Arthur H. Harris

Reconstruction of Mid Wisconsin Environments in Southern New Mexico

Abstract

Abundant vertebrate remains from two mid-Wisconsin cave deposits in New Mexico allow reconstruction of paleoenvironments. Dry Cave lies in southeastern New Mexico, U-Bar Cave in the extreme southwest (Figure 1). Both sites are in the ecotone between woodland and Chihuahuan Desert vegetations. During the mid Wisconsin, both had vertebrate species indicative of woodland, but otherwise differed greatly. Dry Cave had winter temperatures milder than those at the site today, but otherwise the climate was similar to that now found some 450 km to the north. Except for taxa allowed into the area by mild winters, extralimital forms occur in nearby highland woodlands or in northeastern New Mexico. U-Bar Cave probably lacked winter freezes, had cool summers, and had precipitation more evenly distributed than now. Taxa now as distant as the Great Basin occurred together with species from the nearer highlands. Relatively warm summers and retention of seasonal patterns of precipitation at Dry Cave in contrast to cool summers and decreased seasonality of precipitation at U-Bar Cave produced more extreme biotic differences between the sites than is the case now. Whether this was due to different contemporaneous climatic regimes or to chronological differences between the faunas is uncertain.

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The last major subdivision of the Pleistocene Epoch is the Wisconsin Age. Between ice advances in the early Wisconsin, terminating around 60 000 B.P., and a major renewal of glacial activity in the late Wisconsin, commencing around 32 000 to 27 000 B. P., there was a long span of less severe climatic conditions, the mid Wisconsin (see Bradley 1985 for age estimates). Conditions typical of the full glacial may not have appeared in the study area until somewhat later than indicated above (Wendorf 1975), and 25 000 *B.P.* is used here as the division between mid and late Wisconsin times. Compared with the succeeding full glacial, the environments that prevailed during the mid Wisconsin are poorly known. In the Southwest, only Dry and U-Bar Caves provide useful faunas surely assignable to the mid Wisconsin. This report compares their faunas and the floral and climatic conditions inferred from those faunas.

The Sites

Dry Cave

Dry Cave, Eddy County, New Mexico, lies at an altitude of 1280 m in rolling limestone country about halfway between the Pecos River to the east

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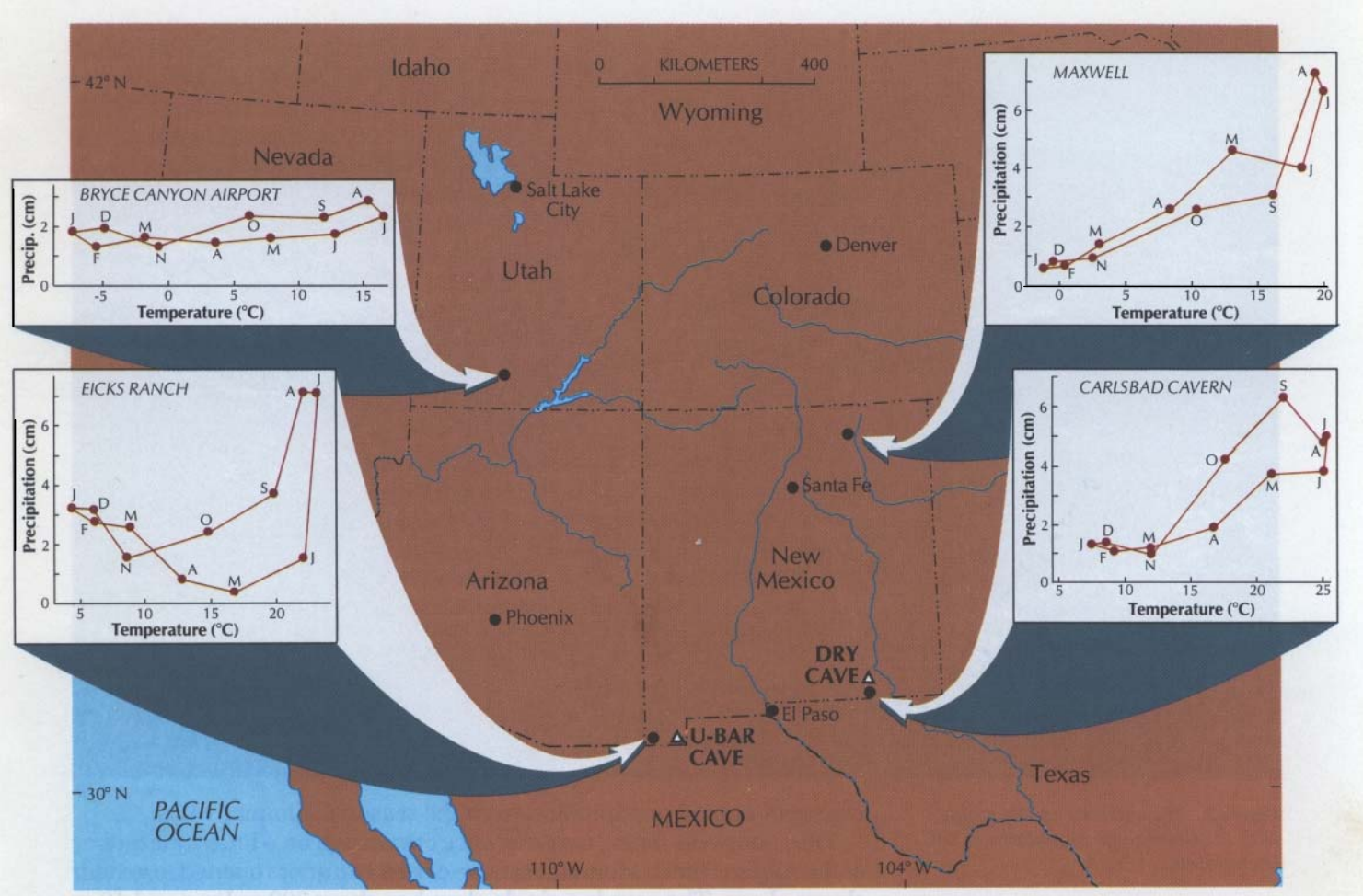

Figure 1. The Four Corners area with locations of the sites and weather data collection stations. The climatographs are based on data ending in 1960, with these durations: Bryce Canyon Airport, 12 to 13 years; Eicks Ranch, 26 to 28 years; Maxwell, 42 to 44 years; and Carlsbad Cavern, 29 to 30 years.

and the Guadalupe Mountains to the west. It is near the margin of a prong of the Chihuahuan Desert extending northward between the Great Plains to the east and the montane woodlands and forests of the western highlands. Plants of the desert intermingle with those of the higher, Upper Sonoran woodland.

Precipitation and temperature data from Carlsbad Caverns (elevation, 1352 m), about 22 km to the south, are summarized in Figure 1. Warm temperatures, a severe winter drought, and relatively plentiful summer rains characterize the region.

The cave is an extensive maze that has intersected the surface sporadically through more than 35 000 years. The sites of mid-Wisconsin age are far from the present entrance (Figure 2), with no surface evidence of the ancient openings. From within the cave, the clogged entrances can be seen as vertical fissures that must have been ideal pitfall traps, bird roosting areas, and habitat for small vertebrates. Fuller description of the cave and present environment are to be found in Harris (1970a).

U-Bar Cave

U-Bar Cave (elevation, 1570 m), some 390 km west-southwest of Dry Cave, in Hidalgo County, New Mexico, is higher than Dry Cave, but it too lies in the ecotone between Chihuahuan Desert vegetation and Upper Sonoran woodland. The Animas Mountains, forested in their higher elevations, mark the continental divide, 32 km westward across the Playas Valley. Precipitation and temperature data (Figure 1) were recorded at Eicks Ranch, near Cloverdale in the Animas Valley (46 km west of the cave) (elevation, 1615 m). A severe spring drought separates the signi -

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Figure 2. The entrance to Dry Cave, with the Guadalupe Mountains in the background.

cant cool-season precipitation from the seasonal summer rains.

The southwest-facing cave entrance opens high on a limestone outlier of the Alamo Hueco Mountains; now-closed entrances opened to gentler slopes above. The cave is a single chamber about 300 m long and 40 to 50 m wide. Depositional relationships within the cave are complex. Thin Holocene deposits with cultural material directly overlie full-glacial deposits in some areas and mid-Wisconsin sediments in others. Animal burrows, slumping, and water action are apparent. In addition, mining of bat guano has removed much fill and greatly disturbed other areas. Lambert & Ambler (1961) and Harris (1985a) should be consulted for general background and details of earlier scientific work.

Materials and Methods

Specimens from the Dry Cave sites are catalogued into the Resource Collections, Laboratory for Environmental Biology, University of Texas at El Paso (UTEP). U-Bar Cave specimens are held at the same depository for study, but ultimately will be deposited permanently at a New Mexican institution yet to be designated.

Dry Cave

Collections from the Dry Cave mid-Wisconsin deposits were made during the period 1966 through 1984. Large or fragile specimens were handpicked at the sites, then packed in fossiliferous matrix for protection during the arduous journey to the entrance. Other specimens were recovered by washing the fossiliferous matrix through mesh screens (1.8-mm mesh, with many samples through 0.5-mm mesh). Most of the resulting concentrate was sorted without magnification. Over 5000 items are catalogued from the mid-Wisconsin sites.

U-Bar Cave

At U-Bar Cave, collection techniques were required to be compatible with the major guano-mining operations that are still continuing. Archaeological salvage work by the Museum of New Mexico early in 1984 established 9-m^2 gridding of the cave, but these grids were divided into 1-m squares where warranted (Harris 1985a).

Various excavation techniques were employed depending on position within the cave, degree of disturbance, richness of deposits, and time constraints. In rich, disturbed deposits, sediments were screened through coarse (6 mm) and fine (1.8 mm) screens, the resulting coarser matrix handpicked, and the finer matrix removed from the cave to be processed in the laboratory. Most laboratory-processed material was wet-screened (0.5-mm mesh) and handpicked without magnification; subsamples were examined at 3 X and 10 X. Samples from undisturbed stratigraphic columns in several regions of the cave were handled similarly, while some areas were excavated by trowel without screening. Other material was recovered from mining spoil.

Bulk samples for radiocarbon dating, palynological examination, and sedimentary studies were collected. Many thousands of specimens have been recovered, and final analysis will require some years. However, large samples have been examined and taxa on which the present paper is based are vouchered by approximately 433 catalogued items.

Results

Chronology and Stratigraphy

Dry Cave

Localities 1 and 26 are sediments introduced through fissures; stratigraphy was not apparent. Locality-5 deposits were water-laid, but shallow.

With insufficient surviving protein for collagen dates, the three radiocarbon dates available for the Dry Cave sites are from carbonates from bone scrap (Table 1). Such dates commonly are considered unreliable because of exchange reactions with modern carbon; such reactions result in dates too young (Bradley 1985).

U-Bar Cave

The so-called red guano unit appears to form a continuous blanket throughout the cave, varying from a few centimeters to more than 1 m thick. The unit may represent in situ emplacement of bat guano, packrat midden material, and mineral material from the roof and walls; most biotic remains except bone have disintegrated to a fine powder.

Disturbance is considerable due to human and other animal activity in the very soft deposits, and slumping is frequent during excavation. Apparently undisturbed sections, however, do not appear to differ faunistically from disturbed areas except for the absence of material judged as Holocene by preservational characteristics.

The uppermost portion of the unit in a seemingly undisturbed section was dated at 29 120 ± 1400 B.P.; the oldest finite date from the unit is 35 890 ± 2640 B.P. (Table 1). Most faunal remains used in the interpretation are from the red guano unit, particularly from two deposits dated at 35 890 ± 2640 and at older than 31 150 B.P. All dates are from bulk samples of the sediments.

In one area, more than 2 m of mid-Wisconsin deposits lie above the red guano unit. Approximately horizontal, water-laid strata, some displaying evidence of periodic ponding, were cut by a channel that filled

Table 1. Radiocarbon Dates from Mid-Wisconsin Sites Within Dry and U-Bar Caves

Lab No.	Years B.P.	Comments
DRY CAVE		
TX-1773	33590 ± 1550	UTEP Loc. 26
TX-1774	29290 ± 1060	UTEP Loc. 1
TX-1775	25160 ± 1730	UTEP Loc. 5
U-BAR CAVE		
A-4222	29120 ± 1400	red guano
A-4362	35090 ± 2170	red guano
A-4221	35890 ± 2640	red guano
A-4414	>3 500	red guano
A-4128	>31150	red guano
A-4223	>34 370	red guano
A-4129	29 000± 2000	
A-4194	28 900± 1700	
A-4217	>29 600	
A-4363	>35 680	
A-4442	>31 000	
A-4443	>30 900	
A-4444	28 300 ± 2000	
A-4445	26 150 ± 1450	

with alternating layers of gravel and finer sediments; other strata, some believed to represent redeposition of material from older deposits, then were laid down. Radiocarbon dates range from 26 150 ± 1450 to older than 35 680 B.P. (Table 1).

Flora

Dry Cave has not produced plant macrofossils except for occasional seeds, mostly hackberry. In U-Bar Cave, hackberry seeds are preserved and small fragments of charcoal occur in some water-laid deposits. Efforts to recover pollen have been unsuccessful at both sites.

Fauna

Identified taxa are listed in Table 2. Taxa marked as extralimital are those believed absent from within about 32 km of a site, the practical maximum distance from which predatory animals bring prey items to a site (Harris 1977).

Discussion

Most of the environmental reconstruction is based on observations of extant taxa and close relatives. However, the degree of genetic similarity between populations tends to diminish through time, and parameters governing ecological distribution are very imperfectly known for living plants and animals. At present, then, reconstructions basically are working hypotheses to be tested by future advances in knowledge of both fossil and living life forms. Principles of environmental reconstruction based on late Pleistocene faunas and the interpretation to be given specific taxa are discussed in more detail elsewhere (Harris 1985b).

Climate

The climatic and biotic parameters that limit distribution tend to differ among taxa. Thus different members of the fauna may supply data on different aspects of the environment.

Winter Temperatures

Several vertebrates are pertinent to the interpretation of winter temperatures. The extant desert tortoise *(Gopherus agassizi) is* restricted today to the Sonoran and Mojave Deserts, apparently by inability to survive the hard freezes characteristic of the regions surrounding these deserts; the extinct Wilson's tortoise *(Geochelone wilsoni)* probably was similarly limited (Moodie & Van Devender 1979). Both taxa were present at Dry Cave. Desert tortoise remains from mining spoil at U-Bar Cave may be mid Wisconsin in age, but this is uncertain. Presence of tapir *(Tapirus* sp.) at Dry Cave may also imply mild winters.

At U-Bar Cave, occurrence of the extinct Stock's vampire bat *(Desmodus stocki)* implies that temperatures were above freezing throughout the year. This bat is somewhat larger than the extant vampire bat (D. *rotundus),* but otherwise similar. A number of late Pleistocene taxa (including bats) were larger than their extant close relatives or descendants; apparently increased size was an adaptation to cooler average temperatures during the warmer season. Freezing temperatures are believed to bar the living bat from extending farther north than its present limit in southern Sonora and southern Chihuahua (Kurten & Anderson 1980), and similar limitations probably applied to the extinct bat.

Dry Cave, then, likely was subjected to no more than light freezing

Table 2. Taxa Identified from Dry and U-Bar Caves

Taxon (Common Name)	Dry Cave	U-bar Cave
Osteichthyes (bony fishes)	P	
Ambystoma tigrinum (tiger salamander)		P
Anura (tailless amphibians)	P	
Scaphiopus sp. (spadefoot toads)		P
Bufo sp. (true toads)		P
Chelonia (turtles)		P
Gopherus agassizi (desert tortoise)	EL	
Geochelone wilsoni (Wilson's tortoise)	X	
?Cophosaurus texanus (greater earless lizard)	P	
Crotaphytus collaris (collared lizard)	P	P
Sceloporus sp. [large] (spiny lizard)		P
Sceloporus sp. [small] (spiny lizard)		P
cf. *Urosaurus ornatus* (tree lizard)		P
Phrynosoma cornutum (Texas horned lizard)	P	P
P. douglassi (short-horned lizard)	EL	P
P. modestum (round-tailed horned lizard)	P	
Cnemidophorus sp. [large] (whiptail lizard)		P
?Salvadora (patch-nosed snake)		P
?Pituophis (gopher snake)		P
Crotalus sp. (rattlesnake)	P	P
cf. *Anabernicula* (extinct sheldgoose)		X
Anas cf. *platyrhynchos* (mallard)		P
A. ?americanus (American wigeon)	P	
Coragyps occidentalis (western vulture)	X	
cf. *Cathartes aura* (turkey vulture)		P
Breagyps clarki (La Brea condor)	X	
Accipiter cf. *striatus* (sharp-shinned hawk)	P	
Aquila chrysaetos (golden eagle)	P	P
cf. *Falco sparverius* (American kestrel)		P
F. ?peregrinus (peregrine falcon)	P	
Meleagris crassipes (big-footed turkey)	X	
cf. *Cyrtonyx montezumae* (Montezuma quail)	EL	
?Colinus virginianus (northern bobwhite)		P
cf. *Callipepla squamata* (scaled quail)	P	
Fulica americana (American coot)	P	
Zenaida macroura (mourning dove)	P	P
Geococcyx californianus californianus (greater roadrunner)	P	
G. c. conklingi (Conkling's roadrunner)		X*
cf. *Otus* (flammulated or screech owl)	P	
Strix cf. *occidentalis* (spotted owl)		P
Bubo virginianus (great horned owl)	P	
Picidae [small] (woodpecker)	P	
Colaptes auratus (northern flicker)	P	P
?Cyanocitta (jay)	EL	
Aphelocoma coerulescens (scrub jay)	EL	
Corvus neomexicanus (New Mexican raven)	X	
C. corax (common raven)	P	
cf. *Salpinctes obsoletus* (rock wren)		P
?Xanthocephalus xanthocephalus (yellow-headed blackbird)		P
Sorex sp. (long-tailed shrew)	EL	
S. merriami (Merriam's shrew)		EL
Desmodus stocki (Stock's vampire bat)		X
Myotis ?lucifugus (little brown myotis)		EL
M. velifer (cave myotis)	P	P
Eptesicus fuscus (big brown bat)		P
Plecotus sp. (big-eared bat)	P	P
Antrozous pallidus (pallid bat)	P	P
Tadarida brasiliensis (Brazilian free-tailed bat)	P	P
T. macrotis (big free-tailed bat)	P	
Nothrotheriops shastensis (Shasta ground sloth)	X	X
Aztlanolagus agilis (Aztlán rabbit)	X	X
Sylvilagus nuttalli (Nuttall's cottontail)	EL	EL
S. auduboni/floridanus (desert or eastern cottontail)		P
S. auduboni (desert cottontail)	P	
Lepus sp. (jackrabbit)		P
L. californicus (black-tailed jackrabbit)	P	
Tamias (*Neotamias*) sp. (chipmunk)	EL	
T. (*Neotamias*) *?dorsalis* (cliff chipmunk)		P
Marmota flaviventris (yellow-bellied marmot)		EL
Ammospermophilus sp. (antelope squirrel)	EL	
Spermophilus (Ictidomys) sp. (ground squirrel)	P	P
S. variegatus (rock squirrel)		P
Cynomys sp. (prairie dog)	P	P
Thomomys sp. (pocket gopher)	P	
T. bottae (Botta's pocket gopher)		P
Pappogeomys sp. (pocket gopher)	P	
Perognathus cf. flavus (silky pocket mouse)		P
P. (Perognathus) sp. (silky pocket mice)	P	
P. (Chaetodipus) sp. (spiny pocket mice)	P	P
Dipodomys sp. [larger] (kangaroo rat)	P	
Dipodomys sp. [smaller] (kangaroo rat)	P	
D. cf. *spectabilis* (banner-tail kangaroo rat)		P
Reithrodontomys cf. *megalotis* (western harvest mouse)		P
Peromyscus eremicus (cactus mouse)		P
P. maniculatus (deer mouse)		P
P. *?boylii* (brush mouse)		P
P. boylii (brush mouse)	EL	
P. truei (pinyon mouse)		P
P. difficilis (rock mouse)		P
Sigmodon sp. (cotton rat)		P
S. hispidus (hispid cotton rat)	P	
Neotoma micropus (Southern Plains pack rat)	P	
N. albigula (white-throated pack rat)	P	P
N. stephensi (Stephen's pack rat)		EL
N. mexicana (Mexican pack rat)		P
N. cinerea (bushy-tailed pack rat)		EL
N. findleyi (Findley's pack rat)	X	X
N. pygmaea (pygmy pack rat)	X	
Microtus pennsylvanicus (meadow vole)		EL
M. mexicanus (Mexican vole)		EL
Pitymys ochrogaster (prairie vole)	EL	
Lagurus curtatus (sagebrush vole)		EL
cf. *Erethizon dorsatum* (porcupine)	P	
Canis latrans (coyote)	P	
C. lupus (gray wolf)	P	
C. dirus (dire wolf)	X	
Vulpes cf. *velox* (swift fox)	EL	
Urocyon cinereoargenteus (gray fox)	P	P
Arctodus simus (giant short-faced bear)		X
Ursus *americanus* (black bear)	P	
U. cf. *americanus* (black bear)		P
Bassariscus sp. (ringtail)	P	
Mustela cf. *frenata* (long-tailed weasel)	P	
Taxidea taxus (badger)		P
cf. *T. taxus* (badger)	P	
Spilogale sp. (spotted skunk)	P	P
Mephitis mephitis (striped skunk)		P
Panthera onca (jaguar)	EL	
Felis concolor (mountain lion)	P	
Lynx rufus (bobcat)	P	P
Tapirus sp. (tapir)	X	
Equus sp. [smaller] (horse)	X	
E. conversidens (Mexican horse)		X
E. cf. *niobrarensis* (Niobrara horse)		X
E. cf. occidentalis (western horse)		X
E. occidentalis (western horse)	X	
cf. *Platygonus* (peccary)	X	
cf. *Camelops* (camel)		X
C. cf. *hesternus* (yesterday's camel)	X	
Hemiauchenia sp. (llama)	X	
Odocoileus sp. (deer)		P
?Navahoceros (mountain deer)		X
Capromeryx sp. (small pronghorn)	X	X
Stockoceros onusrosagris (Quentin's pronghorn)		X
Antilocapra americana (pronghorn)	P	
cf. *Oreamnos harringtoni* (Harrington's mountain goat)		X
cf. *Euceratherium* (shrub-ox)		X

P = *occurs* at site and in area *currently*, **EL** = *extralimital*, ***X*** = *extinct in North* America
**recovered from mining spoil only*

conditions, and U-Bar Cave was frost free for practical purposes during the mid Wisconsin.

Summer Temperatures

Several taxa supply somewhat limited information regarding summer temperatures. Harris & Crews (1983) suggested that the roadrunner *Geococcyx californianus* avoids heat stress under current summer conditions by maintaining a relatively small body size; that in environments of reduced summer heat stress, it optimized winter heat conservation by larger body size. The smaller, extant greater roadrunner *G. c. californianus* occurred at Dry Cave, implying relatively warm summers. At U-Bar Cave, a specimen from mining spoil, exhibits preservation consistent only with that of mid-Wisconsin specimens and represents the larger, extinct Conkling's roadrunner *G. c. conklingi.* On this basis, the U-Bar Cave area likely had cooler summers than did Dry Cave.

The hispid cotton rat *(Sigmodon hispidus)* occurred at Dry Cave. Mohlhenrich (1961:22) found that, in New Mexico, its presence indicated "a mean July temperature of 75°F [24°C] or above." He also found a usual growing season of at least 180 days. Under the more equable temperatures of the mid Wisconsin, these parameter estimates may not hold, but do suggest relatively warm summers and long growing seasons. Rarity of cotton-rat remains at Dry Cave may indicate transportation by raptors from somewhat lower elevations. The climatic implications of the somewhat uncommon occurrences of cotton rats at U-Bar Cave are unknown, since trustworthy identifications to the species level have yet to be made.

Biota

Extralimital Taxa

At both Dry and U-Bar Caves, virtually all of the extant, extralimital forms indicate that more effective moisture was available in the mid Wisconsin than now. However, the current distributions of these extralimital taxa differ markedly between the two sites.

At Dry Cave, extralimital taxa other than the tortoises are drawn predominantly from nearby highlands. Most can be found today in woodlands, which typically are rather open stands of small trees (junipers, pinyon pines, and oaks) with an understory of brushy vegetation, grasses, and forbs. Woodland taxa include the scrub jay *(Aphelocoma coerulescens),* brush mouse *(Peromyscus boylii),* and a western chipmunk *(Tamias sp.).* The short-horned lizard *(Phrynosoma douglassi)* occurs in woodlands, but also in grasslands and into the lower coniferous forest. A non-desert quail (probably the Montezuma quail *Cyrtonyx montezumae*) also may be a woodland form, as likely was the extinct turkey *Meleagris crassipes,* judging from its known distribution (Rea 1980). Some of these taxa also occur in the altitudinally higher ponderosa pine or mixed coniferous forests, but, as currently known, no member of the fauna requires such.

Three extralimital taxa at Dry Cave do not occur nearby. These are a long-tailed shrew *(Sorex sp.),* Nuttall's cottontail *(Sylvilagus nuttalli),* and the prairie vole *(Pitymys ochrogaster).* Most species of long-tailed shrews in the Southwest are found in montane forests; Merriam's shrew *(Sorex merriami),* however, also is recorded down into woodland and brushy grassland situations in west-central and northeastern New Mexico. The single, fragmentary specimen is not inconsistent with this species. The other two species also are found in northeastern New Mexico. Nuttall's cottontail reaches its southeastern limits in forests and wood

lands of this area; the prairie vole occurs in grasses and sedges as a relictual population, south and west of its primary range.

Climatic conditions similar to those where these taxa occur in juxtaposition likely would, with more equable winter conditions, allow all extant Dry Cave taxa to exist close to the cave. Figure 1 allows comparison of the temperature-precipitation regime from a station (Maxwell) in northeastern New Mexico with that from Carlsbad Caverns. Maxwell differs from the latter in earlier cessation of the summer rains and overall cooler temperatures. Absence of the extreme cold fronts now characteristic of the entire region--as has been widely hypothesized by various workers--would result in greater winter equability; with only slightly higher precipitation, summer highs likely could be increased somewhat without violence to the fauna.

Absent Taxa

Interpretation based on absence of taxa in a fauna is dangerous in paleontology, but the large sample size from Dry Cave allows tentative use. Absence of several taxa is consistent with the climatic model. Although it was widespread during full-glacial times, today the yellow-bellied marmot *(Marmota flaviventris)* is barred from most of the Southwest by winter-spring precipitation insufficient to support a continuous supply of green fodder until the onset of summer rains (Harris 1970b). The severe winter drought depicted for the eastern sites in Figure 1 would have just this effect. Voles of the genus *Microtus,* common at Dry Cave in full-glacial deposits, likely are absent from the mid-Wisconsin fauna because of the combination of dry winters and hot summers.

Vegetation

The number of large, grazing animals recorded among both the Dry Cave and U-Bar Cave faunas implies a significant grass component to the vegetation. The smaller faunal members from the sites, however, give evidence for the argument that Great Plains-like, open, extensive grasslands were absent and that the grazing context was one of open woodland with a well-developed grassy understory.

In the Dry Cave paleoenvironment reconstructed here, steeper north-facing slopes may have supported the relatively dense woodland typically inhabited in the southern portions of their ranges by Nuttall's cottontails, western chipmunks, Montezuma quail, brush mice, and scrub jays. On south-facing slopes and the more gentle northerly slopes, the woodlands are interpreted as giving way to an open savanna which would provide habitat for large grazers and such smaller forms as the desert cottontail *(Sylvilagus auduboni),* prairie dogs *(Cynomys* spp.*),* the prairie vole *(Pitymys ochrogaster),* and the swift fox *(Vulpes* cf. *velox).* Thinner soils on upper slopes likely were scantily clothed with only low ground cover, supplying open habitat for kangaroo rats *(Dipodomys* spp.*),* pocket mice *(Perognathus* spp.*),* and ground squirrels *(Spermophilus* spp.*).* Scrub oaks or other brushy growth may have been scattered through these more open areas--ideal habitat for the common black-tailed jackrabbit *(Lepus californicus).*

At U-Bar Cave, as at Dry Cave, some taxa occur now in nearby highland areas. The Mexican pack rat *(Neotoma mexicana)* and pinyon mouse *(Peromyscus truei)* occur in the Animas Mountains, as does the cliff chipmunk *(Tamias dorsalis).* All occupy woodland today, with the pinyon mouse strongly associated with pinyon pines.

Unlike the situation at Dry Cave, however, most extralimital taxa now occur only in relatively distant areas. The Mexican vole *(Microtus mexi-*

canus), represented by a number of specimens, occurs in the pine forests of the Southwest and Mexico, descending in favorable habitats into the upper margin of woodlands. U-Bar Cave lies almost exactly in the center of a 320-km gap in its present range, and it is absent from even the higher mountains of the region. Although the most xeric-adapted of the southwestern *Microtus*, this vole's presence implies considerably more effective moisture than is available today and probably cooler summers.

The meadow vole (*M. pennsylvanicus*) also is recorded; in the Southwest and northern Mexico, it inhabits thick sedge beds. Its presence implies water sufficient to support such hydrosere vegetation.

Well-developed woodland, and therefore more effective moisture, is signaled by such taxa as the bushy-tailed pack rat (*Neotoma cinerea*), Stephen's pack rat (*N. stephensi*), Merriam's shrew, and Nuttall's cottontail. The bushy-tailed pack rat has its range to the north, extending south into northern and northwestern New Mexico, where it is associated with montane forests, woodland, and the upper fringes of Great Basin Desert vegetation. Stephen's pack rat occurs in montane and broken country to the north, almost always in association with junipers.

The sagebrush vole (*Lagurus curtatus*) is associated closely with big sagebrush; its presence evinces good stands of this Great Basin shrub and implies a precipitation regime similar to that characteristic of the Great Basin. Figure 1 shows the seasonal pattern of temperature and precipitation of an area in southern Utah near the margin of sagebrush-vole range. Although precipitation is low, temperatures are cool and no period of emphatic drought occurs. Temperatures at U-Bar Cave must have been somewhat higher because of its more southern position and lower elevation, and the faunal evidence implies much more equable winter conditions. With warmer temperatures, greater precipitation also would be required. The pattern of precipitation, however, likely was broadly similar to that seen in Figure 1. Presence of marmot shows that either the current spring drought was absent or that cooler early-season temperatures allowed a continuous supply of green, marmot-compatible vegetation.

Extant forms implying extensive grasslands are few. Cotton rats and *Microtus* are associated with grasses, but neither requires extensive, open stands. Prairie dogs are rare and, if they represent Gunnison's prairie dog (*Cynomys gunnisoni*), do not require large areas of open grassland. That at least moderately open areas of some type were available is documented by the presence of pocket mice and a kangaroo rat.

As reconstructed, the broken terrain about U-Bar Cave supported open to dense woodland with ample grasses, forbs, and bushes as understory plants. The deeper soils of the Playas Valley supported stands of big sagebrush, probably intermixed with grasses. Permanent water in valley depressions or runoff from permanent springs supported sedge beds and, likely, groves of cottonwoods, willows, and the like.

Summary

Although both the Dry Cave and U-Bar Cave faunas indicate more equable conditions than today, there were significant differences between the sites. At Dry Cave, there was greater seasonality of precipitation, particularly in the form of winter-early spring drought, and summer temperatures probably were depressed less than at U-Bar Cave. Thus animals that require continuous availability of green fodder through the warm season, and forms stressed by hot temperatures, were barred

from the area. Somewhat cooler temperatures than today enhanced effective moisture, allowing the occurrence of woodland plants and animals now found mostly in the nearby highlands, but with the presence of a few more-northern animals.

At U-Bar Cave, absence of high temperatures together with greater effective moisture during the spring allowed occurrence of now-distant plants and animals favored by cool summers and moderate year-round moisture. As a result, the U-Bar Cave fauna differed more from the present fauna of southwestern New Mexico than did the Dry Cave fauna from the present fauna of southeastern New Mexico. This may record primarily geographic differences in climatic regimes or, conversely, temporal differences between the faunas. The broad overlap in radiocarbon dates from the two sites suggests the former, but uncertainty is sufficient to prevent ruling out the latter.

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