Arthur H. Harris

The New Mexican Late Wisconsin—East Versus West

Full-glacial biological and climatic conditions at Dry Cave, in southeastern New Mexico, were generally similar to present conditions in southeastern Idaho. However, a secondary center of faunal similarity occurs in northeastern New Mexico and includes animals that probably remained in the Dry Cave region after the mid Wisconsin. More summer precipitation than was available farther to the northwest likely allowed some of these to remain in the region; others, filling ecologic niches held by close relatives in the Idaho area, may have outcompeted potential invaders. The Dry Cave faunas show increasing disharmony from full-glacial to terminal Pleistocene times, probably as a result of increasing temperature and summer precipitation. These changes allowed invasion of taxa from centers of distribution in the Great Plains or in the southern Southwest. At U-Bar Cave, ~390 km west-southwest of Dry Cave, inferred conditions changed little from the mid Wisconsin to ca. 13000 B.P. Faunas were more disharmonious throughout than at Dry Cave, with an intermixture of taxa now limited to various regions. Summers were far cooler than today, but warmer and drier than at Dry Cave; winters were relatively warm, at least lacking the profound freezes probable at Dry Cave.

Wisconsin-age (late Pleistocene) biological and climatic conditions in the southwestern United States are generally understood. But, intraregional variation, especially in an east–west direction, has received relatively little study. At present, climatic parameters, particularly of temperature and seasonality of precipitation, vary from east to west and are reflected in the floral and faunal communities. Pleistocene climatic conditions also would be expected to have had biotic consequences. Only one study has focused on details of Wisconsin-age, east–west variations in animal distribution; this concerns the mid Wisconsin (Harris 1987). The present study compares the vertebrate faunas and inferred climatic and biotic conditions near two caves in southern New Mexico from the time of pleniglacial conditions ca. 18000 to 19000 B.P. to ca. 13000 B.P.

U-Bar Cave, just east of the continental divide in the "boot heel" of southwestern New Mexico, and Dry Cave, at the western margin of the Great Plains in southeastern New Mexico, are well positioned for studies of east–west faunal differences (Figure **1**). They are close in latitude and, although U-Bar Cave lies almost 300 m higher, they are now in similar vegetation zones, lying within ecotones between Chihuahuan desertscrub and woodland communities. U-Bar Cave, however, is some 390 km west-southwest of Dry Cave.

***Arthur H. Harris,** Curator, Vertebrate Paleobiology, Laboratory for Environmental Biology, University of Texas, El Paso, TX 79968.*

Materials and Methods

Fossil material from Dry Cave is curated into the Resource Collections, Laboratory for Environmental Biology, University of Texas at El Paso (UTEP); U-Bar Cave specimens (catalogued items have been given Museum of New Mexico numbers) will be held at UTEP until study has been completed, at which time they will be formally transferred to a New Mexican institution to be chosen by the state.

Many thousands of uncatalogued specimens have been scanned for taxa not represented in the curated material, adding some validity to the use of absence data. Otherwise, the study depends on catalogued specimens: Animal Fair, 390; Charlies Parlor, 330; Harris' Pocket, 1650; Bison Chamber, 300; post-Bison Chamber (localities 23, 31, and 54) of Dry Cave, 380; U-Bar Cave, 600.

Excavation units were organized in chronological order by stratigraphic reference to ^{14}C-dated sediments (Table **1**). For presentation and interpretation, the Dry Cave fossil material was matched with approximately contemporaneous material from the U-Bar Cave column: Dry Cave, Animal Fair (locality 22), levels 1 to 4, grids A7 and A8, with U-Bar Cave, −0.3 to −0.5 m, 18000 to 20000 B.P.; Dry Cave, Charlies Parlor (locality 22), 15 030 ± 210 B.P., with U-Bar Cave, 0 to −0.3 m, 15000 to 18000 B.P.; Dry Cave, Harris' Pocket (locality 6), 14 470 ± 250 B.P., with U-Bar Cave, +0.3 to 0 m, 14 000 to 15000 B.P.; Dry Cave, Bison Chamber (locality 4), with U-bar Cave, +0.6 to +0.3 m, 13000 to 14 000 B.P. Perspective on change through time at Dry Cave was gained from three Pleistocene sites (localities 23, 31, and 54) that postdate 13000 B.P. and have no known counterpart at U-Bar Cave.

Dry Cave

Dry Cave (1280 m) is in rolling limestone country almost equidistant between the Pecos Valley (950 m) to the east and the Guadalupe Mountains (>1800 m) to the west and southwest. Vegetation about the cave today includes both Chihuahuan desert-scrub elements and marginal woodland plants such as juniper (Harris 1970, 1985a).

Four separate sites within Dry Cave provide faunal material for the main period considered here and are briefly described. Spatial relationships have been figured elsewhere (Harris 1980).

Animal Fair Room, UTEP Locality 22

The present entrance (Entrance Fissure) to Dry Cave began receiving sediments near the time of transition between the mid Wisconsin and the late Wisconsin. The cave entrance migrated southward as the northern end clogged with debris, and capping limestone collapsed at the southern end. At its southernmost extent, the fissure spewed material into a large chamber, dividing it into two rooms, one of which is Animal Fair.

Specimens used for this study come from two 0.84-m^2 grids located near the fissure at its southern end. Material was excavated in four 10-cm levels, bagged in burlap, and removed for later wet-screening.

These grids and levels were chosen because they lie between less mesic faunas and are stratigraphically below a date of ca. 15000 B.P. from Charlies Parlor—thus they should represent full-glacial time.

Charlies Parlor, UTEP Locality 22

These deposits are a continuation of the Animal Fair deposits, but are stratigraphically higher and deposited in the Entrance Fissure itself. The

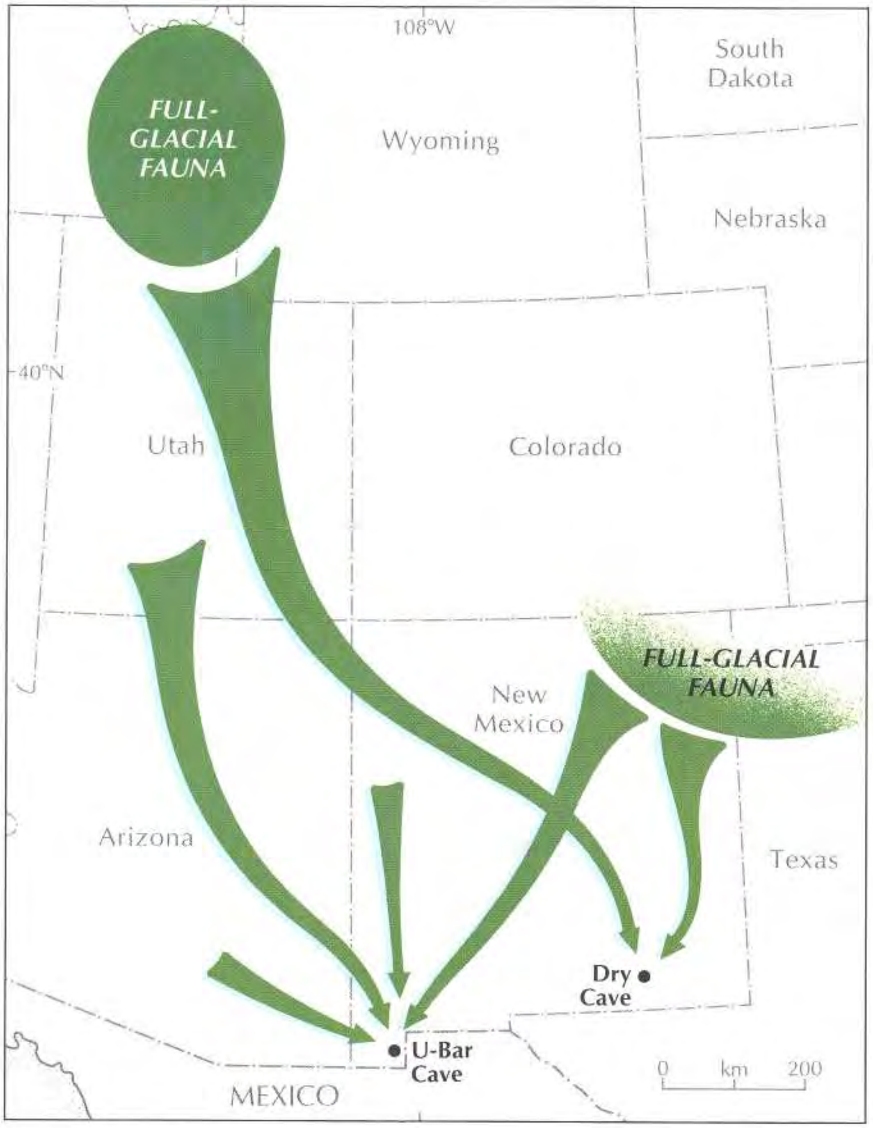

Figure 1. *Location of Dry and U-Bar Caves, with hypothetical source areas for the full-glacial fauna of Dry Cave and the late Wisconsin fauna of U-Bar Cave.*

^{14}C date (Table **1**) comes from a level somewhat higher than the Animal Fair grids but, as the date was obtained from bone collagen, it may be somewhat too young. No stratigraphy was apparent within the narrow fissure and it was not excavated by levels. The excavation method was biased toward recovery of larger elements, and sampling error may account for the absence of many smaller animals.

Harris' Pocket, UTEP Locality 6

At Harris' Pocket, a slight widening of a tight passageway held a mixture of silt, cave breakdown products, rodent feces, and bones. The material probably was redeposited by water in a single event from its original site of deposition nearer a now-closed entrance, Bison Fissure (Harris 1970). The passageway to the presumed source is too constricted to allow confirmation by directly tracing the route. The bias is against large forms, probably because of constraints imposed by passage size and distance from the source.

Bison Chamber, UTEP Locality 4

Mostly excavated by arbitrary levels, Bison Chamber fill has been wet-screened. The deposits are believed to have originated from Bison Fissure after clogging of the route to Harris' Pocket. In turn, the fissure appears to have been blocked by UTEP locality 54 (TT II) sediments, which thus must postdate locality 4. A ^{14}C date for locality 54 of 10 730 (Table **1**) is, judging from the fauna, probably too young.

Table 1. Radiocarbon Dates from Dry Cave Sites and U-Bar Cave Deposits

Site	Date	Dated Material	Lab No.
DRY CAVE SITES			
TT II	10 730 ± 150	bone collagen	I–6200
Stalag 17	11 880 ± 250	charcoal	I–5987
Harris' Pocket	14 470 ± 250	rodent feces	I–3365
Charlies Parlor	15 030 ± 210	bone collagen	I–6201
U-BAR CAVE LEVELS*			
+ 0.50	13 130 ± 180	organic fill	A–4666
− 0.15	15 530 ± 380	organic fill	A–4466
− 0.30	17 900 ± 320	organic fill	A–4716
− 0.40	18 360 ± 330	organic fill	A–4836
− 0.50	$18\ 830\ {}^{+580}_{-540}$	organic fill	A–4715
− 0.50	19 740 ± 200	organic fill	A–4837
− 1.00	21 210 ± 320	organic fill	A–4838

**Levels in meters from cave datum plane*

U-Bar Cave

U-Bar Cave (1570 m) is a large chamber in a limestone outlier of the Alamo Hueco Mountains; the present entrance opens to the southwest near the top of a steep slope, but at least two additional, clogged passages formerly reached the surface. Vegetation is a mixture of desert-scrub with some higher-elevation plants, e.g., juniper and scrub oak. Forested slopes of the Animas (elevations to nearly 2600 m) and San Luis Mountains (Figure **2**) are <35 km to the west; Pleistocene lake deposits occur within a similar radius in the intervening Playas Valley.

Several 1-m^2 grids from area B (Harris 1985b), near the present entrance, supplied the material for the present study. These grids (H-230-1 to -3; H-231-1 to -3; H-232-1 to -3) are near the eastern wall in an area relatively undisturbed by guano mining. Excavation commonly was by 10-cm levels, but collapses and excavation requirements resulted in some other units. Most material has been wet-screened.

The matrix appears to be material from outside the cave, presumably via the present entrance area; cave formations both broken from the nearby ceiling area and formed in situ; and organic material that included guano and plant debris, now decomposed except for hackberry (*Celtis*) seeds. The resulting combination of very fine and relatively coarse material often is unstable and prone to collapse, although carbonate deposition has caused some local cementation.

Bioturbation appears to have caused some mixing. Animal burrows allowed some intermixing of adjacent levels, and some contamination from more distant levels must be assumed. Despite this, ^{14}C dates are in proper order (Table **1**) with an overall deposition rate of ~0.2 mm/y. However, the rate between −0.15 and −0.30 m is only ~0.06 mm/y and suggests a hiatus in deposition. A date from grid F-231-3 related to initiation of carbonate cementation (tentatively correlated as ≈ −0.3 m in the study grids) is 16 100 ± 330 B.P. (A-4761). This is close to the age predicted for the −0.3-m level on the basis of a deposition rate of 0.2 mm/y and suggests an 1800-year gap very close to that level.

Two samples from −0.5 m, separated horizontally by ~0.5 m, differ by 910 years; statistically, they could represent the same date. However, they may have differed in their relationship to a later-recognized contact between lighter colored sediments above (A-4715), and darker deposits below (A-4837) and reflect a real difference. Fossil material is not equally distributed through the deposits, being most common ~ −0.15 m and plentiful from +0.3 to −0.3 m; −0.3 to −0.5 m produced fewer specimens and +0.3 to +0.6 m the fewest by far.

Identification of Taxa

Herpetological remains from localities 4 and 6 were identified by Holman (1970) with some reidentifications by Applegarth (1979). Applegarth also examined in detail the anuran and lacertilian remains from the Animal Fair grids. Herpetological material from the other sites has been identified by the author and lacks the detail (and possibly the accuracy) of the other workers.

Arthur H. Harris

Figure 2. *View from near the entrance of U-Bar Cave, looking southwest across Playas Valley to the San Luis Mountains in Mexico.*

Some of the avian material from localities 4 and 6 was identified by B. McMasters, while Hurley (1972) identified some of the raptorial birds and Campbell & Tonni (1981) reported *Teratornis merriami* (Merriam's teratorn). The author identified other bird specimens; much material remains to be identified, so avian presence–absence data are untrustworthy, as also is true of most herpetological material except that from localities 4, 6, and 22.

The author identified mammalian taxa. Confidence is approximately equivalent over the suite of materials; earlier identifications have been checked recently.

Identifications of vertebrates from each of the four time segments represented at both caves and for the terminal Pleistocene Dry Cave sites are given in Table **2**. Table **3** shows the pattern of first (and subsequent) appearances for selected taxa that can be characterized as having eastern or southern distributions.

Discussion

The means of accumulation of the vertebrate remains appears similar for all sites, though the Dry Cave sites, being located in fissures, appear

Table 2. Animal Taxa in Pleistocene Deposits, Dry and U-Bar Caves

Taxon	18–20 ka[a]	15–18 ka	14–15 ka	13–14 ka	<13 ka
Osteichthyes	D[b]	U[b]	U		
Ambystoma tigrinum	D	D,U	D,U	D	D
Spea sp.	D	U	D	D	D
S. multiplicata	D			D	
S. bombifrons				D	
Bufo sp.	D,U	D,U	D,U	D,U	D
B. alvarius		U			
B. woodhousei	D		D	D	
B. microscaphus			U?		
B. cognatus	D				D(cf)[c]
B. debilis		U(cf)			
Pseudacris triseriata	D		D		D
Rana pipiens, R. p./blairi	D			D	D
Chelonia	U	U	U	U	D
Terrapene ornata			U(cf)[d]	U(cf)[d]	D(cf)
Gopherus sp.	U(cf)		U	U(cf)	
Crotaphytus collaris	D		U	D	D
Sceloporus (large)	U(cf)	D(cf),U			
S. jarrovi	U(cf)	U(cf)			
S. undulatus	D		D	D	D
Phrynosoma cornutum			U(cf)	D	D
P. douglassi	D,U	D,U	D,U(cf)	D,U	D
P. modestum					D
Eumeces multivirgatus	D				
Cnemidophorus, size *C. tigris*					D
Masticophis sp.		U			D
Salvadora sp.		D(cf)	D	D	
Elaphe guttata				D	
Thamnophis sp.	D		D	D	D
T. proximus				D	
Sonora sp.		U?			
Crotalus sp.	D,U	D,U	D,U	D,U	D
C. atrox				D	
Anas platyrhynchos			U(cf)		
A. cyanoptera	D?				
Coragyps occidentalis	D	D	U		D
Cathartes aura			U		D
Gymnogyps californianus				U[e]	
Teratornis merriami	D				
Circus hudsonius		D			
Accipiter cooperi	D				
Buteo sp.	D	D		U?	
B. jamaicensis	D(cf)				
Aquila chrysaetos	D				
Polyborus prelutosus	D	D	D,U[d]	U[d]	D
Falco sp.		D	D(cf),U		
F. sparverius			U		
F. mexicanus		D			
Centrocercus urophasianus		U	U		
Tympanuchus pallidicinctus	D(cf)	D(cf)			D
Meleagris sp.	U(cf)	U(cf)			
Fulica americana	U?	D			
Charadrius vociferus			D		
Numenius americanus		D	D		
Limnodromus scolopaceus	D(cf)				
Geococcyx californianus conklingi		U	U		
Otus kennicotti		U(cf)[d]	U(cf)[d]	U(cf)[d]	
Bubo virginianus		D	D(cf)		
Asio flammeus	D	D(cf)			D
Eremophila alpestris			D	D	
Hirundo pyrrhonota/fulva		D(cf)			D(cf)
Pica pica	D				
Corvus corax	D	D	D(cf),U		D
Sialia sp.			D	D	
Catharus ustulatus			D		
Lanius ludovicianus			D		
Calamospiza melanocorys			D	D	
Agelaius phoeniceus			D		
Sturnella sp.			D		
Carpodacus sp.			D	D	
Sorex sp.	D	D,U	D,U	D,U	D
S. monticolus	D		D		D
S. nanus	D(cf)				
S. merriami	D	D	D,U(cf)	D	D
Cryptotis parva					D
Notiosorex crawfordi	U	U	D,U	D,U	D
Myotis sp. (smaller)	D,U	U	D,U		
M. lucifugus			D		
M. velifer	D(cf),U(cf)	U	D,U(cf)	D(cf),U(cf)	D(cf)
M. californicus			D?		
M. rectidentis			D(cf)	D(cf)	
Eptesicus fuscus	D		D,U	D,U	D
Lasiurus cinereus			D		
Plecotus sp.	D,U	U	D,U	D,U	
P. townsendi	D	U	D,U		
Antrozous pallidus	U		U	U	

to have had better opportunities for pitfall collecting and for bird nesting. However, roosts for predatory birds occurred at all sites, and at least two species of owl, the barn owl (*Tyto alba*) and the great horned owl (*Bubo virginianus*), continue to use U-Bar Cave at present. Much of the material from all sites is consistent with derivation from owl pellets; other material, especially that from the Dry Cave sites, shows the bone and tooth erosion characteristic of diurnal raptors. Mammalian predation is also evident at both caves.

The lessened chance of pitfall entrapment at U-Bar Cave is somewhat balanced by its suitability for shelter for large herbivores. Small animals used both caves. The question of the size of the geographic area represented by a cave fauna appears to have received little research, yet it is vital to interpretation. Figures earlier gleaned from the literature suggest "that the vast majority of vertebrate remains in most cave sites originated within a few kilometers of the cave, with lesser amounts coming from farther away; that only occasionally would the distance exceed 32 km (20 miles)" (Harris 1977:46).

Table 2. *Continued*

Taxon	18–20 ka	15–18 ka	14–15 ka	13–14 ka	<13 ka
Tadarida brasiliensis	U	U	U	U	D
Nothrotheriops shastensis		U	U	U	
Aztlanolagus agilis	U	U	U	U	
Sylvilagus floridanus/nuttalli	U		U	U	
S. nuttalli	D	D,U	D,U	D	D
S. auduboni	U	U	U	U	
Lepus sp.	D,U	D,U	D,U	D,U	D
L. townsendi	D	D	D		D
L. californicus		U	U	U?	D
Tamias (Neotamias) sp.	U	U	U		
Marmota flaviventris	D		D,U		
Spermophilus elegans	D		D		
S. tridecemlineatus	D		D	D	
S. spilosoma/tridecemlineatus	D,U	U	D,U	D	D
S. spilosoma	U	U	U(cf)		D?
S. variegatus	U	U	U		
Cynomys sp.	U	U	D,U	U	
Cynomys (Leucocrossuromys)			D		
Thomomys sp.	D,U	D,U	D,U	D,U	D
T. bottae	D,U	D,U(cf)	D,U	D	D
T. talpoides	D		D	D(cf)	D
Pappogeomys castanops		D,U	D,U	U	D
Perognathus sp.	U	D,U	U	D,U	D
P. (Perognathus) sp.	U	D,U	U	D,U	D
P. (Chaetodipus) sp.			U		D
P. hispidus					D
Dipodomys ordi/merriami		U[f]			D
D. spectabilis	U(cf)	U(cf)	U	D,U(cf)	D
Reithrodontomys sp.			U	D	D
Peromyscus sp.	D,U	D,U	D,U	D,U	D
P. maniculatus	D?		D(cf)		
P. leucopus			D		
P. difficilis			D		
Onychomys leucogaster	D		D,U		D
Sigmodon sp.		U	U		D
S. ochrognathus		U			
Neotoma floridana	U(cf)	U(cf)	U(cf)		D
N. micropus			D(cf)	D?	D
N. albigula	U	U	D(cf),U	U	
N. stephensi	U	U	U	U	
N. mexicana	U	U	U	U	

Table 2. *Continued*

Taxon	18–20 ka	15–18 ka	14–15 ka	13–14 ka	<13 ka
N. cinerea	D,U	D,U	D,U	D,U(cf)	D
Microtus sp.	D,U	D,U	D,U	D,U	D
M. pennsylvanicus	D		U		D
M. longicaudus	D		D	D	D
M. mexicanus	D,U	D,U	D,U	D	D
M. ochrogaster		U?	D	D	D
Lagurus curtatus	D,U	D,U	D	D,U	D
Ondatra zibethicus			D		
Erethizon dorsatum	D	D		D	D
Canis latrans	D	D,U	D,U	U	D
C. dirus		U(cf)	U		
Vulpes velox	D	D	D	D	D
Urocyon cinereoargenteus	U(cf)	U			
Ursus americanus				U	D
Bassariscus sp.			U		
Mustela frenata	D	U	D,U		D
Taxidea taxus		U	U		
Spilogale sp.		U	U		
Mephitis mephitis	D?,U	D,U	U	U	D(cf)
Felis concolor			U	U	
Lynx rufus	U	U	U	U	D
Equus sp.	D	D,U	D,U	D,U	D
E. conversidens	D	D	D,U(cf)	D,U	D
E. niobrarensis	D	D	D(cf),U(cf)	D	D
E. occidentalis	D(cf)	D?			
Camelops hesternus					D
Hemiauchenia macrocephala	D	D			D
Odocoileus sp.	D	D,U	U		D
O. virginianus			U(cf)		
Antilocapra/Stockoceros			D(cf)		
Stockoceros sp.	U(cf)	U	U	U	
Antilocapra americana		D		D	D(cf)
Capromeryx sp.	U	U?	U		D(cf)
Bison sp.	U(cf)[e]		D	D	D
Euceratherium collinum	U(cf)	U	U	U	
Ovis canadensis		D			

[a]*ka = thousands of years before present*
[b]*D = present in Dry Cave, U = present in U-Bar Cave*
[c]*cf = reasonably certain level of confidence*
[d]*excavation unit combined with other marked units*
[e]*from dated stratum elsewhere in cave*
[f]*probably intrusive*

Dry Cave

Many Dry Cave taxa are used here only for general characterization of the faunas because probable biases, particularly among the herpetofaunas and birds, prevent an accurate assessment of intersite distribution and importance; others supply important data.

The pattern of occurrences and absences within the extant members of the full-glacial Animal Fair fauna allows recognition of a modern cognate area, centering approximately in southeastern Idaho. The faunal similarity is not exact, but shows sufficient commonality to suggest similar features of vegetation and climate.

Southeastern Idaho is largely a sagebrush-steppe interrupted by highlands with juniper woodland and coniferous forest. Most stations in the region have July mean temperatures in the mid to upper teens and January temperatures between ~ −5° and −10°C. Annual precipitation averages 300 to 600 mm with good distribution throughout the cooler seasons but decreased amounts during the summer. In both the presence and absence of taxa, the fossil faunas are generally consistent with these climatic features from full-glacial time to ca. 15000 B.P.

About 82% (37 of 45) of the extant taxa in the Animal Fair fauna occur now in the southeastern Idaho area. The remaining 18% are now found only east or south of that area (Table 3), and all occur in northeastern New Mexico and adjacent Colorado except the cave myotis (*Myotis velifer*). Some taxa from the Dry Cave mid-Wisconsin fauna also occur in northeastern New Mexico. This portion of the full-glacial fauna appears to already have been in place or nearby as climatic conditions degenerated at the beginning of the pleniglacial. In some cases, animals may have resisted displacement because they already filled niches held by close relatives in the northern Great Basin (e.g., the prairie chicken *Tympanuchus pallidicinctus* and sharp-tailed grouse *T. phasianellus*, the western spadefoot *Spea multiplicata* and Great Basin spadefoot *S. intermontana*). However, a greater availability of warm-season moisture than occurs in the northern Great Basin also probably played an important role in allowing some taxa to remain in place. The subsequent Charlies Parlor fauna suggests conditions very similar to those of Animal Fair time, though the appearance of two additional taxa from outside the southeastern Idaho region (Table 3) may hint of minor changes.

The faunas strongly suggest a heavy shrub–grassland cover with big sagebrush (*Artemisia tridentata*) as a major component. Today, the sagebrush vole (*Lagurus curtatus*) is strongly tied to this shrub economically, and a number of taxa in the fauna, such as Nuttall's cottontail (*Sylvilagus nuttalli*), are commonly found in sagebrush areas of the Great Basin. Grasses were common, as indicated by forms reliant on them, such as voles of the genus *Microtus*, horses (*Equus*, three species), and the Wyoming ground squirrel (*Spermophilus elegans*).

The absence of several taxa seems best explained by a heavy ground cover of shrubs, grasses, and forbs. Pocket mice (*Perognathus*) are apparently absent from the large samples of fossil rodents from Animal Fair despite near ubiquity now throughout lower elevations in the West. Heavy plant cover may also explain other absences. Prairie dogs (*Cynomys*) have always occurred in the Dry Cave area nearly as far as Idaho; however, a view unobstructed by heavy vegetation appears necessary. Likewise, kangaroo rats normally prefer vegetation with considerable openness. The unexpected absence of chipmunks (*Tamias*) also could relate to the presence of heavy cover. The rare occurrence of the collared lizard (*Crotaphytus collaris*), which requires rocks and areas open enough to run (Applegarth 1979), suggests occasional interruption of heavy cover by patches of sparse vegetation and shallow soils too small and disconnected to support the absent taxa.

Tree cover is more difficult to determine from the fauna. No taxa that require forests, such as tree squirrels, have been found. Woodrat midden evidence from the Southwest strongly indicates, however, that woodland at least was present (Van Devender et al. 1979); larger conifers could be expected under proper slope and edaphic conditions as would riparian trees along drainageways.

Two important taxa unknown from Animal Fair appear in the Charlies Parlor fauna and continue into the modern regional fauna: silky pocket mice (*Perognathus [Perognathus]*) and yellow-faced pocket gopher (*Pappogeomys castanops*). The latter occurs neither in the Great Basin nor west of New Mexico and thus is a sign of new eastern influence into the area. This gopher tends to live in more arid habitat than does its relative *Thomomys* when the two occur together. This, and the appearance of pocket mice, may indicate lessening effective moisture or a shifted seasonal precipitation, resulting in thinning ground cover.

Several important taxa appear for the first time in the Harris' Pocket fauna (Table **3**). Presence of prairie dogs of the white-tailed group (*Cynomys [Leucocrossuromys]*) suggests continued opening up of the vegetation. Both woodrats, the white-throated (*Neotoma albigula*) and the Southern Plains (*N. micropus*), occur in the cave region now, with the major affinity of *N. micropus* to the east. The woodrats and desert shrew (*Notiosorex crawfordi*) range distinctly less far north than do most taxa thus far considered, reaching their current limits in southern Utah and southern Colorado. All four taxa occur commonly in woodland and down into deserts and arid grasslands.

The prairie vole (*Microtus ochrogaster*) is a Great Plains taxon particularly adapted to more arid grasslands than are competing microtines. Taken in conjunction with the other taxa, this suggests that warming, drying, or increased emphasis on summer precipitation continued the trend seen in the Charlies Parlor fauna with an intensification of an eastern faunal influence.

The trend continued into the time of the Bison Chamber fauna with the first appearance of several southern or eastern taxa (Table **3**). The plains spadefoot toad (*Spea bombifrons*) is of Great Plains affinity as is the western ribbon snake (*Thamnophis proximus*). The bannertail kangaroo rat (*Dipodomys spectabilis*) indicates continued increase in openness of vegetation; the Texas horned lizard (*Phrynosoma cornutum*) requires a warm climate, but some dense vegetation may be required (Applegarth 1979).

Finally, Pleistocene sites postdating the Bison Chamber fauna continue the trends with the appearance of several taxa of decidedly eastern or southern affinities (Table **3**). Cotton rats (*Sigmodon*) indicate warm temperatures (Mohlhenrich 1961); the least shrew (*Cryptotis parva*), hispid pocket mouse (*Perognathus hispidus*), and eastern woodrat (*Neotoma floridana*) indicate influence from the east. The southerly distributed, round-tailed horned lizard (*Phrynosoma modestum*) occurs for the first time as does another lizard, which is quite likely the tiger whiptail *Cnemidophorus tigris*.

Despite the trends discussed above, most of the extant fauna earlier characterized as cognate with that of southeastern Idaho was maintained from the pleniglacial to the end of the Pleistocene (Table **2**). During the post-pleniglacial, southern and eastern species were added. These additions imply that changes in climate were not dramatic and that invasion of the region by taxa of eastern or southern affinity occurred only into particularly favored sites.

Spaulding & Graumlich (1986) indicate that increased summer insolation occurred following the pleniglacial; Van Devender et al. (1987), on the basis of woodrat-midden data, argue against this having a distinguishable effect on the biota. The changes at Dry Cave strongly suggest that such changes were important, at least along the interface between the Great Plains and the Southwest.

The climatic conditions during full-glacial times may be summarized as having cold winters (hard freezes) and summers cool enough to severely restrict egg-laying reptiles. Effective moisture increased because of cooler temperatures and perhaps an absolute increase in precipitation. The pattern of seasonal precipitation probably differed greatly from the present, with precipitation being more evenly distributed throughout the year, but summer months likely were drier than those of the cold season. Faunas from full-glacial to Bison Chamber times suggest slowly warming summer temperatures and increasing summer precipitation; the post-13000 B.P. sites show the effect of both warmer winter and warmer summer temperatures with a strong pulse of warm-season moisture, but continued availability of cold-season precipitation.

The Dry Cave faunas became increasingly disharmonious from full-glacial time until the terminal Pleistocene. Although the pleniglacial fauna is, to a degree, disharmonious, the number of taxa not now occurring in the cognate area is small. Unlike most later disharmonious additions, at least some of these absent taxa seem to have closely related ecologic vicars (organisms that fill a particular ecologic role in a different geographic area and thus "substitute" for the organisms they are being compared with) (Table 3). The increase in association of taxa that now have separate geographic ranges may well have been allowed by summer temperatures that were still relatively cool while winters were warming, as suggested by Hibbard (1960) and various other researchers for other disharmonious faunas.

Table 3. Taxa Considered as Southern or Eastern in Distribution, Occurrence in Dry Cave Sites

Taxon	Animal Fair	Charlies Parlor	Harris' Pocket	Bison Chamber	<13 000 B.P.
Microtus mexicanus	•	•	•	•	•
Vulpes velox	•	•	•	•	•
Myotis velifer	cf		•	cf	cf
Tympanuchus pallidicinctus	cf	cf			•
Bufo cognatus	•				•
Spermophilus tridecemlineatus	•		•	•	
Spea multiplicata	•			•	
Eumeces multivirgatus	•				
Pappogeomys castanops		•	•		•
Salvadora sp.		cf	•	•	
Notiosorex crawfordi			•	•	•
Microtus ochrogaster			•	•	•
Neotoma micropus			cf	?	•
Neotoma albigula			cf		
Phrynosoma cornutum				•	•
Dipodomys spectabilis				•	•
Spea bombifrons				•	
Elaphe guttata				•	
Thamnophis proximus				•	
Crotalus atrox				•	
Phrynosoma modestum					•
Cnemidophorus sp.					•
Terrapene ornata					cf
Cryptotis parva					•
Perognathus hispidus					•
Sigmodon sp.					•
Neotoma floridana					•

U-Bar Cave

The most notable feature within the U-Bar Cave samples is the relative constancy through time, from well within the mid Wisconsin (Harris 1987) to the end of the dated record at ca. 13000 B.P. The fauna, as during the mid Wisconsin, is a mixture of taxa from diverse regions with no modern area showing sympatry of most forms.

Taxa that seem likely to represent late-Wisconsin arrivals include *Pappogeomys castanops* and *Microtus ?ochrogaster* (queried only because it is based on a single specimen, and occasionally aberrant teeth of other microtines mimic teeth of this taxon). The yellow-faced gopher was absent during the mid Wisconsin and is most common in the disturbed surface material (post-13000 B.P.). The specimens (mostly isolated teeth) from the study levels may be intrusive. The taxon now approaches to some 180 km east of the site.

With little change from conditions during the mid Wisconsin, the interpretation of the environment for that time (Harris 1987) changes little for the latter part of the Wisconsin. Absence of Stock's vampire bat (*Desmodus stocki*) might indicate slightly colder winter temperatures than earlier, but generally mild winters and cool summers are indicated. Vegetation was open-to-dense woodland (possibly with larger conifers in favored habitats) with a well-developed understory that included shrubs, forbs, and grasses. Big sagebrush, probably intermixed with grasses, formed stands on the deeper valley soils.

Intersite Comparisons

The U-Bar Cave region seems to exhibit no major change between the mid and the late Wisconsin, although some winter cooling is possible. However, for Dry Cave, with a mid-Wisconsin fauna quite similar to that of nearby northeastern New Mexico (Harris 1987), the area of greatest faunal similarity shifted >1000 km to the northwest, to the northern Great Basin and beyond.

The faunas from U-Bar Cave differ from those recovered from Dry Cave mostly in ways that make sense in terms of the hypothesized differences in climatic conditions and vegetation cover. A few faunal differences, however, do not seem to be explained by these factors.

The climate generally appears to have been warmer, with less effective moisture at U-Bar Cave than at Dry Cave. As a result of climatic and vegetational differences, a suite of taxa is absent from U-Bar Cave, including: the montane shrew (*Sorex monticolus*), *Spermophilus elegans*, northern pocket gopher (*Thomomys talpoides*), long-tailed vole (*Microtus longicaudus*), and white-tailed jack rabbit (*Lepus townsendi*), though the last was identified from Howell's Ridge Cave some 55 km to the north (Harris 1985a). Other forms, now less restricted to northern or high-elevation climes than these, did occur together with more xeric-adapted species; e.g., both *Sylvilagus nuttalli* and the desert cottontail (*S. auduboni*) were present at U-Bar Cave. On the other hand, taxa such as *Neotoma albigula* and *Dipodomys spectabilis* are widespread in the U-Bar Cave deposits but absent until relatively late at Dry Cave; and the gray fox (*Urocyon cinereoargenteus*) and the rock squirrel (*Spermophilus variegatus*) do not appear in the latter until the Holocene.

Continuance of such taxa as *Cynomys, Perognathus, D. spectabilis,* and *Tamias* from the mid Wisconsin through the late Wisconsin at U-Bar Cave, while absent in full-glacial Dry Cave, may be related to a scantier ground cover at U-Bar Cave.

The absence of any species of *Vulpes* at U-Bar Cave is not understood. The swift fox (*V. velox*) was common in all Dry Cave faunas, and the kit fox (*V. macrotis*) occurs in the Playas Valley now. Absence of Stephen's woodrat (*Neotoma stephensi*) at Dry Cave may be explainable on geographic grounds, its present range being entirely west of the Rio Grande; its occurrence at U-Bar Cave indicates the presence of junipers. Absence of the Mexican woodrat (*N. mexicana*), which now occurs in the highlands west of Dry Cave, in any of the Dry Cave glacial faunas is less easily accounted for. This species may be a late entrant into southeastern New Mexico, where it appears in Dry Cave Holocene deposits. Logan & Black (1979) reported *N. mexicana* from an elevation of 2000 m at Upper Sloth Cave, apparently as early as ca. 12000 B.P.

The extinct Aztlán rabbit (*Aztlanolagus agilis*) is moderately common throughout the column at U-Bar Cave, but disappeared at Dry Cave well before full-glacial conditions. This may be a direct result of deteriorating climatic conditions at Dry Cave, or unknown factors may already have been at work, eroding the margins of its range.

Most other faunal differences may be a matter of sampling. For example, *Cryptotis parva* is present in the latest Dry Cave Pleistocene (locality 54) but not at U-Bar Cave; it is known from Howell's Ridge Cave, however (Harris et al. 1973). Likewise, four-horned pronghorn (*Stockoceros*) and shrub-oxen (*Euceratherium*) are not recognized at Dry Cave, though common at U-Bar Cave; both occurred at Burnet Cave, ~30 km west of Dry Cave (Schultz & Howard 1935).

Climatically, the strong differences implied by the faunas of the two sites suggest that in full-glacial times, as today, southern New Mexico west of the chain of mountains bounding the western edge of the Southern Plains escaped the full brunt of cold-front activity that at Dry Cave dropped winter temperatures into the lethal zone for such animals as *Gopherus* and perhaps for such taxa as *Notiosorex crawfordi* and *Spermophilus variegatus*.

Of the numerous other vertebrate cave sites in southern New Mexico, only Upper and Lower Sloth Caves (2000 m), in the southern Guadalupe Mountains, have dates that allow correlation with the Dry Cave and U-Bar Cave sequence. Their faunas apparently date to 11 500 to 12 000 B.P. and are consistent with the late Dry Cave faunas (Logan 1983, Logan & Black 1979). For the same sites, Van Devender et al. (1979) noted from plant macrofossils that by this time, mixed coniferous forest had replaced a subalpine forest habitat at ca. 13 000 B.P., in keeping with the faunal evidence of warming from Dry Cave.

Conclusions

The Dry Cave late-Wisconsin, full-glacial fauna differed notably from mid-Wisconsin faunas from the same cave system; the U-Bar Cave fauna showed little change from mid-Wisconsin to full-glacial time.

Most extant members of the Dry Cave full-glacial fauna can be found in an area centered in southeastern Idaho; the other extant taxa occur in a secondary area of sympatry in northeastern New Mexico. Extant members of the U-Bar Cave, full-glacial fauna are represented in a variety of regions, and the fauna was more disharmonious than that of Dry Cave.

At Dry Cave, increasing numbers of Great Plains–associated taxa appeared between the full-glacial and terminal Pleistocene; southern forms appeared toward the end of that span. At U-Bar Cave, the faunas were similar throughout the late-Wisconsin deposits.

Climatic conditions at Dry Cave included cool summers, cold winters, and more cold-season available moisture than now; warm-season precipitation became increasingly important after full-glacial time. At U-Bar, summers were much cooler than now, but warmer and drier than at Dry Cave; winters were warmer (few prolonged, hard freezes) than at Dry Cave but with similar emphasis on cold-season precipitation.

Acknowledgments

The National Geographic Society has supplied partial support for research at both Dry Cave and U-Bar Cave, and this is gratefully acknowledged. The National Museum of Natural History lent modern comparative material, and numerous students and colleagues have aided in excavation and processing over the years. The Bureau of Land Management and the New Mexico State Land Office granted excavation permits.

Bibliography

Applegarth, J. S.

1979. Herpetofauna (anurans and lizards) of Eddy County, New Mexico, Ph.D. dissertation. University of New Mexico, Albuquerque.

Campbell, K. E. Jr.; & Tonni, E. P.

1981. Preliminary observations on the paleobiology and evolution of teratorns (Aves: Teratornithidae). *Journal of Vertebrate Paleontology* 1:265–272.

Harris, A. H.

1970. The Dry Cave mammalian fauna and late pluvial conditions in southeastern New Mexico. *Texas Journal of Science* 22:3–27.

1977. Wisconsin age environments in the northern Chihuahuan Desert: evidence from the higher vertebrates. Wauer, R. H. & Riskind, D. H., editors: *Transactions of the Symposium on the Biological Resources of the Chihuahuan Desert Region, United States and Mexico. National Park Service Transactions and Proceedings Series* 3:23–52.

1980. The paleoecology of Dry Cave, New Mexico. *National Geographic Society Research Reports* 12:331–338.

1985a. *Late Pleistocene Vertebrate Paleoecology of the West.* University of Texas Press, Austin.

1985b. Preliminary report on the vertebrate fauna of U-Bar Cave, Hidalgo County, New Mexico. *New Mexico Geology* 7:74–77, 84.

1987. Reconstruction of mid-Wisconsin environments in southern New Mexico. *National Geographic Research* 3:142–151.

Harris, A. H.; Smartt, R. A.; & Smartt, W. R.

1973. *Cryptotis parva* from the Pleistocene of New Mexico. *Journal of Mammalogy* 54:512–513.

Hibbard, C. W.

1960. An interpretation of Pliocene and Pleistocene climates in North America. *Annual Report of the Michigan Academy of Science, Arts, and Letters* 62:5–30.

Holman, J. A.

1970. A Pleistocene herpetofauna from Eddy County, New Mexico. *Texas Journal of Science* 22:29–39.

Hurley, P.A.

1972. Late Pleistocene raptors from Dry Cave, Eddy County, New Mexico, Master's thesis. University of Texas, El Paso.

Logan, L. E.

1983. Paleoecological implications of the mammalian fauna of Lower Sloth Cave, Guadalupe Mountains, Texas. *National Speleological Society Bulletin* 45:3–11.

Logan, L. E.; & Black, C. C.

1979. The Quaternary vertebrate fauna of Upper Sloth Cave, Guadalupe Mountains National Park, Texas. Genoways, H. H. & Baker, R. J., editors: *Biological Investigations in the Guadalupe Mountains National Park, Texas. National Park Service Proceedings and Transaction Series* 4:141–158.

Mohlhenrich, J. S.

1961. Distribution and ecology of the hispid and least cotton rats in New Mexico. *Journal of Mammalogy* 42:13–24.

Schultz, C. B.; & Howard, E. B.

1935. The fauna of Burnet Cave, Guadalupe Mountains, New Mexico. *Proceedings of the Academy of Natural Sciences of Philadelphia* 87:273–298.

Spaulding, W.G.; & Graumlich, L. J.

1986. The last pluvial climate episodes in the deserts of southwestern North America. *Nature* 320:441–444.

Van Devender, T. R.; Spaulding, W.G.; & Phillips, A. M. III.

1979. Late Pleistocene plant communities in the Guadalupe Mountains, Culberson County, Texas. Genoways, H. H. & Baker, R. J., editors: *Biological Investigations in the Guadalupe Mountains National Park, Texas. National Park Service Proceedings and Transaction Series* 4:13–30.

Van Devender, T. R.; Thompson, R. S.; & Betancourt, J. L.

1987. Vegetation history of the deserts of southwestern North America; the nature and timing of the late Wisconsin–Holocene transition. Ruddiman, W. F. & Wright, H. E. Jr., editors: *North America and Adjacent Oceans During the Last Glaciation, The Geology of North America*, vol. K-3. Geological Society of America, Boulder.

Accepted 12 January 1988.