soil formation begins around 8500 yr BP (HOLLIDAY, 1982, 1985a).

The late Pleistocene and early Holocene pluvial period is one of milder winters, cooler summers, and more available moisture than under modern conditions. Within this period, however, the equitable climate of the latest Pleistocene shifts to a warming trend and greater seasonality in the early Holocene marked by colder winters and warming summers. A 1000 year period of some stability ensues with gradual adjustments and realignments occurring. Another major climatic shift of increased warming and drying marks the end of pluvial conditions by 8500 yr BP. Although the warming trend began in the earliest Holocene, this shift appears to reflect a major jump along that trajectory of increased warming coupled with drying. This warming and drying trend persists into the xeric conditions of the middle Holocene.

The extensive Lubbock Lake local faunas form a continuous record that reflects regional conditions as well as local environs. In spite of different recovery strategies, this position is supported and enhanced by the BWD#1 local faunas. This first-approximation model is based primarily on microvertebrate resolution supported with geologic data. The local faunas are stratigraphically distinct and from within well-dated contexts. The disharmonious local faunas and the proxy data they provide illustrate the complexity of disharmony occurring in unglaciated regions during the deglaciation and modernization of North America.

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REFERENCES

BRYANT, V. M. Jr. and SHAFER, H. J. (1977): The Late Quaternary Paleoenvironment of Texas: A Model for the Archaeologist, *Bulletin of the Texas Archeological Society*, 48, 1-25.

DAVIS, W. B. (1974): The Mammals of Texas, *Texas Parks and Wildlife Department Bulletin*, 41, 1-294.

EVANS, G. L. and MEADE, G. E. (1945): Quaternary of the Texas High Plains, *University of Texas Publication, Contributions to Geology*, 4401, 485-507.

FINDLEY, J. S., HARRIS, A. H., WILSON, D. E. and JONES, C. (1975): *Mammals of New Mexico*, University of New Mexico Press, Albuquerque, 360 p.

HARAGAN, D. R. (1976): Spatial Variation of Precipitation on the Texas High Plains, *Water Resources Bulletin*, 12(6), 1191-1204.

——— (1983): *Blue Northers to Sea Breezes: Texas Weather and Climate*, Hendrick-Long Publishing Co., Dallas, 98 p.

HAWLEY, J. W., BACHMAN, G. O. and MANLEY K. (1976): Quaternary Stratigraphy in the Basin and Range and Great Basin Provinces, New Mexico and Western Texas, *in Quaternary Stratigraphy of North America*, W. C. Mahaney (ed.), Dowden, Hutchinson, and Ross, Inc., Stroudsburg, 512 p.

HAYNES, C. V. (1975): Pleistocene and Recent Stratigraphy, *in Late Pleistocene Environments of the Southern High Plains*, Fred Wendorf and James J. Hester (ed.), Fort Burgwin Research Center, Southern Methodist University, Dallas, 290 p.

HESTER, J. J. (1972): *Blackwater Locality No. 1: A Stratified Early Man Site in Eastern New Mexico*, Fort Burgwin Research Center, Southern Methodist University, Dallas, 239 p.

HOLLIDAY, V. T. (1982): *Morphological and Chemical Trends in Holocene Soils, Lubbock Lake Site, Texas*, Unpublished Ph.D. dissertation, University of Colorado, Boulder, 103 p.

——— (1983): *Guidebook to the Central Llano Estacado*, Friends of the Pleistocene South-Central Cell Field Trip. ICASALS and The Museum, Texas Tech University, Lubbock, 165 p.

——— (1985a): Archaeological Geology of the Lubbock Lake Site, Southern High Plains of Texas, *Geological Society of America Bulletin*, 96(2), 1483-1492.

——— (1985b): New Data on the Stratigraphy and Pedology of the Clovis and Plainview Sites, Southern High Plains, *Quaternary Research*, 23(3), 388-402.

HOLLIDAY, V. T., JOHNSON, E., HAAS, H. and STUCKENRATH R. (1983): Radiocarbon Ages from the Lubbock Lake Site, 1950-1980: Framework for Cultural and Ecological Change on the Southern High Plains, *Plains Anthropologist*, 28(101), 165-182.

——— (1985): Radiocarbon Ages from the Lubbock Lake Site: 1981-1984, *Plains Anthropologist*, 30(110), 277-291.

HUGHES, E. (1984): *Blackwater Draw Locality #1 Collection of The Museum, Texas Tech University: A Case Study in Conservation, Collection Management, and Data Reconstruction,* Unpublished master's thesis, Texas Tech University, Lubbock, 164 p.

JOHNSON, E. (1976): *Investigations into the Zooarchaeology of the Lubbock Lake Site*, Unpublished Ph.D. dissertation, Texas Tech University, Lubbock, 589 p.

——— (1983): The Lubbock Lake Paleoindian Record, *in Guidebook to the Central Llano Estacado*, V. T. Holliday (ed.), Friends of the Pleistocene South-Central Field Trip. ICASALS and The Museum, Texas Tech University, Lubbock, 165 p.

JOHNSON E. and HOLLIDAY, V. T. (1985): A Clovis-Age Megafaunal Processing Station at the Lubbock Lake Landmark, *Current Research in the Pleistocene*, 2, 17-19.

——— (1986): The Archaic Record at Lubbock Lake, *Plains Anthropologist Memoir*, in press.

LUNDELIUS, E. L., Jr. (1972): Vertebrate Remains from the Gray Sand, *in Blackwater Locality No. 1, A Stratified Early Man Site in Eastern New Mexico*, James J. Hester (ed.), Fort Burgwin Research Center, Southern Methodist University, Dallas, 239 p.

LUNDELIUS E. L., Jr., GRAHAM, R. W., ANDERSON, E., GUILDAY, J., HOLMAN, J. A., STEADMAN, D. W., and WEBB, S. D. (1983): Terrestrial Vertebrate Faunas, *in Late Quaternary Environments of the United States*; Vol. I *The Late Pleistocene*, University of Minnesota Press, Minneapolis, ch. 16, 407 p.

NOAA (National Oceanic and Atmospheric Administration) (1982a): *Climate of Texas*, NOAA Environmental Data Service, National Climatic Center, Asheville, North Carolina, 46 p.

——— (1982b): *Climate of New Mexico*, NOAA Environmental Data Service, National Climatic Center, Asheville, North Carolina, 20 p.

OBERHOLSER, H. C. and KINCAID, E. B., Jr. (1974): *The Bird Life of Texas*, University of Texas Press, Austin, 1069 p.

OLSON, S. L. (1974): The Pleistocene Rails of North America, *Condor*, 76(2), 169-175.

PIERCE, H. G. (1975): *Diversity of Late Cenozoic Gastropods on the Southern High Plains*, Unpublished Ph.D. dissertation, Texas Tech University, Lubbock, 245 p.

REA, A., CHANDLER, R. and JOHNSON, E. (ms): Late Quaternary Paleoavifaunas from the Southern High Plains, USA, in preparation.

SELLARDS, E. H. (1952): *Early Man in America*, University of Texas Press, Austin, 211 p.

SEMKEN, H. A., Jr. (1974): Micromammal Distribution and Migration During the Holocene, *American Quaternary Association Abstracts*, 3, 25.

——— (1983): Holocene Mammalian Biogeography and Climatic Change in Eastern and Central United States, *in Late Quaternary Environments of the United States*; Vol. II *The Holocene*, H. E. Wright, Jr., (ed.), University of Minnesota Press, Minneapolis, ch. 12, 277 p.

SLAUGHTER, B. H. (1975): Ecological Interpretation of Brown Sand Wedge Local Fauna, *in Late Pleistocene Environments of the Southern High Plains*, Fred Wendorf and James J. Hester (ed.), Fort Burgwin Research Center, Southern Methodist University, Dallas, 290 p.

STRAHLER, A. N. and STRAHLER, A. H. (1983): *Modern Physical Geography*, 2nd ed., John Wiley and Sons, New York, 502 p.

WINANS, M. C. (1985): *Revision of North American Fossil Species of the Genus* Equus (Mammalia: Perissodactyla: Equidae), Unpublished Ph.D. dissertation, University of Texas, Austin.