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PALEONTOLOGICAL RESOURCES OF LAKE MEREDITH NATIONAL RECREATION AREA AND ALIBATES FLINT QUARRIES NATIONAL MONUMENT, WEST TEXAS

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Abstract. – Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument are units of the National Park Service located northeast of Amarillo in the Panhandle of Texas. They preserve a sequence of sedimentary rock units that range from Late Permian to Holocene in age. These strata have yielded significant paleontological resources, but they have not been widely reported upon. The fossils are Triassic, Miocene-Pliocene, Pleistocene and Holocene in age and include trace fossils and plant, invertebrate and vertebrate specimens. The most important specimen found to date is a female skull of the giant Pleistocene bison, *Bison latifrons*.

INTRODUCTION

Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument are located northeast of Amarillo in the Panhandle of Texas (Fig. 1). Lake Meredith was established primarily to provide a surface water supply for 11 municipalities in the Texas Panhandle experiencing increased urbanization and industrialization and a lowering water table. Construction of Sanford Dam, named for the adjacent community, was started in 1962 and the resultant reservoir was named Lake Meredith for A. A. Meredith, a civic leader who was instrumental in the completion of the project. Water is pumped to the area communities, including Amarillo and Lubbock, via 518 km of pipeline, 10 pumping plants and 3 regulating reservoirs. The Canadian River Municipal Water Authority operates and maintains the facilities. Since 1965, a recreation area of over 41,000 acres around the reservoir has been managed by the National Park Service, since 1972 as Lake Meredith National Recreation Area (Fig. 2).

Alibates Flint Quarries National Monument was established by Congress in 1965 to protect prehistoric chert quarries. This area has been quarried since Clovis time for the distinct and abundant chert. Flint is concentrated within the monument in a horseshoe-shaped area that includes 736 quarry pits that are mainly oblong in shape. The current monument includes 1,370.97 acres adjacent to the east-central portion of Lake Meredith National Recreation Area.

Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument have yielded significant paleontological specimens, but they have been poorly documented. The purpose of this paper is to document what is currently known of the paleontological resources of the area for scientific reasons and to act as an aid to resource management, interpretation, and strategic planning for the National Park Service. This study is based on fieldwork at Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument, study of museum collections and a literature review. WTSU refers to West Texas State University, now West Texas A and M University, Canyon and PPHM to Panhandle Plains Historical Museum, Canyon.

GEOLOGIC OVERVIEW

Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument straddle the boundary between two major structural basins - the Palo Duro basin and the Anadarko basin. This boundary is formed by the Amarillo-Wichita uplift that is a large regional structure that extends southeast-northwest from New Mexico to central Oklahoma. Because of this structure, the stratigraphy of the southwestern end of Lake Meredith National Recreation area is distinct from the remainder of the recreation area and from Alibates Flint Quarries National Monument. Notably, Triassic strata are only preserved in the southwest portion of the study area (Palo Duro basin).

There is limited primary geologic literature on the local geology. The most important reference is the Master's thesis of Wilson (1988) which includes a detailed study and mapping of four U. S. Geological Survey 7.5 quadrangles (Alibates Ranch, Chunky, Berry Sand Draw and McDowell Creek). A useful older reference is the 1963 guidebook of the Panhandle Geological Society "Field trip, September 14, 1963, Alibates Flint Quarries, Alibates Indian Ruin, Santa Fe Trail, Sanford Dam." Summaries of the geology and paleontology of the area can be found in sections of the draft EIS for the area written by Lisa Norby and Vincent Santucci, respectively (Santucci, 2000).

Permian

There are four distinct Upper Permian (Ochoan) rock units exposed in the study area, but they have a confused stratigraphic nomenclature (Wilson, 1988)(Table 1). The medial unit is the 6-7 m-thick Alibates Dolomite or Alibates Formation, the latter name being utilized here because this unit contains lithologies other than dolostone. Above this unit are 13 m of red beds that have been referred to the Quartermaster Formation/Group or Dewey Lake Formation and below it are more red beds that have been referred to as the Artesia Group or Whitehorse Sandstone/Formation/Group or Salado-Tansill Formation. At the base of the lower red-

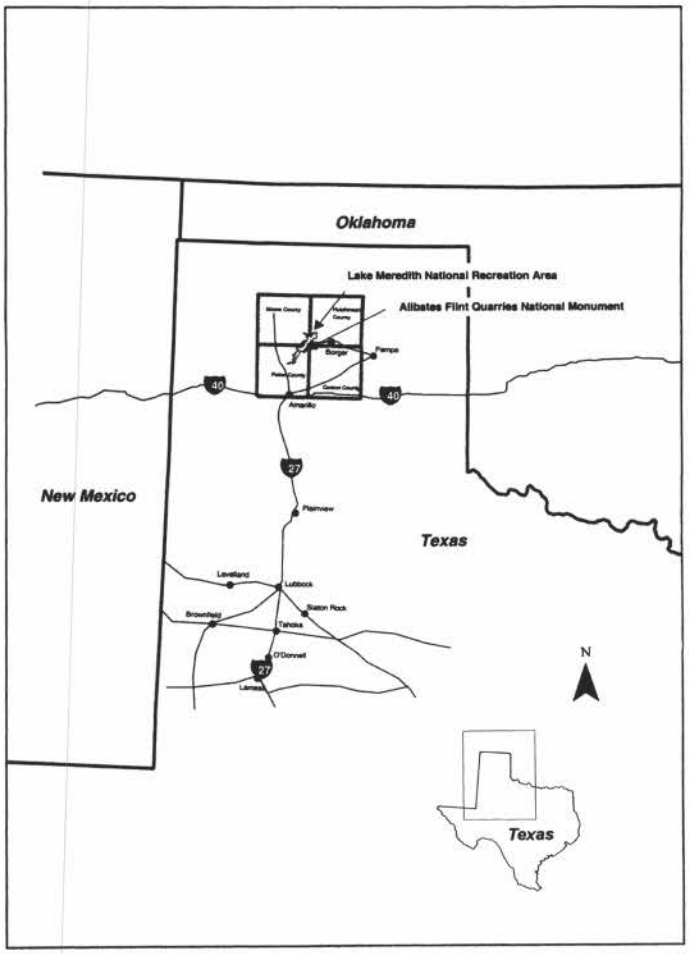

FIGURE 1. Location of Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument, Panhandle of Texas.

beds is a prominent gypsum originally called the Saddlehorse Gypsum and now referred to the Cloud Chief Gypsum. The stratigraphic nomenclature that we will use is, from youngest to oldest: Dewey Lake Formation, Alibates Formation, Whitehorse Formation and Cloud Chief Gypsum. These Permian strata were deposited in restricted marine and intertidal settings (Wilson, 1988).

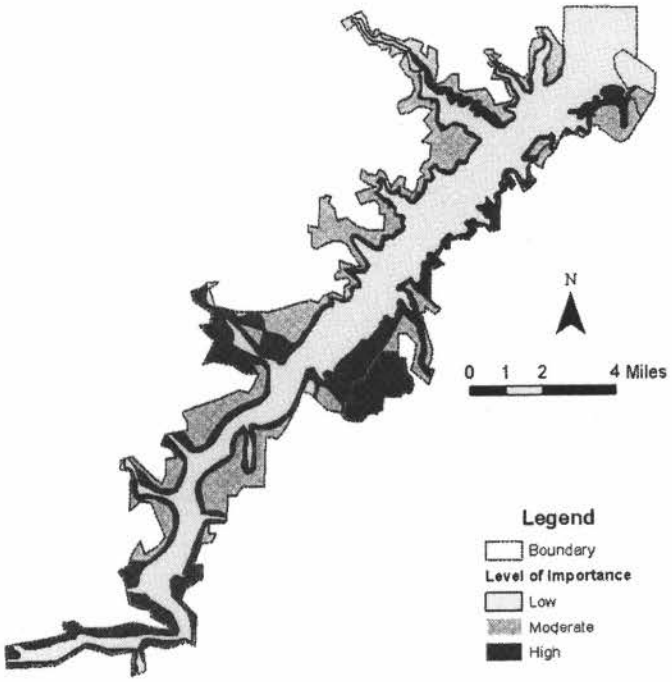

FIGURE 2. Map showing boundaries of Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument and paleontological sensitivity ratings of different outcrop areas.

Triassic

The Upper Triassic (upper Carnian) strata in the western portion of Lake Meredith National Recreation area are the Tecovas and Trujillo formations of the Chinle Group (sensu Lucas, 1993, 2001)(= Dockum Formation of older workers). The lowermost unit is the Tecovas Formation, which is up to 60 m thick and consists of mudstone and lesser amounts of sandstone and conglomerate of fluvial origin. The Trujillo is up to 13 m thick and is mostly fluvial sandstone with minor conglomerate and mudstone. Locally, basal conglomerates in the Tecovas can be assigned to the Camp Springs Conglomerate (Table 1).

TABLE 1. Overview of stratigraphy and paleontology of Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument.

Age	Formation/Member	Environment of deposition	Paleontology
Holocene	Unnamed sands, gravels, soils	Fluvial, soil	Diverse mammals, reptiles, birds, fish
Pleistocene	Unnamed gravels, sands, conglomerate, loess	Fluvial, eolian, lacustrine	*Bison latrifrons*, mammoth, gastropods, Cretaceous oysters, plants, wood, trace fossils
Miocene-Pliocene	Ogallala Formation:		
	"Caprock"	Paleosol	Unfossiliferous
	Coetas Member	Fluvial, lacustrine	"Mastodon", mammals, fish, gastropods, plants, trace fossils
	Potter Creek Member	Fluvial	Bone scrap, Cretaceous oysters
Triassic	Trujillo Formation	Fluvial	Unfossiliferous
	Tecovas Formation	Fluvial	Amphibians, reptiles, logs
	Camp Springs Conglomerate	Fluvial	Unfossiliferous
Permian	Dewey Lake Formation	Restricted marine	Unfossiliferous
	Alibates Formation	Intertidal	Unfossiliferous
	Whitehorse Formation	Restricted marine	Unfossiliferous
	Cloud Chief Gypsum	Restricted marine	Unfossiliferous

Miocene-Pliocene

Vertebrate fossils date the Ogallala Formation (or Group) as Miocene-Pliocene (Wood et al., 1941; Schultz, 1977). In general, the Ogallala in the Panhandle consists of a basal conglomerate, medial sandy interval and an upper calcrete-rich interval. These units are all of fluvial origin except for the calcrete that is pedogenic.

The lower Potter Creek Member consists of conglomerate and conglomeratic sandstone that formed in low-sinuosity streams; it is locally 130 m thick. The medial sandy unit is the Coetas Member, which is about 55 m thick and consists of sandstone, mudstone and locally flaggy limestone. Wilson (1988) separated the lower 33.5 m of this unit as his LX member which was dominantly composed of sandstone and silty sandstone that he distinguished from an upper unit (his Coetas Member) that included flaggy limestone, sandy limestone and thinly laminated mudstone and siltstone. The name LX Member is still unpublished and thus is an informal name. The upper unit of the Ogallala is up to about 75 m thick and includes sandstone, gravel and calcrete, including a capping calcrete caprock that is up to 10 m thick.

Pleistocene and Holocene.

The study area contains significant Pleistocene deposits that include terrace gravels, fluvial sandstones and conglomerates, alluvial sandstone and loess. Holocene deposits in the study area include alluvium, eolian sand and soils.

PALEONTOLOGY

Permian

There are no known fossils from the Permian strata of Lake Meredith National Recreation area or Alibates Flint Quarries National Monument. The restricted marine environment represented by these rocks indicates a low chance of fossil preservation. However, rare footprints have been found in intertidal deposits associated with similar marine environments in the Permian Mesita Blanca Member of the Yeso Formation in central New Mexico (Robert Colpitts, personal commun., 1994). However, Late Permian fossils are rare worldwide, and any occurrences in the study area would be of great significance.

Triassic

The Panhandle of Texas in general, and the Canadian River Valley in particular, have yielded very significant Triassic vertebrate fossils as well as abundant petrified wood and smaller numbers of invertebrate fossils (Murry, 1986, 1989). These fossils include a variety of reptiles notably phytosaurs, aetosaurs and rauisuchians, and metoposaurid amphibians. Regionally, the Chinle of West Texas is one of the most important sources of Late Triassic vertebrate fossils in the world.

Wilson (1988) reported numerous fragments of Triassic amphibians and reptiles from the Tecovas Formation, although it is unclear how these localities relate to the boundaries of the recreation area.

The Triassic rocks of the Panhandle of Texas have also yielded significant plant fossils, including the best-preserved specimen of the enigmatic *Sanmiguelia*. Wilson (1988) reported fossil logs up to 4 m long and 1 m in diameter on the southwest rim of Corral Creek in the Tecovas Formation. Wes Phillips (personal commun., 2000) also indicated that significant petrified wood had been found near the west end of Lake Meredith National Recreation Area.

In conclusion, Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument are located in a region where the Late Triassic rocks contain abundant fossils, and there is evidence that some fossils have been found in the study area, even though there has been no systematic paleontological exploration. The Triassic rocks thus have great potential for yielding significant specimens.

Miocene-Pliocene

There are at least six documented localities in the Ogallala Formation at Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument:

1. A "mastodon" (probably gomphothere) tooth, now lost, was found at Cedar Canyon when a restroom pipe was placed. The tooth derived from the medial sandy interval of the Ogallala.
2. Wes Phillips (personal commun., 2000) reported a locality with *in situ* bone including turtle specimens in Alibates Flint Quarries National Monument.
3. Wes Phillips (personal commun., 2000) reported a bonebed with multiple elements in the Turkey Creek area.
4. Wilson (1988) reported root casts, silicified grass anthoecia, endocarps of *Celtis* sp. and insect burrows from the "LX Member. He also mentioned that vertebrate fossils of Clarendonian (late middle Miocene) age are found in the upper 6-7 m of the LX Member.' However, it is unclear what specimens were found within the boundaries of Lake Meredith Recreation Area or Alibates Flint Quarries National Monument.
5. Wilson (1988) reported molds of gastropods, imprints of two fish and Clarendonian (late middle Miocene) vertebrate fossils from thin, flaggy beds of the upper Coetas Member (above his LX Member). Again, it is unclear what specimens were found within the boundaries of Lake Meredith Recreation Area or Alibates Flint Quarries National Monument.
6. Wilson (1988) reported a large number of Cretaceous oysters (presumably *Texigryphaea*), clasts of Cretaceous fossiliferous limestone and bone scraps from the Potter Member. Again, it is unclear what specimens were found within the boundaries of Lake Meredith Recreation Area or Alibates Flint Quarries National Monument.

The last three Cenozoic land mammal "ages" (Clarendonian, Hemphillian, Blancan) were named for the abundant vertebrate faunas from the Texas Panhandle (Wood et al., 1941; Schultz, 1977; Lucas and Morgan, 2001). These ages are standards of reference for North America during the late Cenozoic. They were based on faunas from the Texas Panhandle because of the abundance and diversity of fossils of this age in this area. There are at least six known localities within the study area, and possibly

FIGURE 3. *Bison latifrons* skulls at Panhandle Plains Museum. A. WTSU unnumbered, female skull from Lake Meredith National Recreation Area, Potter County, Texas. B. PPHM 2315-1, male skull, Waters Ranch, Lipscomb County, Texas. Scale bars are 25 cm.

several more, depending on the details of Wilson's (1988) discoveries. The known paleontological potential of the region and the fact that several sites have been found within the study area, without any paleontological exploration, suggests a strong potential for finding significant fossils of this age in Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument.

Pleistocene

There are 5 documented sites of Pleistocene age in Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument.

1. The most significant, and best documented, site produced a bison skull and other specimens in the 1970's (Anderson, 1977; Dalquest and Schultz, 1992). The principal, and first specimen, is a partial skull of a large bison with both horn cores complete almost to their tips and is at the Panhandle Plains Historical Museum, Canyon (Fig. 3A). This specimen (WTSU unnumbered) has a single horn core length on the upper curve of 520 mm (measurements follow McDonald, 1981)), on the lower curve of 540 mm, with a basal circumference of 305 mm and vertical and transverse diameters of 110 mm (Anderson, 1977). This specimen is referable to the giant Pleistocene bison, *Bison latifrons,* on the basis of an upper curve length of the horn core of greater than 500 mm and to a female of the species on the basis of a basal horn core circumference of less than 400 mm (McDonald, 1981). Females of the species have more gracile horn cores than males (Fig. 3B). Complete specimens of female *Bison latifrons* are rare and McDonald (1981, table 19) lists only one other.

Anderson (1977) examined the site and found additional specimens, including a bison rib fragment and assorted snails, as well as a rodent burrow with charcoal that could be Holocene in age. The bones were found in a layer of fine sand and gravel about 2-m-thick. The gastropods and rodent burrow occur in another fine sand that is stratigraphically lower than the bone-bearing sand and is separated from it by a 1.5 m-thick layer of coarse gravel (Anderson, 1977). This locality is on the north side of Lake Meredith, east of the boat ramp near Plum Creek, in an inset terrace.

2. A mammoth humerus (?) was discovered, and removed prior to study, from just west of Alibates Flint Quarries National Monument. With information from Wes Phillips, Jim Rancier and APH rediscovered this locality. It is located on a cliff of alluvium adja-

cent to an oil well. The bone came from a 6.5 m-thick coarse, pebbly sandstone, that is overlain by 2 m of reddish brown conglomerate and underlain by 1 m of brown conglomerate that is poorly sorted and has clasts up to 10 cm in diameter. The conglomerates contain petrified wood and *Texigryphaea* shell fragments. This is part of an inset terrace that occurs over a fairly wide area.

3. In the area of South Canyon, there are thick exposures of the Lava Creek B (Pearlette type O) ash that dates to about 610,000 years ago. This was produced by the final eruptions of the Yellowstone caldera. One locality was investigated on a hill behind a well. The white ash bed is about 3-m-thick at this locality. The ash contains abundant trace fossils in the form of burrows. Also, the ash contains abundant plant debris and has the potential to produce leaves or other diagnostic megafossil remains as well as pollen. The lensoid geometry of the ash and its thickness at this locality suggests an aqueous pond deposit that probably contains microfossils of diatoms and ostracodes. Crayfish burrows have apparently been found in this ash (Wes Phillips, personal commun., 2000).

4. Petrified wood and *Texigryphaea* fragments were found in Pleistocene gravels near the Ogallala "mastodon" site mentioned previously.

5. Within the boundaries of Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument there are several breccia pipes that are presumably associated with Pleistocene? dissolution. The Eagle's Nest was examined just west of Alibates Flint Quarries National Monument. This pipe extends through bedded Quartermaster strata. The infilling consists of chert and Permian sedimentary rocks and other lithologies. There is an outer rind consisting principally of rounded chert clasts. The only fossil found at this locality was a small piece of petrified wood. However, such pipes have the potential to be natural traps and to yield vertebrate fossils. These pipes may, in some cases, date back to the Miocene (Eck and Renfield, 1963).

In addition, it is important to mention two significant Pleistocene localities that lie within a few km of the northeast border of Lake Meredith National Recreation Area that demonstrate the potential of strata with the National Park Service lands.

i. The Sanford-Big Creek Local Fauna was collected from a roadcut on the north side of Farm-to-Market Road 687, 0.8 km west of Big Creek, approximately 3.2 km north of the town of Sanford in Section 39, Blk. 41, H and TC RR Co. Survey (Dalquest and Schultz, 1992). This diverse fauna is reposited at West Texas A & M University (Table 2).

ii. The Merchant Ranch locality lies 120 m south of Farm-to-Market Road 687 in the banks of a tributary of Big Creek, 1.6 km north of the Canadian River, 3.2 km north of Sanford in Section 39, Blk. 46, H and TC RR Co. Survey (Dalquest and Schultz, 1992). This fauna, reposited at the Panhandle Plains Historical Museum, includes a partial mammoth skeleton (Table 2).

Very significant vertebrate fossils have been found in the Pleistocene deposits of the study area, notably the *Bison latifrons* skull, without any systematic paleontological survey. These finds, together with the proximity of important localities to the study area indicates that the Pleistocene of Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument has great potential to yield significant specimens in the future. It also appears that petrified wood and abraded *Texigryphaea* specimens are relatively common in conglomerates.

Holocene

Duffield (1964; 1970) reviewed the vertebrate material from most of the Panhandle Aspect archeological sites in the Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument. These localities are Alibates 28, Pickett Ruin, Roper site, Sanford Ruin, Medford Ranch and Spring Canyon:

1. Alibates 28 was excavated by W.P.A. workers from 1938-1941 and is situated on the top edge of the bluffs overlooking Alibates Creek Canyon (Table 3).

2. In 1958, the Panhandle Plains Historical Museum and the Norpan Archeological Society excavated the Pickett Ruin site on the eastern side of the promontory that now forms the southern end of the Sanford Dam (Table 4).

3. The Roper site was excavated by the Panhandle Plains Historical Museum and the Norpan Archeological Society in 1957. This site is west-northwest of the town of Sanford on the west side of South Canyon (Table 4).

4. The Sanford Ruin site was excavated in 1953 by the Panhandle Plains Historical Museum. This site was on a promontory that now forms the southern end of Sanford Dam (Table 4).

5. The Medford Ranch site was excavated in 1961 by the Texas Archeological Salvage Project, a co-operative project of the University of Texas and the National Park Service to salvage sites in the vicinity of the proposed location of the Sanford Reservoir dam. This locality is on the west fork of Spring Canyon (Table 4).

TABLE 2. Pleistocene local faunas of the of the Lake Meredith Area, Hutchinson County, Texas (Dalquest and Schultz, 1992).

PLEISTOCENE LOCAL FAUNAS FROM NEAR LAKE MEREDITH NATIONAL RECREATION AREA

Sanford-Big Creek Local Fauna

Gastropoda (Snails - at least 12 species)
Fish
Frog
Snake
Castor canadensis (Beaver)
Geomys sp. (Pocket gopher)
Ondatra sp. (Muskrat)
Microtus pennsylvanicus (Meadow vole)
Canis cf. *latrans* (Coyote)
Canid sp. (Small fox)
Camelid sp. (Camel)
Odocoileus sp. (Deer)
Equus sp. (Horse)

Merchant Ranch Local Fauna

Castor canadensis (Beaver)
Geomyid (Pocket gopher)
Ondatra cf. *nebracensis* (Nebraska muskrat)
Mammuthus sp. (Mammoth)
Equus sp. (Horse)

6. The Spring Canyon site, on the eastern side of Spring Canyon, was excavated in 1961 by the Texas Archeological Salvage Project (Table 5).

It is clear that there are many paleontological specimens that have been found in an archeological context within Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument. The collection housed at Lake Meredith National Recreation Area includes many vertebrate specimens, principally of *Bison* sp.

PALEONTOLOGICAL RESOURCES AND DEVELOPMENT OF OIL AND GAS RESOURCES

Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument are unusual among National Park Service units in that they include active and extensive exploitation of oil and gas reserves (Santucci et al., in press). During preparation of an Oil and Gas Management Plan/Environmental Impact Statement (EIS) for Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument, paleontological resource inventories were initiated for each of these National Park Service units. This document was written in 2000 in order to define a long-term management direction for existing and anticipated oil and gas operations. Specifically the document addressed the issues associated with the exercise of non-federal oil and gas interests underlying the parks and the activities undertaken in the existing transpark pipeline right-of-ways.

TABLE 3. Holocene vertebrate fauna from Alibates 28 archeological site, Alibates Flint Quarries National Monument (Duffield (1964; 1970).

VERTEBRATE FAUNA OF ALIBATES 28 ARCHEOLOGICAL SITE
Sylvilagus sp. (Cottontail rabbit)
Lepus californicus (Jack rabbit)
Cynomys ludovicianus (Prairie dog)
Geomys bursarius (Plains pocket gopher)
Pappogeomys castanops (Chestnut-faced pocket gopher)
Canis familiaris (Dog)
Canis latrans (Coyote)
Vulpes velox (Swift fox)
Taxidea taxus (Badger)
Canidae
Lynx rufus (Bobcat)
Odocoileus hemionus (Black-tailed deer)
Odocoileus sp. (Deer)
Deer and/or antelope
Antilocapra americana (Antelope)
Bison bison (Bison)
Bos taurus (Cow)
Olor buccinator(?) (Trumpeter swan)
Branta canadensis (Canada goose)
Anser albifrons (White-fronted goose)
Anas acuta (Pintail)
Anas discors (Blue-winged teal)
Spatula clypeata (Shoveler)
Aythya americana (Redhead)
Aythya vaslisineria (Canvasback)
Buteo jamaicensis (Red-tailed hawk)
Pediocetes phasianellus (Sharp-tailed grouse)
Bubo virginianus (Great horned owl)
Corvus sp. (Crow or raven)
Terrapene sp. (Box turtle)
Trionyx sp. (Softshell turtle)
Kinosternon flavescens (Mud turtle)
Pseudemys scripta elegans (Red-eared turtle)
Snake

TABLE 4. Holocene vertebrate fossils from archeological sites at Lake Meredith National Recreation Area (Duffield, 1964; 1970).

Archeological site	Vertebrate fauna
Pickett Ruin site	*Antilocapra americana* (antelope)
	Bison bison (Bison)
	Terrapene sp. (Box turtle)
Roper site	*Scalopus aquaticus* (Eastern mole)
	Sylvilagus sp. (Cottontail rabbit)
	Lepus californicus (Jack rabbit)
	Geomys bursarius (Plains pocket gopher)
	Pappogeomys castanops (Chestnut-faced pocket gopher)
	Odocoileus sp. (Deer)
	Deer and/or antelope
	Antilocapra americana (Antelope)
	Bison bison (Bison)
	Bird
	Terrapene sp. (Box turtle)
Sanford Ruin site	*Sylvilagus* sp. (Cottontail rabbit)
	Spermophilus sp. (Ground Squirrel)
	Geomys bursarius (Plains pocket gopher)
	Pappogeomys castanops (Chestnut-faced pocket gopher
	Neotoma sp. (Wood rat)
	Deer and/or antelope
	Antilocapra americana (Antelope)
	Bison bison (Bison)
	Terrapene sp. (Box turtle)
	Snake
	Frog and/or toad
Medford ranch site	*Sylvilagus* sp. (Cottontail rabbit)
	Geomys bursarius (Plains pocket gopher)
	Odocoileus sp. (Deer)
	Antilocapra americana (Antelope)
	Bison bison (Bison)
	Birds
	Chelydra serpentina (Snapping turtle)
	Terrapene sp. (Box turtle)
	Trionyx mutica (Spineless soft-shell turtle)
	Trionyx spinifer(?) (Spiney soft-shell turtle)

As part of the planning effort, the National Park Service developed a Reasonably Foreseeable Development Scenario (RFD) to project future oil and gas development in the parks and to provide a basis to measure potential environmental impacts. The RFD scenario estimated that over the next 15 to 20 years, in areas of the parks where drilling and production could be permitted, up to 85 new wells could be developed. Ground disturbing activities associated with oil and gas development can potentially damage or destroy non-renewable paleontological resources.

The Oil and Gas Management Planning Team identified the need to consider the paleontological resources in the planning process. A comprehensive paleontological resource inventory was conducted for Lake Meredith and Alibates Flint Quarries consisting of literature reviews, museum collections searches and field inventories (Hunt, 2000). A Paleontological Resource Sensitivity Map was developed identifying areas of high, moderate, and low probability for the occurrence of fossils (Fig. 2).

The Oil and Gas Management Plan/EIS identifies Standard Operating Procedures for Locating and Protecting Paleontological Resources (Santucci, 2000). These procedures outline circumstances when a paleontological survey should be required and how the survey should be implemented. The procedures also provide guidance in situations where there is an unanticipated discovery of fossils during approved operations or when damage occurs to fossils within previously identified paleontological localities.

Three alternative actions are identified in the EIS for paleontological resources. Alternatives B and C designate the entire park as a Special Management Area for protection of the paleontological resources. Additionally, Alternatives B and C indicate the application of the Standard Operating Procedures for Locating and Protecting Paleontological Resources and other park resources.

The Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument Oil and Gas Management Plan and Environmental Impact Statement represents the first time that paleontological resources have been considered in this type of planning effort within a National Park Service area. The benefits resulting from the consideration of fossils in the planning process include: the completion of paleontological resource inventories for the sites, the development of new Standard Operating Procedures for locating and protecting fossils, and an increase in park management's ability to better protect the non-renewable paleontological resources at Lake Meredith and Alibates Flint Quarries (Santucci et al., in press).

TABLE 5. Holocene vertebrate fauna from Spring Canyon archeological site, Lake Meredith National Recreation Area (Duffield, 1964; 1970).

Vertebrate fauna of Spring Canyon site
Sylvilagus sp. (Cottontail rabbit)
Lepus californicus (Jack rabbit)
Spermophilus sp. (Ground squirrel)
Cynomys ludovicianus (prairie dog)
Geomys bursarius (Plains pocket gopher)
Pappogeomys castanops (Chestnut-faced pocket gopher)
Neotoma cf. *albigula* (White-throated wood rat)
rodent
Canis familiaris (dog)
Taxidea taxus (Badger)
Odocoileus sp. (Deer)
Deer and/or antelope
Antilocapra americana (Antelope)
Bison bison (Bison)
Corvus sp. (Crow)
Duck
Passerine bird
Terrapene sp. (Box turtle)
Trionyx sp. (Soft-shell turtle)
Turtle
Snake
Fish
Cypridae
Ictalurus sp. (Catfish)

CONCLUSIONS

Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument are located in the Texas Panhandle, which has produced abundant and important collections of fossils of Triassic, Miocene-Pliocene, Pleistocene and Holocene age (Table 1). All of these ages of rocks are found within the study area. In addition, all these ages of rocks have produced important fossils within Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument despite the fact that there has been no paleontological survey of any part of the area.

The fossils from Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument are Triassic, Miocene-Pliocene, Pleistocene and Holocene in age and include trace fossils and plant, invertebrate and vertebrate specimens. This represents a remarkable range of fossils for such a restricted geographic area. It is evident that paleontology represents a significant resource at Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument.

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