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LATE PLEISTOCENE MEGAFAUNA FROM MISSISSIPPI ALLUVIUM PLAIN GRAVEL BARS

Nina L. Baghai-Riding, Danielle B. Husley, Christine Beck, and Eric Blackwell

Department of Biological Sciences, Delta State University, Cleveland, Mississippi 38733, U.S.A., nbaghai@deltastate.edu; bhusley@okramail.deltastate.edu; cbeck1@okramail.deltastate.edu; eblackwell@deltastate.edu

ABSTRACT

The late Pleistocene of North America is characterized by vertebrate animals (mostly mammals weighing ≥ 44 kg) including *Mammut americanum* (American mastodon), *Bison* spp. (bison), *Megalonyx jeffersonii*, and *Arctodus simus*. Disarticulated skeletal elements of vertebrate fauna are frequently exposed on floodplain and gravel bar deposits after floodwaters retreat throughout the Mississippi Alluvial Plain. One unpublished vertebrate compilation, known as the Looper Collection, is stored at Delta State University. This collection consists of 546 vertebrate cranial and post-cranial elements from Mississippi River gravel bars that spanned 210.5 river km (130.8 miles) and 19 counties within three states (Arkansas, Mississippi, and Louisiana) from Coahoma County Mississippi in the north to East Carroll Parish, Louisiana in the south. Mammals assigned to seven different orders are represented, as well as bone fragments of Aves, fin spines of *Pylodictis olivaris*, *Ictiobus bubalus*, and Teleostei, and shell fragments of Testudines (turtles and tortoises). This collection is significant because it contains remains of several species that have not been previously published from Mississippi: *Canis dirus*, *Mammuthus columbi*, and *Paleolama mirifica*. Other species including *Trichechus manatus*, *Castor canadensis*, *Tapirus haysii*, *Tapirus veroensis*, and *Ursus americanus*contained in this collection represent rare Late Pleistocene occurrences within the southeastern United States. The abundance of assorted megafauna may be the result of the Mississippi Alluvial Plain serving as a migratory route and offering a variety of habitats.

INTRODUCTION

The central part of North America during the late Pleistocene looked considerably different than today. Two large glacial ice sheets covered most of the northern half of North America. The Laurentide ice sheet, centered near Hudson Bay, extended from the Atlantic seaboard, into Alberta and spread down to 37° latitude (Ives, 1978; Clark, 1994). The ice sheet covered an area more than 13,000,000 km^2. In the west, the smaller Cordilleran ice sheet covered the seaboard mountains in British Columbia, the southern Yukon Territory, and parts of Alaska, Idaho, Montana and Washington (Clague and James, 2002; Fariña et al., 2013). Both of these ice sheets would coalesce to form a single sheet at times of glacial maxima (Fariña et al., 2013). Globally, sea levels were lower and large landmasses became exposed. The Bering land bridge connected Asia with North America. The closure of the Central American Seaway allowed Central America to become exposed, which linked North America with South America (Fariña et al., 2013). Episodes of faunal exchange occurred among the continents. For example, mastodons and bison came into North America from Asia, and tapirs, llamas, wolves, and saber-toothed cats moved into Central and South America from North America (Grayson, 2016; Fariña et al., 2013)

The wealth of information from well-known late Pleistocene vertebrate fossil sites throughout North America has provided insight regarding biodiversity, population assemblages, taphonomy, depositional environments, paleoecology, and diet. Some important sites include Rancho La Brea, CA (Holden et al., 2013), Wekiva River, FL (Nowak, 1979), Big Bone Lick, KY (Tankersley et al, 2009), Twelve-Mile Creek, KS (Nowak, 1979), Térapa in the desert of north central Sonoran, Mexico (Nunez et al., 2010), Black Mesa area, Cimmaron Co., OK (Czaplewski and Smith, 2012), Hot Springs, SD (Agenbroad, 1997), Kincaid Shelter, TX (Lundelius, 1967), the Great Basin of North America (Grayson, 2006; Grayson and Meltzer, 2015), and Saltville Quarry, VA (France et al., 2007). None of these sites, however, are associated with gravel/sand bar deposits along streams or rivers. For example, marsh deposits are associated with the Térapa, Sonoran, Mexico site (Nunez et al., 2010), tar pits served as animal traps at the Rancho La Brea, CA site (Holden et al., 2013), fluvial and lacustrine sediments represent the Saltville Quarry locality (France et al., 2007), water-laid cave deposits characterize the Cimmaron Co., OK (Czaplewski and Smith, 2012), and sinkholes trapped mastodons and mammoths at Hot Springs, SD (Martin, 1990).

Quaternary alluvium sediments, associated with Mississippi River Valley, contain late Pleistocene and Holocene sediments (Dockery and Thompson, 2016). Numerous skeletal elements of late Pleistocene megafauna erode from the banks of creeks, tributaries, and rivers and become exposed along gravel and sand bars when the Mississippi River water level is low (Morse and Morse, 1983; Dockery, 1997; Dockery and Thompson, 2016). Late Pleistocene skeletal elements are especially common on gravel and sandbar sites that span from Helena, AR to Greenville, MS (Dockery and Thompson, 2016).

One collection, referred to as the Delta State University (DSU) Looper Collection, was amassed by Mr. Lonnie Looper, a citizen of Greenville, MS, who navigated the river with a boat. He surveyed nineteen modern gravel bars over a six-year (1989-1995) span. The bars extend from East Carroll Parish in northern LA into Bolivar, Washington, and Issaquena counties in northwestern MS and Chicot, Desha, and Phillips counties in northeastern AR (Figure 1). This collection is significant in that it contains 546 disarticulated remnants from 20 species of late Pleistocene mammals including teeth, cranial (horn cores, antlers, skulls) and post-cranial elements (ribs, humeri, scapulae, vertebrae, femora, etc.), as well as spines of fish, shell fragments of turtles, and bone elements of fish, turtles and birds (Tables 1-3; Figures 2-4). This collection has not been published previously, with the exception of the right radius-ulna flipper bone of *Trichechus manatus* that was obtained from the Ludlow Bar, Phillips County, AR (Williams and Domning, 2004; Domning, 2005).

Few published written accounts document late Pleistocene vertebrate fossils from the Central Mississippi Alluvial Valley. Ruddell (1999), assisted by Manning, completed a doctorate dissertation on the late Pleistocene vertebrate Connaway Collection that was obtained from Mississippi River gravel bars that spanned from southwestern TN, southeastern AR, and northwestern MS. The Connaway Collection, housed in the Pink Palace Museum in Memphis, TN (Dockery and Thompson, 2016), contains 2,288 skeletal elements of 27 mammalian species. The Wrenn laboratory at Louisiana State University (LSU) analyzed pollen and unidentified phytoliths from the occlusal surface of canine teeth of a *Megalonyx jeffersonii* specimen from the Danny West Collection (Looper, 2006; Table 2); Danny West is another private collector from Greenville, MS who surveyed Mississippi River gravel bars in the lower Central Mississippi Alluvial Valley (Table 2); his unpublished collection contains more than 500 late Pleistocene vertebrate skeletal elements. Dr. George Phillips (2016, personal written communication) generated unpublished lists of vertebrate taxa from various areas in Mississippi including southwestern coastal plain, Tunica Hills, Bolivar and Coahoma Counties, and Black Prairie. Brister et al. (1981) published on a mastodon site from Nonconnah Creek, Memphis, Shelby Co., TN; a small tributary stream of the Mississippi River. Daly (1992) also listed 56 Pleistocene mammals throughout the state of Mississippi including *Bootherium bonbifroms*, *Bison latifrons*, *Equus* sp., *Tapirus copei*, *Mammuthus*, *Mammut americanum*, *Castoroides ohioensis*, *Panthera leo atrox*, *Arctodus simus*, *Ursus americanus*, *Megalonyx jeffersonii* and more but most of these remains are contained in blue clay underneath the loess at Natchez, MS.

The purpose of this paper is to provide an overview of the Looper Collection and discuss its importance regarding the geologic setting, paleoclimate and paleoecology, and local biodiversity. Fauna noted in this collection also provide a perspective on the, animal communities as well as habitats that existed during the late Pleistocene in the Mississippi Delta.

GEOLOGIC SETTING

During the late Pleistocene (64 ± 5 to 11 ± 1 ka (kilo-annum)), the middle Mississippi Valley and Ohio River consisted of extensive braided broad channel belts (Rittenour et al., 2007; Dockery and Thompson, 2016). Upstream fluctuations in glacial meltwater and sediment discharge controlled the formation and abandonment of braid belts (Teller et al., 2002; Rittenour et al., 2007). Rittenour et al. (2007) identified and correlated seven major braid belts based on stratigraphy and geomorphological relationships throughout the lower Mississippi River Valley. These braid belts are now present in disconnected remnants east and west of Crowley's Ridge from Cape Girardeau, MO into the Yazoo basin south of Natchez, MS (Rittenour et al., 2007). For example, the Sikeston braid belt (19.7 ±1.6 – 17.8± 1.3 ka) originated near Sikeston, MO and extended along the eastern side of Crowley's Ridge, Jonesboro, AR, into the northern Yazoo Basin. South of Greenville, MS (see Figure 3 in Rittenour et al., 2007) the Sikeston braid belt was buried by floodplain mud deposited during the Holocene (Rittenour et al., 2007). The Kennett braid belt (16.1 ± 1.2 – 14.4 ± 1.1ka) originated near Kennett, MO and terminates north of Vicksburg, MS. The Kennett belt extends into Arkansas, Mississippi and Louisiana, and encompasses most of the Yazoo basin. Many segments of the various braid belts are overlain with Holocene black mud, Pleistocene silt and loess, Holocene splay and over bank deposits, or have been removed by erosion (Ruddell, 1999; Rittenour et al., 2007). Topographic variation, associated with this braided stream belts were present including river terraces, backswamps, and blufflands.

FIGURE 1. Location map depicting the 19 gravel/sand bar sites associated with the Looper Collection: 1. Wilson Point Dikes, East Carroll Parish, LA; 2. Corregidor Dike, Issaquena Co., MS; 3. Cracraft Dikes, Chicot Co., AR; 4. Leota Bar, Washington Co., MS; 5. Leland Neck, Washington Co., MS; 6. Luna Chute, Chicot Co., AR; 7. Choctaw Bar, Desha Co., AR; 8. The Bar, Desha Co., AR; 9. Prentiss Bar, Bolivar Co., MS; 10. Terrene Bar, Bolivar Co., MS; 11. Victoria Bar, Desha Co., AR; 12. South White Rive Chute, Desha Co., AR; 13. North White River Chute, Desha Co., AR; 14. Henrico Dikes, Desha Co., AR; 15. Rosedale Gravel Co.; Bolivar Co., MS; 16. Island 64, Phillips Co., AR; 17. Island 62, Phillips Co., AR; 18. Miller Point, Phillips Co., AR; 19. Ludlow Dikes, Phillips Co., AR.

Historically, the Mississippi River entered into the Mississippi Valley by three channel paths. One pathway was the Thebes Gap, which existed as a narrow bedrock gorge, 1.5 km across, (Rittenour et al., 2007) near Cape Girardeau, MO. Approximately 10 ka, Lake Agassiz in Canada overflowed its dam that flooded the entire upper Mississippi Valley and created a breach at Thebes Gap (Blum et al., 2000; Dockery and Thompson, 2016). The Mississippi and Ohio rivers merged, creating a hydrological shift of the Mississippi River from a braided to a meandering regime (Dockery and Thompson, 2016). The Charleston Alluvial fan east of Sikeston Ridge (circa 10– 9.5 ka) is regarded as the last braided-stream influx of sediments (Guccione et al., 1988; Ruddell, 1999). Former stream terraces and relict channel deposits eroded from the meandering behavior of the river, causing dislodge of late Pleistocene elements (Ruddell, 1999; Dockery and Thompson, 2016). The original conditions in which the bones, teeth, and horns were deposited remains speculative. The skeletal elements represent an allochthonous assemblage and the taphonomic history is complicated (Ruddell et al, 1997). Quick burial is probably likely because of the excellent preservation quality (Dockery and Thompson, 2016). The lack of roundness and abrasion of the skeletal elements also imply that they were not distant from their original source.

REGIONAL CLIMATE

Several glacial-interglacial cycles characterized the Pleistocene epoch (1.8 Ma - 10 ka (kilo-annum)) in the Central Mississippi Alluvial Valley (Delcourt and Delcourt, 1988; Lyons et al., 2010). Glacial cycles lasted about 90,000 years and interglacial cycles lasted 10,000 years. Recent geomorphic provinces associated with the Mississippi Alluvial Valley that encompasses northwest MS, northeastern AR, and western TN are delineated as the Central Lowland; northeastern LA is associated with the Gulf Coastal Plain (Riddel, 1996).

Paleovegatation/paleoclimate maps of the southeastern United States during the late Pleistocene were compiled from plant remains: pollen (Delcourt and Delcourt, 1987, 1988; Ruddell, 1999), and leaves, shoots, and cones (Brown, 1938; Watts, 1980; Beerling and Woodward 1993). Delcourt and Delcourt (1987) suggest that a boreal forest-tundra ecotone occurred along the southern margin of the Laurentide ice sheet south of 40° N latitude, extending to coastal regions near 23° N during the late Wisconsin glacial maximum 20 ka – 16.5 ka. Dominant trees of the boreal forest-tundra ecotone consisted of *Pinus* (down to 33° N latitude), *Picea* (spruce), *Fraxinus* (ash), *Populus* (aspen), *Quercus* (oak), and *Carya* (hickory) (Delcourt and Delcourt, 1987; Delcourt et al., 1997; Williams et al., 2000). Within the western and eastern lowlands of the Mississippi Alluvial Valley, the fluvial regime was dynamic, gravel bars were shifting, and glacial meltwaters produced a cold microclimate (Royall et al., 1991). *Picea*, *Abies* (fir), *Salix* (willow), *Populus*, *Larix laricina* (tamarack), boreal shrubs and herbs occurred on terrace deposits along the channel bars (Royall et al., 1991; Schubert et al., 2004). Scoured open areas and alluvial bottomlands became occupied by *Alnus* (alder) thickets, Cyperaceae (sedges), *Fagus grandfolia* (beech), *Juglans nigra* (black walnut), *Liriodendron tulipifera* (tulip poplar), Poaceae (grasses) and *Salix* spp. occurred along the loess mantled Eastern lowlands (Delcourt et al., 1980; Ruddell, 1999). *Picea* - *Pinus banksiana* (spruce-jack pine) forest occurred on inactive sandy plain terraces that bordered Crowley's Ridge, AR (Delcourt et al., 1997).

Climatic warming associated with the retreat of continental glaciers, occurred from 14.5 – 10 ka (Delcourt and Delcourt, 1987, 1988, 1994, 1996; Royall et al., 1991) and caused plant community shifts. The water table in the Western Lowlands bordering the Mississippi River was raised from substantial glacial meltwater. The Tunica Hills in northwestern MS represent the southernmost end of an area known as the Blufflands (Delcourt and Delcourt, 1975; Delcourt and Delcourt, 1996); this region possessed a thick blanket of Peoria loess and served as a north-south migration corridor of cool-temperate and boreal species along the Lower Mississippi Alluvial Valley. According to Delcourt and Delcourt (1996), the Lower Mississippi Valley south to Baton Rouge, Louisiana was an 'archipelago of pocket refuges' for deciduous tree species of *Quercus* spp., *Acer saccharum* (sugar maple), *Fagus* spp., *Carya* spp., and *Juglans nigra*. In response to glacial warming, *Ostrya virginiana* (ironwood) and *Carpinus* (hornbeam) invaded and became established in the region (Delcourt and Delcourt, 1994, 1996). The melting of the Laurentide ice sheet around 13 ka permitted Gramineae (grasses) and Cyperaceae (sedges) to colonize broad open areas that were frequently disturbed by river aggregation and changing fluvial geomorphology (Delcourt et al., 1980).

Drier climatic conditions prevailed from 12.8 to 11.2 ka. By 12 ka, *Quercus* and *Carya* forests expanded onto abandoned channel bar terraces located east and west of Crowley's Ridge, AR (Delcourt et al., 1997; Ruddell, 1999). This time segment possessed a fluctuating hydrologic regime and vegetation was ephemeral in some regions (Delcourt et al., 1997). Palynomorph samples from core sites along the Yazoo River near Greenwood, MS dated at 10 ka yielded

TABLE 1. Summary of fossil elements associated with the Delta State University Looper Collection. Extinct species are marked with an asterisk * based on information from Grayson (2006, 2016), Hulbert and Pratt (2010), Nye (2007), and Kurtén and Anderson (1980).

Order	Family	Species	Number of Elements	Skeletal elements
Cypriniformes	Catostomidae	*Ictiobus bubalus*	1	operculum
Siluriformes	Ictaluridae	*Pylodictis olivaris*	3	fin spines
Infraclass Teleostei		unidentified teleost sp.	1	partial fin spine
Unidentified Fish			1	partial fin spine
Testudines	Triconychidae	*Apalone* sp.	3	scapula, plastron fragments
	Chelydridae	*Macroclemmys temminckii*	1	scapula, plastron fragments
	Emydidae	Unknown sp.	10	carapace and plastron fragments
	Testudinidae	**Hesperotestudo crassiscutata*	7	carapace fragments
	Cheloniidae (unidentified)		12	carapace fragments
Class Aves (unidentified)			4	humerus, ulna, diaphysis
Artiodactyla	Bovidae	*Bison* sp.	129	molars, tibia, scapula, humeri, pelvis, vertebra, femur, radius, ribs, phalanxes, metatarsals
		**Bootherium bombifrons*	2	axis vertebra, molar
	Camelidae	**Paleolama mirifica*	3	phalanx, tibia diaphysis, metapodial distal diaphysis
	Cervidae	**Cervalces scotti*	3	antler fragments, mandibular ramus fragment
		Odocoileus virginianus	126	antler fragments, metatarsal, vertebrae, calcaneum, femurs, ramus, scapula, ulna
	Tayassuidae	**Mylohyus nasutus*	1	partial mandibular ramus with two molars
Carnivora	Canidae	**Canis dirus*	1	proximal radius
Unidentified Large			1	pelvis
Unidentified Small			3	tibiae, pelvis
	Procyonidae	*Procyon* sp.	1	dentary

TABLE 1 (continued)				
	Ursidae	**Arctodus simus*	1	mandibular ramus with canine root and two molars
		Ursus americanus	1	left mandibular ramus with canine and molar
Edentata	Megalonychidae	**Megalonyx jeffersonii*	23	neural spine, patella, phalanx, metacarpal, tibia, vertebrae
Perissodactlya	Equidae	**Equus complicatus*	110	molars, scapula, tibia metatarsals
		Equus spp.	5	molars
	Tapiridae	**Tapirus haysii*	5	metapodial, mandibular ramus fragment with molar roots
		**Tapirus veroensis*	1	right cheek tooth
Proboscidea	Elephantidae	**Mammuthus columbi*	1	molar fragment
	Mammutidae	**Mammut americanum*	32	mandibular ramus, skull fragments, tusk fragments, molars, limb elements, ribs, tibia
Rodentia	Castoridae	*Castor canadensis*	4	ramal fragments with incisor and molars, femur
		**Castoroides ohioensis*	3	partial incisors
Sirenia	Trichechidae	*Trichechus manatus*	1	radius/ulna
Class Mammalia (unidentified megafauna)			59	ribs

Pinus, *Quercus*, *Carya*, Poaceae, Ambrosineae, and *Nyssa* (tupelo) (Holloway and Valastro, 1983). *Quercus* and *Pinus* were also dominant trees during the Quaternary around Nonconnah Creek, Shelby County, TN (Delcourt et. al., 1980; Delcourt and Delcourt 1996).

The beginning of the Holocene (ca. 10 ka.), saw the continued expansion of oak-hickory forests throughout the Mississippi Delta, and willow-cane plant communities became associated with active meandering belts of the Mississippi River (Delcourt et al., 1997: Ruddell, 1999). Pollen from the Pearl River floodplain associated with the proposed Shoccoe Dam Project in Mississippi suggest that deciduous species of *Liquidambar styraciflua* (sweetgum), *Taxodium distichum* and *Nyssa* spp. (gum) occurred in the Mississippi Alluvial Plain (Dockery and Thompson, 2016). Gramineae and *Ambrosia* (ragweed) displaced *Quercus-Carya* forests on abandoned stream terraces around 8,000 ka in response to climatic warming (Delcourt et al., 1997).

MATERIALS AND METHODS

The Looper vertebrate assemblage was collected over a six-year span (1989 – 1995) from nineteen gravel bars that are located in three states. Areas perused included East Carroll Parish, LA; Bolivar, Washington, and Issaquena counties, MS; and Chicot, Desha, and Phillips Counties, AR (Figure 1). Looper collected from some gravel/sand bars only once: Islands 62 and 64, Phillips Co., AR; Luna Chute, Chicot Co., AR; Wilson Dikes, East Carroll Parish, LA; Prentiss Bar, Bolivar Co., MS; Leland Neck, Washington Co, MS, and Leota Bar, Washington Co., MS. In contrast, he made multiple trips to other bars: The Bar and Henrico Dikes in Desha Co., AR and Ludlow Dikes, Phillips Co., AR . River mileage

TABLE 2. A comparison of the Looper Collection to the Connaway (Ruddell et al., 1997; Ruddell, 1999) and Jerry West's unpublished private collection from the Central Mississippi River Valley, and the Black Belt region of Mississippi (Kaye, 1974).

Taxa	Looper	Connaway	West	Kaye
OSTEICHTHYES				
Atractosteus spatula - alligator gar		X		
Lepisosteus sp. - gars		X		
ACTINOPTERYGII				
Aplodinotus grunniens - freshwater drum		X		
Ictiobus bubalus - smallmouth buffalo	X			
Pylodictis olivaris - modern flathead catfish	X	X		
Teleostei sp. - bony fish	X			
REPTILIA				
Alligator mississippiensis - American alligator		X		
Apalone spinifera - Eastern spiny softshell turtle		X		X
Apalone sp. - softshell turtles	X	X		
Chelydra serpentine - common snapping turtle		X		
Chrysemys sp. - pond turtle		X		
Emydidae sp. - pond turtle	X			
Hesperotestudo crassiscutata - giant land tortoise	X	X		X
Hesperotestuda sp.				
Macrachelys temminckii - alligator snapping turtle	X	X		
Terrapene sp. - box turtle		X		
Trionychidae - softshell turtles (unknown genus)	X			
AVES				
Ardea herodius - great blue heron		X		
Branta canadensis - Canada goose		X		
Unidentified Aves	X			
MAMMALIA				
Arctodus sp. - short-faced bear		X		x
Arctodus simus - giant short-faced bear	X			
Bison sp.	X	X	X	X
Bison latifrons - long-horned bison		X		X
Bison bison bison - plains bison		X		
Bison bison occidentalis - bison		X		
Bison bison antiquus - antique bison		X		
Bootherium bombifrons - Harlan's muskox	X	X	X	
Canis dirus - dire wolf	X		X	
Canis sp.				X
Castor canadensis - American beaver	X	X		X
Castoroides ohioensis - giant beaver	X	X		X
Cervus canadensis - elk		X		
Cervus elephus - wapiti		X		X
Cervalces scotti - stag moose	X	X		
Dasypus bellus - long-nosed armadillo		X		X
Didelphis sp. - opossum				X
Emotherium sp. – ground sloth			X	X
Equus sp.	X	X	X	X
Equus complicatus - fossil horse	X			
Felis cf. *weidii* – margay, tree ocelot				X
Hemiauchenia sp. – large-headed llama				X
Holmesina septentrionalis – extinct giant armadillo				X
Hydrochoerus sp. - capybera				X
Lutra canadensis - river otter		X		X
Lynx rufus - bobcat				X
Mammut americanum - American mastodon	X	X	X	X
Mammuthus columbi - Columbian mammoth	X	X	X	
Mammuthus sp.				X
Megalonyx jeffersonii - giant ground sloth	X	X	X	
Mylohyus fossilis - long-nosed peccary	X	X		X
Nothrotheriops sp. - megatherian ground sloth		X		
Odocoileus sp. - deer		X	x	

Odocoileus hemionus - black-tailed deer			X	
Odocoileus virginianus - white-tailed deer	X	X	X	X
Ondatra sp. - muskrat				X
Palaeolama mirifica - large-headed llama	X			
Panthera leo atrox - American lion		X		
Paramylodon harlani - Harlan's ground sloth		X		
Platygonus sp. – extinct peccary				X
Procyon lotor - raccoon				X
Procyon sp.	X			
Rangifer sp. - reindeer		X		
Sylvilagus floridanus - eastern cottontail		X		
Sylvilagus cf. *aquaticus* ? swamp rabbit				X
Tapirus americanus - American Tapir				
Tapirus copei - Cope's tapir				
Tapirus haysii - large tapir	X	X		
Tapirus veroensis - Vero tapir	X	X		
Trichechus manatus - American manatee	X			
Urocyon sp. - fox				X
Ursus americanus - American black bear	X	X	X	X

markers, the appropriate USGS 7 ½ minute topographic map, UTM East and UTM North coordinates, the year of collection, and the name of the collector were referenced for each vertebrate specimen (Table 1). Specimens were identified to genus and species (when possible) by direct comparison with those of recent and fossil vertebrates contained in vertebrate paleontology collections at The Louisiana State University (LSU) Museum of Natural Science, LSU, Baton Rouge, LA, Pink Palace Museum, Memphis, TN, and the Mississippi Museum of Natural Science (MMNS), Jackson, MS. Drs. Judith Schiebout, Earl Manning, and George Phillips assisted in identifying many of these specimens. Published reports and internet photographs were employed to identify the various cranial and postcranial elements. A few specimens are too fragmentary to discern even to a family level and are only classified to Class. All specimens were photographed, digitized, and logged into the DSU Looper Collection. A unique specimen number, assigned by Mr. Looper and marked on each specimen, are documented in an Excel database. Bone color was determined using Munsell color charts to help study taphonomy and depositional environment. Mammalian organisms were categorized into foregut, hindgut, and no gut digestive processes to aid in evaluating late Pleistocene ecological food chains, and niches in the Mississippi Alluvial Plain (see France et al., 2007; Don Spalinger, personal communication, June 2016).

RESULTS

The greatest biodiversity of vertebrate elements in the Looper Collection was obtained from gravel bars located in Chicot, Desha, and Phillips Counties, AR (Figure 5; Table 3). For example, 17 assorted taxa were acquired from Ludlow Dikes, 15 were found on Henrico Dikes, and 13 were recovered from Cracraft Dikes. Some gravel bars characterized by lower biodiversity yielded some important finds. For example, the only specimen of *Mylohyus nasutus* in this collection was obtained from Rosedale, Bolivar Co., MS (Table 3).

The general condition of the fossil specimens, color, and mineral replacement can help to infer taphonomic conditions, although complicated. On the Munsell color chart, specimens possessed hues mainly in the 7.5 YR – 10 YR with chroma ranging from 4-7 and the value ranging from 1 – 4. Overall, the colors vary from dark to yellowish brown, reddish-brown, or brownish- black, but some skeletal elements are light gray, tan, or white. Many skeletal remains are premineralized and darkened with hematite. Blackened regions occur on some bones. Nonindigenous colors of skeletal materials could be due to infiltrated clay minerals or from oxidation, reduction or decomposition of indigenous organic compounds in the skeletal material.

Specimens included skulls, isolated teeth, horn cores, antlers, scapulae, vertebrae, humeri, ulnae, sacra, femurs, neural arches, ribs, metatarsals, turtle shell

FIGURE 2. Late Pleistocene animals with foregut digestion associated with the Looper Collection. A. *Bison* sp. articulated left foot 1. third phalanx (hoof core), 2. second phalanx, 3. first phalanx, 4. metapodial; B. *Odocoileus virginianus*: assorted mandibles; C. *Mylohyus nasatus*: partial left mandibular ramus with two molars; D. *Bison* sp.: 1. skull fragment, 2-3. horn cores; E. *Paleolama mirifica*: 1. left tibia diaphysis, 2. proximal view of second phalanx, 3. metapodial distal diaphysis; F. *Cervalces scotti*: 1. base of large antler with burr 2. flat narrow antler fragment, 3. right mandibular ramus fragment with one molar; G. *Bootherium bombifrons*: 1. axis vertebra missing neural spine 2. right lower molar; H. *Odocoileus virginianus*: antler fragments, 2. spike antler, 7-8, 13, 15 possess a burr, 10-13 possess a pedicle.

FIGURE 3. Late Pleistocene animals with hindgut digestion associated with the Looper Collection. A. *Equus complicatus*: lower molars; B. *Megalonyx jeffersonii*: claw core fragments, 1. distal phalanx, pes digit 3 without claw; 2. distal phalanx, pes digit 3 with complete basal flange, 3. distal phalanx, pes digit 3 with complete basal flange; C. (1 – 3) *Castor canadensis*: 1. left side of mandible fragment with two molars, 2. right mandibular ramus with incisor and four molars, 3. proximal left femur fragment; (4 – 6) *Castoroides ohioensis*: 4. left lower molar, 5. right lower incisor fragment (tip incomplete), 6. partial incisor (enamel side); D. *Trichechus manatus*: right radius-ulna; E. *Tapirus haysii*: 1. molar, 2. two metapodial bones, 3. edentulous symphysis,4. left mandibular ramus fragment with two molar roots; F. *Mammut americanum*:1. juvenile deciduous premolar (worn), 2. adult upper molar (worn); G. *Mammut americanum*: exterior side of a small tusk fragment; H. *Mammuthus columbi*: cheek tooth fragment with thin enamel plates.

FIGURE 4. Late Pleistocene carnivorous animals with no gut/intestinal digestion as well as elements of birds, turtles, and fish associated with the Looper Collection. A. *Canis dirus*: partial proximal radius fragment; B. *Ursus americanus*: left mandibular ramus with canine and molars; C. small carnivores: 1. *Procyon*: edentulous left dentary, 2. *Procyon* or *Vulpinus*: left tibia, 3. pelvis, 4. tibia, 5. humerus; D. *Arctodus simus*:left mandibular ramus with canine root, and two molars; E. Emydidae sp: 1-2, 13-14 costal scute fragments; 3, 6, 8 vertebral scute fragments, 4. 2 gular and two humeral scute fragments, 5. gular scute fragment and humeral scute, 9. nuchal scute, 10. costal and vertebral scute fragment, 11. marginal scute, 12. two marginal scute fragments, 7. Aves furcula F. *Hesperatestuda crassiscutata*: unidentified carapace fragments; G. assorted avian elements: 1. proximal end of a humerus (incomplete), 2. possible humeral diaphysis fragment, 3. ulna, 4. large ulna; H. freshwater fish spines: 1-3. unidentified dorsal spines, 4. right pectoral fin spine of a modern catfish; 5. unidentified freshwater fish operculum.

fragments, and more. All of the bones are disarticulated from adjoining elements. Cranial elements represented 35% of the assemblage, whereas post-cranial elements comprised 65% of the assemblage. The Looper Collection contains 12 orders, 21 families, 23 genera, and 26 species. (Tables 1-2).

Six fish elements are recognized from Henrico Dikes and Ludlow Dikes in Arkansas and Corregidor Dike in MS. Elements include a partial left operculum of *Ictiobus bubalus*, two right pectoral fin spines and a complete first dorsal fin spine of *Phylodictus olivaris*, a partial fin spine of an unidentified teleost species and an unidentified fish spine (Table 1-3; Figure 4H).

Isolated turtle carapace and plastron elements are the most common reptilian fossils (Figure 4D-F). Three turtles and a tortoise have been identified*:* *Apalone* sp., Emydidae sp., *Macroclemmys temminki* and *Hesperotestudo crassiscutata*. These elements were found on eight different gravel bars. Emydids were the most abundant and were collected from six gravel bars: Henrico Dikes in Desha Co., Ludlow Dikes in Phillips Co. and Cracraft Dike in Chicot Co., AR and Corregidor Dike in Issaquena Co., Leland Neck in Washington Co., and Terrene Bar in Bolivar Co., MS. In addition, a scapula assigned to *Apalone* sp. was acquired from Victoria Bar, Desha Co., AR.

Four avian fossils are present but their fragmentary nature prevents exact identification. A diaphysis and an ulna were obtained from Ludlow Dike, Phillips Co., AR and the proximal end of a humerus was collected from Victoria Bar, Desha Co., AR (Figure 4G).

Nineteen species represent large or medium size mammals, which may indicate a bias in collecting (Figures 2-4); most mammals represent classic members of the extinct North American Pleistocene megafauna. These include Proboscidea, Edentata, Artiodactyla, Perissodactyla, Rodentia, Sirenia, and Carnivora. The number of body elements of *Bison* (129), *Equus* (115), *Odocoileus* (126), and *Mammut* (32) comprise 73% of the collection. Approximately half of the elements assigned to *Equus* are upper or lower cheek teeth, fourteen isolated molars (9 lower and 5 upper) are assigned to *Bison* (Table 1). One-third of the specimens assigned to *Odocoileus* are antlers; eight are associated with attached cranial fragments and the other 36 represent shed antlers (Figure 2H; Figure 6). Specimens of *Mammut* consisted of cranial elements including tusk, molars, premolars, a mandibular ramus and a hyoid, as well as limb elements, and ribs. Seven species are represented by one specimen each: *Mylohyus nasutus*, *Canis dirus*, *Arctodus simus*, *Ursus americanus*, *Tapirus veroensis*, *Mammuthus columbi*, and *Trichechus manatus*.

Overall, herbivorous skeletal elements were dominant (98.5%) whereas carnivorous skeletal elements were rare (1.5%). Only eight carnivore specimens were documented; one specimen each of *Ursus americanus*, *Arctodus simus*, *Canis dirus*, *Procyonan*, an unidentified large carnivore, and three unidentified small carnivores. *Ursus americanus* and *Arctodus simus* are regarded as omnivores since they could kill, scavenge, and eat plant matter (Figueirido et al, 2009, 2010; Grayson, 2016).

Of the mammalian elements categorized to genus, hindgut represented 57.9% of the taxa (Figure 7). Hindgut animals include *Equus complicatus*, *Equus* sp., *Mammut americanum*, *Mammuthus columbi*, *Castor canadensis*, *Castoroides ohioensis*, *Trichechus manatus*, and *Megalonyx jeffersoni* (but see France et al., 2007). Foregut/ruminants represented 39.25% of the mammalian elements categorized to genus including *Bison*, *Bootherium bombifrons*, *Mylohyus nasutus*, *Paleolama mirifica*, *Cervalces scotti*, and *Odocoileus virginianus*. Tapirs possess both hindgut and foregut digestive capabilities and represented 1.3% of the categorized taxa. No gut represented 1.54 % of the total skeletal elements associated with the Looper Collection.

GEOLOGIC AGE

It cannot be assumed that the specimens associated with the Looper Collection are contemporaneous. The specimens were probably deposited throughout the late Pleistocene. No collagen is preserved in pre-Holocene or post-Eocene material from the Mississippi River (Ruddell et al. 1997; Ruddell, 1999; Dr. George Phillips, written communication, 2016, 2017). The Mississippi River and Loess Hills loose association of late Pleistocene vertebrates is no older than late Illinoian according to Phillips (written communication, 2016). Phillips added that the Mississippi River material falls comfortably within the Rancholabrean North American Land Mammal Age based on fluvial geochronology and geomorphic age of the Mississippi River Basin fluvial systems.

The Rancholabrean age is defined by the occurrence of *Bison* in North America below 55° N latitude and it concludes with the termination of *Bison* at the same latitude (Kurtén and Anderson, 1980; Behrensmeyer et al., 1992; Morgan and Hulbert 1995; Bell et al., 2004; Mead, 2007). *Bison* crossed Beringia into North America (Fariña et al., 2013) and invaded grasslands occupied by *Equus* and *Mammut* for more than a million years (Grayson, 2016). Elements of *Bison* occurred on 18 of the 19 gravel bars; only North White River Chute lacked an element (Table 3). The

TABLE 3. Vertebrate elements found on designated gravel bars that pertain to the Looper Collection.** Fifteen elements in the Looper Collection did not possess gravel bar data.

Species	Quantity of elements	Locality	County/Parish	State
Bison sp.	1	Wilson Point Dikes (West side)	East Carroll Parish	LA
Odocoileus virginianus	1	Wilson Point Dikes (West side)	East Carroll Parish	LA
Megalonyx jeffersonii	1	Wilson Point Dikes (West side)	East Carroll Parish	LA
Equus complicatus	2	Wilson Point Dikes (West side)	East Carroll Parish	LA
Teleost sp.	1	Corregidor Dikes (East side)	Issaquena Co.	MS
Emydid sp.	2	Corregidor Dikes (East side)	Issaquena Co.	MS
Bison sp.	4	Corregidor Dikes (East side)	Issaquena Co.	MS
Odocoileus virginianus	6	Corregidor Dikes (East side)	Issaquena Co.	MS
Equus complicatus	2	Corregidor Dikes (East side)	Issaquena Co.	MS
Mammut americanum	1	Corregidor Dikes (East side)	Issaquena Co.	MS
unidentified large mammal	1	Corregidor Dikes (East side)	Issaquena Co.	MS
Ictiobus bubalus	1	Cracraft Dikes (West side)	Chicot Co.	AR
Emydidae sp.	1	Cracraft Dikes (West side)	Chicot Co.	AR
Bison sp.	9	Cracraft Dikes (West side)	Chicot Co.	AR
Odocoileus virginianus	8	Cracraft Dikes (West side)	Chicot Co.	AR
Megalonyx jeffersonii	3	Cracraft Dikes (West side)	Chicot Co.	AR
Equus complicatus	18	Cracraft Dikes (West side)	Chicot Co.	AR
Equus sp.	1	Cracraft Dikes (West side)	Chicot Co.	AR
Tapirus veroensis	1	Cracraft Dikes (West side)	Chicot Co.	AR
Mammuthus columbi	1	Cracraft Dikes (West side)	Chicot Co.	AR
Mammut americanum	5	Cracraft Dikes (West side)	Chicot Co.	AR
Castor canadensis	1	Cracraft Dikes (West side)	Chicot Co.	AR
Castoroides ohioensis	1	Cracraft Dikes (West side)	Chicot Co.	AR
unidentified large mammal	4	Cracraft Dikes (West side)	Chicot Co.	AR
Bison sp.	4	Leota Bar (East side)	Washington Co.	MS
Equus complicatus	4	Leota Bar (East side)	Washington Co.	MS
unidentified large mammal	1	Leota Bar (East side)	Washington Co.	MS
Emydidae sp.	2	Leland Neck	Washington Co.	MS
Bison sp.	1	Leland Neck	Washington Co.	MS
Odocoileus virginianus	2	Leland Neck	Washington Co.	MS
unidentified large mammal	1	Leland Neck	Washington Co.	MS
Bison sp.	1	Luna Chute	Chicot Co.	AR
Odocoileus virginianus	6	Luna Chute	Chicot Co.	AR
Equus complicatus	1	Luna Chute	Chicot Co.	AR
unidentified large mammal	1	Luna Chute	Chicot Co.	AR
Bison	3	Choctaw Bar	Desha Co.	AR
Odocoileus virginianus	1	Choctaw Bar	Desha Co.	AR
Megalonyx jeffersonii	1	Choctaw Bar	Desha Co.	AR
Tapirus haysii	1	Choctaw Bar	Desha Co.	AR
Equus complicatus	3	Choctaw Bar	Desha Co.	AR
Mammut americanum	3	Choctaw Bar	Desha Co.	AR
unidentified large mammal	1	Choctaw Bar	Desha Co.	AR
Hesperotestudo crassiscutata	1	The Bar (NW side)	Desha Co.	AR
Bison sp.	16	The Bar (NW side)	Desha Co.	AR
Cervalces scotti	1	The Bar (NW side)	Desha Co.	AR
Odocoileus virginianus	23	The Bar (NW side)	Desha Co.	AR
Arctodus simus	1	The Bar (NW side)	Desha Co.	AR
Megalonyx jeffersonii	4	The Bar (NW side)	Desha Co.	AR

TABLE 3 (continued)				
Equus complicatus	17	The Bar (NW side)	Desha Co.	AR
Equus sp.	2	The Bar (NW side)	Desha Co.	AR
Mammut americanum	9	The Bar (NW side)	Desha Co.	AR
Castor canadensis	1	The Bar (NW side)	Desha Co.	AR
Castor ohioensis	1	The Bar (NW side)	Desha Co.	AR
unidentified large mammal	7	The Bar (NW side)	Desha Co.	AR
Bison sp.	1	Prentiss Bar (east side)	Bolivar Co.	MS
Megalonyx jeffersonii	1	Prentiss Bar (east side)	Bolivar Co.	MS
Emydidae sp.	1	Terrene Bar (east side)	Bolivar Co.	MS
Bison sp.	6	Terrene Bar (east side)	Bolivar Co.	MS
Odocoileus virginianus	2	Terrene Bar (east side)	Bolivar Co.	MS
Megalonyx jeffersonii	2	Terrene Bar (east side)	Bolivar Co.	MS
Equus complicatus	4	Terrene Bar (east side)	Bolivar Co.	MS
Mammut americanum	2	Terrene Bar (east side)	Bolivar Co.	MS
Apalone sp.	2	Victoria Bar (west side)	Desha Co.	AR
unidentified bird	1	Victoria Bar (west side)	Desha Co.	AR
Bison sp.	16	Victoria Bar (west side)	Desha Co.	AR
Odocoileus virginianus	5	Victoria Bar (west side)	Desha Co.	AR
Megalonyx jeffersonii	4	Victoria Bar (west side)	Desha Co.	AR
Equus complicatus	10	Victoria Bar (west side)	Desha Co.	AR
Mammut americanum	2	Victoria Bar (west side)	Desha Co.	AR
unidentified large mammal	5	Victoria Bar (west side)	Desha Co.	AR
Bison sp.	1	South White River Chute	Desha Co.	AR
Equus complicatus	1	North White River Chute	Desha Co.	AR
Pylodictis olivaris	1	Henrico Dikes (west side)	Desha Co.	AR
Apalone sp.	1	Henrico Dikes (west side)	Desha Co.	AR
Emydidae sp.	1	Henrico Dikes (west side)	Desha Co.	AR
Hesperotestudo crassiscutata	3	Henrico Dikes (west side)	Desha Co.	AR
Bison sp.	23	Henrico Dikes (west side)	Desha Co.	AR
Bootherium bombifrons	2	Henrico Dikes (west side)	Desha Co.	AR
Odocoileus virginianus	19	Henrico Dikes (west side)	Desha Co.	AR
Canis dirus	1	Henrico Dikes (west side)	Desha Co.	AR
Procyon sp.	1	Henrico Dikes (west side)	Desha Co.	AR
Megalonyx jeffersonii	2	Henrico Dikes (west side)	Desha Co.	AR
Equus complicatus	24	Henrico Dikes (west side)	Desha Co.	AR
Equus sp.	1	Henrico Dikes (west side)	Desha Co.	AR
Tapirus haysii	1	Henrico Dikes (west side)	Desha Co.	AR
Mammut americanum	6	Henrico Dikes (west side)	Desha Co.	AR
unidentified large mammal	12	Henrico Dikes (west side)	Desha Co.	AR
Pylodictis olivaris	1	Ludlow Dikes (west side)	Phillips Co.	AR

TABLE 3 (continued)				
unidentified fish	1	Ludlow Dikes (west side)	Phillips Co.	AR
Emydidae sp.	1	Ludlow Dikes (west side)	Phillips Co.	AR
unidentified bird	2	Ludlow Dikes (west side)	Phillips Co.	AR
Bison sp.	27	Ludlow Dikes (west side)	Phillips Co.	AR
Paleolama mirifica	1	Ludlow Dikes (west side)	Phillips Co.	AR
Cervalces scotti	1	Ludlow Dikes (west side)	Phillips Co.	AR
Odocoileus virginianus	44	Ludlow Dikes (west side)	Phillips Co.	AR
Small carnivore	1	Ludlow Dikes (west side)	Phillips Co.	AR
Ursus (*Euarctos*) *americanus*	1	Ludlow Dikes (west side)	Phillips Co.	AR
Megalonyx jeffersonii	3	Ludlow Dikes (west side)	Phillips Co.	AR
Equus complicatus	17	Ludlow Dikes (west side)	Phillips Co.	AR
Mammut americanum	1	Ludlow Dikes (west side)	Phillips Co.	AR
Castoroides ohioensis	1	Ludlow Dikes (west side)	Phillips Co.	AR
Castor canadensis	1	Ludlow Dikes (west side)	Phillips Co.	AR
Trichechus manatus	1	Ludlow Dikes (west side)	Phillips Co.	AR
unidentified large mammal	20	Ludlow Dikes (west side)	Phillips Co.	AR
Bison sp.	2	Island 64 (West side)	Phillips Co.	AR
Paleolama mirifica	2	Island 64 (West side)	Phillips Co.	AR
Odocoileus virginianus	2	Island 64 (West side)	Phillips Co.	AR
Megalonyx jeffersonii	1	Island 64 (West side)	Phillips Co.	AR
Equus complicatus	3	Island 64 (West side)	Phillips Co.	AR
unidentified large mammal	1	Island 64 (West side)	Phillips Co.	AR
Hesperotestudo crassiscutata	1	Island 62 (West side)	Phillips Co.	AR
Bison sp.	1	Island 62 (West side)	Phillips Co.	AR
Odocoileus virginianus	1	Island 62 (West side)	Phillips Co.	AR
Equus sp.	1	Island 62 (West side)	Phillips Co.	AR
Bison sp.	1	Miller Point	Phillips Co.	AR
Macrochemmys temminki	1	Rosedale Gravel Co.	Bolivar Co.	MS
Bison sp.	7	Rosedale Gravel Co.	Bolivar Co.	MS
Cervalces scotti	1	Rosedale Gravel Co.	Bolivar Co.	MS
Mylohyus nasatus	1	Rosedale Gravel Co.	Bolivar Co.	MS
Odocoileus virginianus	3	Rosedale Gravel Co.	Bolivar Co.	MS
Megalonyx jeffersonii	1	Rosedale Gravel Co.	Bolivar Co.	MS
Equus complicatus	3	Rosedale Gravel Co.	Bolivar Co.	MS
Mammut americanum	2	Rosedale Gravel Co.	Bolivar Co.	MS
Unidentified large mammal	2	Rosedale Gravel Co.	Bolivar Co.	MS

end of the Rancholabrean is characterized by the extinction of large mammals that weighed ≥ 44 kg, including *Megalonyx*, *Mammut*, *Smilodon* and other mammalian megafauna (Martin, 1984, Faith and Surovell, 2009; Grayson and Meltzer, 2015; Grayson, 2016).

Fossil Rancholabrean deposits contain a diverse record of amphibians, reptiles, birds, and mammals but the most comprehensively studied are the mammals (Mead, 2007). Some extinct species within the Looper Collection such as large Rodentia (*Castoroides ohioensis*), Carnivora (*Canis dirus* and *Arctodus simus*), Edentata (*Megaloynx jeffersonii*), Perissodactyla (*Equus complicatus*, *Equus* spp., *Tapirus haysii*, and *Tapirus veroensis*), Proboscidea (*Mammuthus columbi* and *Mammut americanum*), and Artiodactyla (*Bootherium bombifrons*, *Cervalces scotti*, *Mylohyus nasutus*, and *Paleolama mirifica*) fall securely within the late Rancholabrean (Beck, 1996; Faith and Surovell 2009). With the exception of *Bison*, seventeen mammalian genera from the Looper Collection extend into earlier Pleistocene land mammal ages. Three late Pleistocene mammalian species contained in the Looper Collection are extant: *Castor canadensis*, *Trichechus manatus*, and *Ursus americanus*.

GEOGRAPHIC DISTRIBUTION OF TAXA

Many species of late Pleistocene mammals contained in the Looper Collection represent new accounts of large mammalian megafauna from the mid-Mississippi Alluvial Valley: *Arctodus simus*, *Ursus americanus*, *Cervalces scotti*, *Canis dirus*, *Mylohyus nasutus*, *Equus complicatus*, *Tapirus haysii*, *Tapirus veroensis*, *Mammuthus columbi*, *Mammut americanum*, *Castor canadensis*, *Castoroides ohioensis*, and *Trichechus manatus*. Only *Megalonyx jeffersonii* was documented from this area on species maps composed by Grayson (2016). *Odocoileus virginianus* was noted by Kurtén and Anderson (1980) from sites in central and eastern parts of the North American continent including Mississippi, Arkansas, Louisiana, Florida and Georgia. *Arctodus simus* was reported previously from the Black Belt, MS area as well as from Alabama, Missouri, and Texas (Kurtén and Kaye, 1982). *Bootherium bombifrons*, *Cervalces scotti*, *Paleolama mirifica*, *Tapirus haysii*, *Platygonus compressus*, *Equus complicatus*, and *Trichechus manatus*, however, are not well known from late Pleistocene fossil sites throughout the southeastern United States.

Several species in the Looper Collection, although not previously reported from the Mississippi Delta region, possess wide geographic distributions throughout North America. For example, *Arctodus simus* is known from 100 Rancholabrean sites extending along the west coast from northern Alaska through California to Mexico, and eastward through north central Alabama to Virginia and Florida (Schubert et al., 2010; Grayson, 2016). A left mandibular ramus with canine root and two molars was found from The Bar, Desha County, AR (Figure 4D). *Bootherium bombifrons* is known from many parts of North America except for the southwest and most of the southeast (Grayson, 2016). Two elements including a right lower molar and an axis vertebra from Desha County, AR, are contained in the Looper Collection (Figure 2G). Late Pleistocene fossils of *Tapirus* have been discovered from coast to coast in the United States, including northeast Arkansas, southwest Alabama, throughout Florida, and along the eastern coastline of Georgia, South Carolina and North Carolina. A metapodial of *Tapirus haysii* (large tapir) was found on Terrene Bar in Bolivar Co., MS (Figure 3E). A left mandibular ramus fragment with molar roots, a right mandibular ramus with two molars, and an edentulous symphysis were obtained in Desha Co., AR, and a right cheek tooth of *Tapirus veroensis* was acquired from Chicot Co., AR. *Equus complicatus*, a common large horse in eastern North America during the late Pleistocene, is recorded from the Gulf Coast of Texas eastward to Florida, South Carolina, Kentucky, and Missouri. Numerous specimens were collected from 17 gravel bars (Figure 3A) associated with the Looper Collection.

Canis dirus ranged throughout North and South America (Dundas, 1999). Late Pleistocene sites are concentrated in Texas, California, Florida, Missouri and San Josecito Cave, Mexico (Dundas, 1999). For example, more than 200,000 specimens of *Canis dirus* are from the Rancho La Brea tar pits (Lindsey, 2017). A proximal radius was identified from Henrico Dikes, Desha County, AR (Figure 4A) and a crushed skull was found in Rosedale, MS by Dr. George Phillips in the early part of this century (Phillips, 2017, personal communication) that is reposited at MMNS.

Remains of *Castoroides ohioensis*, the largest rodent in North America, are associated with sites in Indiana, Illinois, Florida, eastern Tennessee and Texas (Kurtén and Anderson, 1980; Grayson 2016). Skeletal elements including mandibles and a partial femur came from Chicot, Desha, and Phillips counties, AR (Figure 3C).

Proboscideans were a dominant group during the late Pleistocene. *Mammuthus columbi* is well known from sites ranging from Alaska south to Nicaragua and eastward into Florida and throughout the Midwest (Yansa and Adams, 2012), although published accounts are not listed for Louisiana, Mississippi and Alabama with the exception of mammoth bones from Natchez, MS (Domning, 1969). The Looper Collection contains a cheek tooth fragment with thin enamel

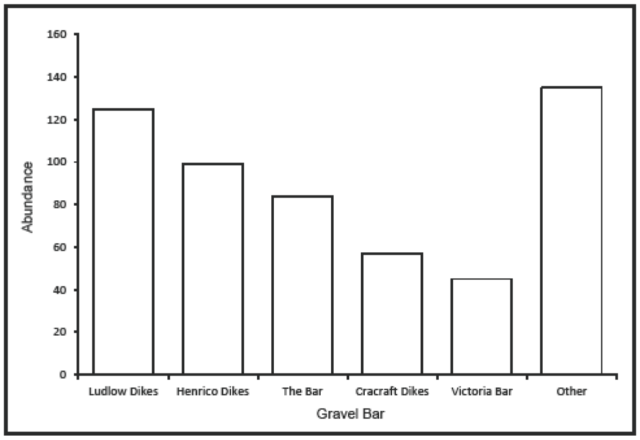

FIGURE 5. The number of skeletal elements from designated gravel bars associated with the Looper Collection.

plates from Cracraft Dikes, Chicot Co, AR (Figure 3H). *Mammut americanum* ranged from Alaska to Florida, into Central America (Graham, 1990; Yansa and Adams, 2012), and Costa Rica (Grayson, 2016) with large clusters found in the Great Lakes region and Atlantic Coast (Yansa and Adams, 2012). A partial palate, cheek teeth, worn upper molars, skull fragments, a hyoid, left scapula, proximal rib head, and pelvis fragments were acquired from gravel bars located in Chicot, Desha. and Phillips Counties, AR, and a deciduous premolar, limb bone, and skull fragment from Bolivar Co., MS (Figures 3F-G).

Some mammals with more limited geographic distribution are not documented from the Central Mississippi Alluvial Valley. For example, skeletal elements of *Cervalces scotti*, including a right mandibular ramus fragment with a molar, the base of a large antler with burr, and a flat narrow antler fragment, were collected from Desha and Phillips Counties, AR and from Rosedale, MS respectively (Figure 2F). The southernmost range of *Cervalces* previously extended into southwestern North Carolina and northwestern AR, but not into other southeastern states (Grayson, 2016). Additionally, *Palaeolama mirifica* is known primarily from Florida, Georgia, and South Carolina (Ruez, 2005), but it has also been found in a few scattered localities including the Central Mississippi River Valley in southern Missouri (Graham, 1992), Tennessee (Breitburg and Corgan, 1998), the Texas Gulf Coastal Plain (Graham, 1992) and southern California (Jefferson, 1991). Three elements documented in the Looper Collection include a proximal phalanx, a left tibia diaphysis, and a metapodial distal diaphysis from Phillips County, AR (Figure 2E). A partial left mandibular ramus with two molars of *Mylohyus nasutus* was obtained from the Rosedale Gravel Co., Bolivar Co., MS (Figure 2C). The only previous reports of this species are from northwestern Arkansas, central Tennessee, northern Georgia, Florida, Virginia, Oklahoma, Pennsylvania, and other Midwestern States (Kurtén and Anderson, 1980; Grayson, 2016).

The radius-ulna of *Trichechus manatus* found on Ludlow Bar, Phillips County, AR (Figure 3D) represents a unique record during the late Pleistocene. Manatees are warm water animals. Its presence indicates an incursion into the Mississippi drainage system during the late Pleistocene (Williams and Domning, 2004; Domning, 2005). Other late Pleistocene records of manatees from the southeastern United States range along the east coast from Florida to North Carolina (Domning, 2005) although ribs and vertebrae are known from Welsh, Jefferson Davis Parish, LA (Domning, 2005). According to Domning (2005) the Arkansas manatee elements may be the result of an accidental encroachment into the Mississippi and Ohio rivers during the Sangamonian. The Mississippi River however, consisted of many large braided belts until circa 10 ka (see geology section) and did not resemble its current longitudinal profile until the end of the last interglacial (Rittenour et al., 2007). As a result, the manatee may be time equivalent to the other late Pleistocene ice age elements or perhaps Holocene.

DISCUSSION

The Mississippi River, North America's longest and largest river, and its tributaries were major sources of food and water for many vertebrates during the late Pleistocene. The meandering behavior of the Mississippi River dislodged fossil elements from late Pleistocene and Holocene sediments and redeposited them onto Late Holocene gravel bars. Fluvial transport was probably minimal since most of the bones and teeth possess little rounding and abrasion. Damage on many of the permineralized bones probably took place during redeposition due to skeletal elements being dredged up and reworked into gravel bars. Similar processes occurred in terrace deposits along the western part of the Kansas River drainage, east of Manhattan, KS (Martin et al., 1979). The majority of the skeletal elements in the Looper Collection are from large herbivores, which may represent a taxonomic bias in the composition of the fossils collected; skeletal elements of smaller fauna may have been destroyed from strong river currents or transported downstream.

There is no modern equivalent to late Pleistocene mammalian communities. It is also difficult to determine the absolute abundance and diversity of late Pleistocene species that existed in the Lower Central Mississippi Valley. Fossil elements collected along Mississippi gravel/sand bars suggest that late Pleistocene megafauna existed along the Mississippi

River (Ruddell et al., 1997; Ruddell, 1999; Dockery and Thompson, 2016). Although several mammals, including *Bison*, *Bootherium*, *Mammuthus*, *Mammut*, *Megalonyx* are usually associated with cold environments (Graham, 1990), the climate of the Lower Central Mississippi Valley may have been characterized by reduced seasonal extremes, especially during the winter and summer as compared to other areas in the southeast, perhaps causing animals to migrate to this region where food was more abundant. The braided stream branches associated with the Mississippi River probably served as preferred watering places, especially at times of severe drought. Coniferous cones of *Picea*, palynomorphs from sedimentary cores, and fossilized wood suggest that the Lower Central Mississippi Valley, from which the Looper Collection was derived, possessed a mosaic of vegetational ecosystems: grasslands, boreal forests, woodlands, and bog/marshes (Dockery and Thompson, 2016). Even with potential migration to this area, the variety of vegetation may have alleviated animal competition for plant resources and possibly resource partitioning. Having various food resources could provide less dependency on specific dietary requirements (France et al., 2007). Foregut fermentation (ruminants) and hindgut fermentation (non-ruminants) require different plant sources for energy assimilation (France et al., 2007). As a result, many large megaherbivores were likely to coexist, and carnivores such as *Arctodus simus* and *Canis dirus* probably did not suffer from starvation. *Bison*, *Bootherium*, *Equus*, and *Mammuthus* probably frequented grasslands (Grayson, 2016); woodlands and forests provided food and shelter for *Mammut*, *Odocoileus*, *Cervalces*, *Paleolama*, *Megalonyx*, *Tapirus*, and *Castor*; large Testudines probably searched for food in the water or along riverbanks (Ruddell et al., 1997; Ruddell, 1999).

Detailed dietary studies analyzed tooth enamel, dung, and stomach remains on several late Pleistocene mammals. France et al. (2007) stated that some species of ground sloths, including *Megaloynx jeffersoni* might have been opportunistic scavengers, insectivores, or even carnivores. Individuals of this species probably were herbivores based on ∂^{15} N and ∂^{13} C data from Saltville Quarry, VA specimens (France et al., 2007). Teeth and dung of *Mammut americanum* suggest that it was a mixed feeder, eating high and low vegetation (Hoppe and Koch, 2006; Fariña et al., 2013). It ate significant amounts of *Picea* but also consumed water plants, *Poa*, bark of *Taxodium*, young branches of *Salix*, fruits of *Diospyros*, *Rubus*, and *Carya* and gourds of *Cucurbita* (Hoppe and Koch, 2006; Teale and Miller, 2012; Grayson, 2016). Beside grasses,

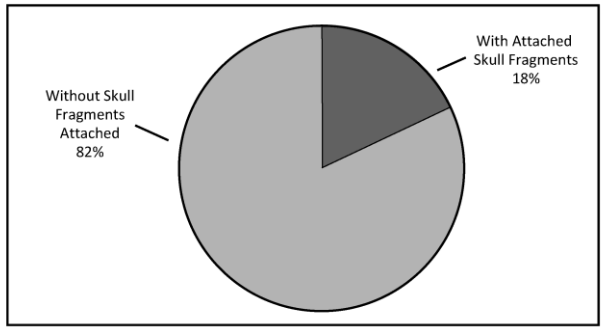

FIGURE 6. The percentage of antlers of *Odocoileus virginianus*that are shed without skull fragments attached compared to those with cranial inclusions from the Looper Collection.

Mammuthus fed on twig tips of *Picea*, *Salix*, *Alnus*, and *Larix* (larch) (Van Geel et al., 2008; Grayson, 2016). *Cervales scotti* lived in bogs and marshes similar to modern moose (Grayson, 2016). These plant taxa were native to the Mississippi Alluvial Valley throughout the late Pleistocene as discussed in the regional climate section.

Climatic warming prevailed throughout North America from 14,000 to 10,000 ka, which probably caused environmental gradients to shift and species distributions to change (Graham, 1990; Graham and Grimm, 1990; Haynes, 1991; Delcourt and Delcourt, 1994; Delcourt et al., 1997; Fariña et al., 2013; Grayson, 2016). Species of *Bison*, *Odocoileus*, and *Equus*, are social animals that form herds. This behavior may account for the large quantity of fossilized skeletal elements associated with the Looper Collection. Although species of *Bison*, *Equus*, *Bootherium*, *Mammut*, *Mammuthus*, *Canis* and others were more common in more northern climes of North America (Fariña et al., 2013), they probably migrated along river valleys in the spring to find suitable habitats, which could explain their presence in the Mississippi Alluvial Valley. *Paleolama* however, was restricted to more southern regions (Fariña et al., 2013) and probably did not migrate extensively to more northern latitudes.

Many specimens in the Looper Collection may be representative of spring season. For example, there are 36 shed antlers of *Odocoileus virginianus*. Male *Odocoileus virginianus* shed antlers in the spring (Price et al., 2005) and only occasionally lose them during fighting or displays. In contrast, only 18% of the antlers possessed cranial attachments, implying that these deer served as prey items (Churcher and Pinsof, 1987). Male cervids, including *Odocoileus virginiana*, often are weak from malnutrition during the winter months, which can increase their vulnerability to predation, accidents, and disease (Barnosky, 1985). Male cervids, as compared to females, prefer valley bottoms and as a result die near water sources such as lake shores (Barnosky, 1985).

Other unpublished accounts of lists for late Pleistocene fauna from the Mississippi Delta are comparable to the Looper Collection. Approximately 50% of the taxa in the Connaway Collection have been identified to species. Most of the taxa represent regional terrestrial megafauna of mammals whereas aquatic fauna are minor constituents. Ruddell (1999) stated that 610 skeletal elements are representative of grassland taxa, and 431 are associated with mixed woodland and forest adapted taxa. Similar to the Looper Collection, the largest quantity of skeletal elements were *Odocoileus*, *Bison*, and *Equus* respectively (Ruddell et al., 1997; Ruddell, 1999). Carnivores were also rare compared to the herbivores. The Connaway Collection possesses 17 taxa that are associated with the Looper Collection (Table 2), including *Bison* sp., *Bootherium bombifrons*, *Castoroides canadensis*, *Castoroides ohioensis*, *Equus* sp., *Mammut americanum*, *Megalonyx jeffersonii*, *Odocoileus virginianus*, *Tapirus haysii*, and *Ursus americanus*, *Hesperotestudo crassiscutata*, *Pylodictis olivaris* as well as others. The Connaway Collection, however, contains additional species of late Pleistocene taxa of fish, reptiles, birds and mammals (Table 2): four species of *Bison* (*B. latifrons*, *B. bison antiques*, *B.* bison *occidentalis*, and *B. bison bison*), *Cervus canadensis*, *Cervus elephus*, *Dasypus bellus*, *Odocoileus hemionus*, *Rangifer* sp., *Nothrotheriops*, *Panthera leo atrox*, *Paramylodon harlen*, and *Sylvilagus floridanus*. The Connaway Collection spanned a greater area along the Mississippi River compared to the Looper Collection, sampling gravel bars in Shelby County, TN; Chicot, Crittenden, Desha, Lee, and Phillips counties, AR; and Bolivar, Coahoma, Desoto, Tunica, and Washington Co., MS (Ruddell, 1999). Additionally, a baby *Mammuthus* tooth and a partial atlas vertebra of *Eremotherium* is known from the Danny West Collection (Table 2).

Similarly, late Pleistocene fauna specimens from the Black Belt area in northeastern Mississippi are representative of open grassland and mixed-woodlands (Kaye, 1974). These fossils are comparable to the Looper and Connaway collections (Table 2) and are associated with floodplain deposits that were later redeposited on recent gravel bars (Kaye, 1974; Ruddell, 1999). Although *Equus* and *Bison* made up the highest proportion of the fauna, Kaye (1974) noted some additional taxa including *Hemiauchenia*, *Holmesina septentrionalis*, *Hydrochoerus*, and *Platygonus*. Like the Looper Collection, most of the bone elements are fragmented. The fragmentation is speculated to result from the expansion and contraction of montmorillonitic clays and stream transport (Kaye, 1974).

Thirteen species of megafauna mammals and one Testudinidae that became extinct at the end of the late Pleistocene North America are represented in the Looper Collection (Table 1). According to Grayson and Meltzer (2015) and Meltzer (2015) thirty-seven genera of large mammals became extinct at the end of the Pleistocene. Herbivores (n=30) were the most affected and the remainder were carnivores (n=7). A disproportionate number of large mammals (32 out of 37) weighed ≥44 kg (Meltzer, 2015). Hypotheses that account for their extinction are various: degradation and changes in habitat, slow reproductive rates (Koch and Barnosky, 2006), ambush blitzkrieg by humans (Barnosky, 1989; Martin, 2005), the loss of keystone species (Brook and Bowman, 2004), reduced genetic diversity (Lorenzen et al., 2011), extraterrestrial impact (Firestone et al., 2007), lethal pathogens unknown to their immune system (e.g. canine distemper, rinderpest, and leptospirosis) (Stevens, 1997), and climate change (Barnosky, 1989; Clark et al, 2012).

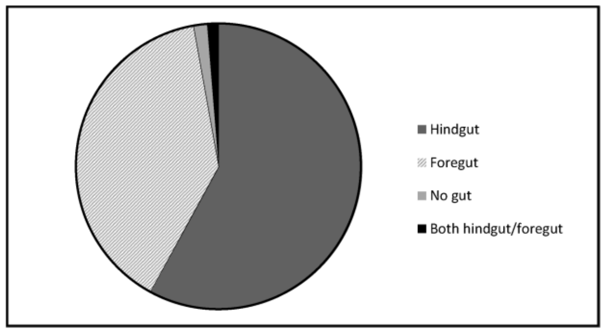

FIGURE 7. The percentage of skeletal elements associated with foregut, hindgut, both foregut/hindgut, and no gut digestion from the Looper Collection. [planned for column width]

It remains puzzling how the megafauna represented by the Looper Collection disappeared. Climate instability was occurring in North America from 20 ka – 10 ka including in the Central Mississippi Alluvial Valley. Rising levels of greenhouse gases and increased solar radiation caused ice sheets to melt starting approximately 16.5 ka (Meltzer, 2015). As noted in the Regional Climate section, vegetation shifts occurred due to rising temperatures, and the Mississippi River changed from a braided to a meandering regime circa 10 ka (see Geologic Section). Geomorphic changes probably caused cold-temperate species to migrate away from this region. Water sources resulting from former braided streams were disappearing, which may have caused water stress for large megafauna. It is probably unlikely that early human settlers caused the extinction of large megafauna taxa (see Meltzer, 2015), although rich chert sources are associated with Crowley's Ridge, AR

(Gillam, 1995). Uncatalogued arrowheads in the DSU Biological Sciences museum also are associated with this time period, implying that human colonizers may have migrated to the Mississippi Alluvial Valley because of the diverse megafauna.

The river channel sand/gravel bars associated with the Central Mississippi Alluvial Valley do not lend themselves to site excavations and exhibits about late Pleistocene fauna compared to skeletal elements concentrated in localized areas. For example, Hot Springs, SD, contains 50+ Columbian mammoths associated with sinkholes (Agenbroad, 1997); Big Bone Lick in Boone Co., KY, known as the birthplace of vertebrate paleontology, possesses complete skulls and articulated remains of *Bootherium bombiforns*, *Cervalces scotti*, *Mammut americanum*, *Mammuthus sp.*, and *Megalonyx jeffersonii*, where saline springs and salt licks attracted fauna communities (Tankersley et al, 2009); and Rancho La Brea in southern CA, known as the most important late Pleistocene fossil locality, possesses tar pits where thousands of bones of late Pleistocene fauna (Holden et al, 2013) have been recovered.

The Looper Collection, however, illustrates how gravel/sand channel bars are a major source of vertebrate fossils, although the skeletal elements are scattered. As a result of this collection, the geographic distribution of several late Pleistocene megafauna mammalian taxa has been expanded, and meaningful paleoecological content can be applied to the Central Mississippi Alluvial Valley. The Looper Collection possesses grazers, browsers, animals that lived near water, herding animals, omnivores, and carnivores that lived during the late Pleistocene. The majority of the animals are large mammalian herbivores but other vertebrate taxonomic classes are represented as well. Differences in dietary requirements are also portrayed by the percentages of foregut, hindgut, and no gut mammalian taxa. Future studies can incorporate more detailed taxonomic analysis of the skeletal elements in order to determine additional insight about dietary information, animal behavior, and past habitats. Rare earth elements could be used to decipher a more precise age province as Yann (2010) did for late Pleistocene vertebrates from Tunica Hills, LA.

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LITERATURE CITED

Agenbroad, L. D. 1997. Mammoth site. Natural History 106:77-79.

Barnosky, A. D. 1985. Taphonomy and herd structure of the extinct Irish elk, *Megaloceros giganteus*. Science 228 (4697):340-344.

Barnosky, A. D. 1989. The late Pleistocene event as a paradigm for widespread mammal extinction; pp. 235-253 in S. K. Donovan (ed.), Mass Extinctions: Processes and Evidence. Belhaven, New York, New York, 266 pp.

Beck, M. W. 1996. On discerning the cause of late Pleistocene megafaunal extinctions. Paleobiology 22:91-103.

Beerling, D. J., and F. I Woodward. 1993. Ecophysiological responses of plants to global environmental change since the last Glacial Maximum. New Phytologist 125:641-648.

Bell, C. J., E. L. Lundelius Jr., A. D. Barnosky, R. W. Graham, E. H. Lindsay, D. R. Ruez Jr., H. A. Semken Jr., S. D. Webb, and R. J. Zakrzewski. 2004. The Blancan, Irvingtonian, and Rancholabrean Mammal Ages; pp. 232-314. In M. O. Woodburne (ed.), Late Cretaceous and Cenozoic Mammals of North America: Biostratiography and Geochronology. Columbia University Press, New York, New York, 376 pp.

Behrensmeyer, A. K., J. D. Damuth, W. A. DiMichele, R. Potts, H.-D. Sues, and S. L. Wing. 1992. Terrestrial Ecosystems Through Time. Evolutionary Paleoecology of Terrestrial Plants and Animals. The University of Chicago Press, Chicago, Illinois, 568 pp.

Blum, M. D., M. J Guccione, D. A Wysocki, P. C. Robnett, and E. M. Rutledge. 2000. Late Pleistocene evolution of the lower Mississippi River valley, southern Missouri to Arkansas. Geological Society of America Bulletin 112:221-235.

Boardman, G. S. 2008. First lamine camel (cf. *Paleolama*) reported from the Tunica Hills of Louisiana. Current Research in the Pleistocene. 25:163-165.

Breitburg, E., and J. X. Corgan. 1998. Recent discoveries of Pleistocene vertebrates in

Tennessee. Journal of the Tennessee Academy of Science 73:25.

Brister, J., W. Armon, and D. H. Dye. 1981. American mastodon remains and late glacial conditions at Nonconnah Creek, Memphis, Tennessee. Memphis State University Anthropological Research Center, Occasional Papers, No. 10.

Brook, B. W., and B. M. J. S. Bowman. 2004. The uncertain blitzkrieg of Pleistocene megafauna. Journal of Biogeography 31:517-523.

Brown, C. A. 1938. The flora of Pleistocene deposits in the western Florida Parishes, west Feliciana Parish, and east Baton Rouge Parish, Louisiana. Louisiana Department of Conservation, Geological Bulletin 12:59-96.

Churcher, C. S., and J. D. Pinsof. 1987. Variation in the antlers of North American *Cervalces* (Mammalia; Cervidae): review of new and previously recorded specimens. Journal of Vertebrate Paleontology 7:373-397.

Clague, J. J., and T. S. James. 2002. History and isostatic effects of the last ice sheet in southern British Columbia. Quaternary Science Reviews 21:71-87.

Clark, P. U. 1994. Unstable behavior of the Laurentide ice sheet deforming sediment and its implications for climate change. Quaternary Research 41:19-25.

Clark, P. U., J. Shakun, P. Baker, P. Bartlein, S. Brewer, E. Brook, A. E. Carlson, H. Cheng, D. S. Kaufman, Z. Liu, T. M. Marchitto, A. C. Mix, C. Morrill, B. L. Otto-Bliesner, K. Pahnke, J. M. Russell, C. Whitlock, J. F. Adkins, J. L. Blois, J. Clark, S. M. Colman, W. B. Curry, B. P. Flower, F. He, T. C. Johnson, J. Lynch-Stieglitz, V. Markgraf, J. McManus, J. X. Mitrovica, P. I. Moreno, and J. W. Williams. 2012. Global climate evolution during the last deglaciation. Proceedings of the National Academy of Sciences of the United States 109(19):E1134-E1142.

Czaplewski, N. J., and K. S. Smith. 2012. Late Pleistocene vertebrates from a rockshelter in Cimarron County, Oklahoma. The Southwestern Naturalist 57:399-411.

Daly, E. 1992. A list, bibliography and index of the fossil vertebrates of Mississippi. Mississippi Office of Geology Bulletin 128:1-47.

Delcourt, H. R., and P. A. Delcourt, 1975. The Blufflands Pleistocene pathway into the Tunica Hills. American Midland Naturalist 94:395-400.

Delcourt, H. R., and P. A. Delcourt. 1988. Quaternary landscape ecology: relevant scales in space and time. Landscape Ecology 2:23-44.

Delcourt, H. R., and P. A. Delcourt. 1994. Postglacial rise and decline of *Ostrya virginiana* (Mill.) and *Carpinus caroliniana* in Eastern North America: predictable responses of forests species to cyclic changes in seasonality of climates. Journal of Biogeography 21: 137-150.

Delcourt, P. A., and H. R. Delcourt. 1987. Late-Quaternary dynamics of temperate forests: applications of Paleoecology to issues of global environmental change. Quaternary Science Reviews 6:129-146.

Delcourt, P. A., and H. R. Delcourt. 1996. Quaternary paleoecology of the Lower Mississippi Valley. Engineering Geology 45:219-242.

Delcourt, H. R., P. A. Delcourt, and P. D. Royall. 1997. Late Quaternary vegetational history of the western Lowlands; pp. 103-122. in D. Morse (ed.), Sloan: a Paleoindian Dalton Cemetery in Arkansas. Smithsonian Institution Press, Washington D.C., 157 pp.

Delcourt, P. A., H. R. Delcourt, R. C. Brister, and L. E. Lackey 1980. Quaternary vegetation history of the Mississippi Embayment. Quaternary Research 13:111-132.

Dockery, D. T., III. 1997. Windows into Mississippi Geologic Past. Mississippi Office of Geology Circular 6:64.

Dockery, D. T. III., and D. E. Thompson. 2016. The Geology of Mississippi. University Press of Mississippi, Jackson, Mississippi, 751 pp.

Domning, D. P. 1969. A list, bibliography, and index of the fossil vertebrates of Louisiana and Mississippi. Transactions of the Gulf Coast Association of Geological Societies XIX:385-422.

Domning, D. P. 2005. Fossil Sirenia of the West Atlantic and Caribbean region. VII. Pleistocene *Trichechus manatus* Linnaeus, 1758. Journal of Vertebrate Paleontology 25:685-701.

Dundas, R. G. 1999. Quaternary records of the dire wolf, *Canis dirus*, in North and South America. Boreas 28:375-385.

Faith, J. T., and T. A. Surovell. 2009. Synchronous extinction of North America's Pleistocene mammals. Proceedings of the National Academy of Science of the U.S.A. 106:20641-20645.

Fariña, R. A., S. F. Vizcaíno, and G. D. Iuliis. 2013. Megafauna: Giant Beasts of Pleistocene South America. Indiana University Press, Bloomington, Indiana, 436 pp.

Figueirido, B., P. Palmqvist, and J. A. Pérez-Claros. 2009. Ecomorphological correlates of craniodental variation in bears and paleobiological implications for extinct taxa: an approach based on geometric morphometrics. Journal of Zoology 277:70-80.

Figuerido, B., J. A. Pérez-Claros, V. Torregrosa, A. Martin-Serra, and P. Palmqvist. 2010.

Demythologizing *Arctodus simus*, the 'short-faced' long-legged and predaceous bear that never was. Journal of Vertebrate Paleontology 30:262-275.

Firestone, R. B., A. West, J. P. Kennett, L. Becker, T. E. Bunch, Z. S. Revay, P. H. Schultz, T. Belgya, D. J. Kennett, J. M. Erlandson, O. J. Dickenson, A. C. Goodyear, R. S. Harris, G. A. Howard, J. B. Kloosterman, P. Lechler, P. A. Mayewski, J. Montgomery, R. Poreda, T. Darrah, S. S. Que Hee, A. R. Smith, A. Stich, W. Topping, J. H. Wittke, and W. S. Wolbach. 2007. Evidence for an extraterrestrial impact 12,900 years ago that contributed to the megafaunal extinctions and the Younger Dryas cooling. Proceedings of the National Academy of Science of the U.S.A. 104:16016-16021.

France, C. A. M., P. M. Zelanko, A. J. Kaufman, and T. R. Holtz. 2007. Carbon and nitrogen isotopic analysis of Pleistocene mammals from the Saltville Quarry (Virginia, USA): implications for trophic relationships. Palaeogeography, Palaeoclimatology, Palaeoecology 249:271-282.

Gillam, J. C. 1995. Paleoindian settlement in the Mississippi Valley of Arkansas. M.A. thesis, Department of Anthropology, University of Arkansas, Fayetteville, Arkansas, 79 pp.

Graham, R. W. 1990. Evolution of new ecosystems at the end of the Pleistocene; pp. 54-60 in L. D. Agenbroad, J. I. Mead, and L. W. Nelson (eds.), Megafauna and Man: Discovery of America's Heartland. Mammoth Site of Hot Springs, South Dakota, Inc., 143 pp.

Graham, R. W. 1992. *Palaeolama mirifica* from the central Mississippi River Valley; paleoecological and evolutionary implications. Journal of Vertebrate Paleontology 12:31A.

Graham, R. W., and E. C. Grimm. 1990. Effects of global climate change on the patterns of terrestrial biological communities. Trends in Ecology and Evolution 5:289-292.

Grayson, D. K. 2006. The late Quaternary biogeographic histories of some Great Basin mammals (western USA). Quaternary Science Reviews 25:2964-2991.

Grayson, D. K. 2016. Giant Sloths and Saber Tooth Cats: Extinct Mammals and the Archaeology of the Ice Age Great Basin. The University of Utah Press, Salt Lake City, Utah, 421 pp.

Grayson, D. K. and D. J. Meltzer. 2015. Revisiting Paleoindian exploitation of extinct North American mammals. Journal of Archaeological Science 56:177-193.

Guccione, M. J., W. L. Prior, and E. M. Rutledge. 1988. Crowley's Ridge, Arkansas; pp. 225-230 in O. T. Haywood (ed.), Decade of North American Geology, Centennial Field Guide. Volume 4, South-Central Section of the Geological Society of America. Boulder, Colorado, 468 pp.

Haynes, C. V., Jr. 1991. Geoarchaeological and paleohydrological evidence for a Clovis-age drought in North America and its bearing on extinction. Quaternary Research 35:438-450.

Holden, A. R., J. M. Harris, and R. M. Timm. 2013. Paleoecological and taphonomic implications of insect-damaged Pleistocene vertebrate remains from Rancho la Brea, Southern California. PLOS One 8(7): e67119, doi: 10.1371/journal.pone.0067119.

Holloway, R. G., and S. Valastro. 1983. Palynological investigations along the Yazoo River. pp. 159-257 in R. M. Thorne and H. K. Curry (ed.), Cultural Resource Survey of Items 3 and 4, Upper Yazoo River Projects, Mississippi with a Paleoenvironmental Model of the Lower Yazoo Basin. Archeological Papers for the Center for Archaeological Research, Department of Sociology and Anthropology, The University of Mississippi, Oxford, Mississippi, 307 pp.

Hoppe, K. A. and P. L. Koch. 2006. The biogeochemistry of the Aucilla River fauna. pp. 379-401 in S. D. Webb (ed.), First Floridians and Last Mastodons: The Page-Ladson Site in the Aucilla River. Springer, Dordrecht, Netherlands, 588 pp.

Hulbert, R. C., and A. E. Pratt. 2010. New Pleistocene (Rancholabrean) vertebrate faunas from coastal Georgia. Journal of Vertebrate Paleontology 18:412-429.

Ives, J. D. 1978. The maximum extent of the Laurentide Ice Sheet along the East Coast of North America during the last glaciation. Arctic 31:24-53.

Jefferson, G. T. 1991. A catalogue of late Quaternary vertebrates from California. Part two, mammals. Natural History Museum of Los Angeles County Technical Report 7:1–129.

Kaye, J. M. 1974. Pleistocene sediment and vertebrate fossil associations in the Mississippi Black Belt: a genetic approach. Ph.D. dissertation, Louisiana State University, Baton Rouge, Louisiana, 116 pp.

Koch, P. L., and A. D. Barnosky. 2006. Late Quaternary extinctions: state of the debate. Annual Review of Ecology and Systematics 37:215-250.

Kurtén, B., and E. Anderson. 1980. Pleistocene Mammals of North America. Columbia University Press, New York, New York, 442 pp.

Kurtén, B., and J. M. Kaye. 1982. Late Quaternary Carnivora from the Black Belt, Mississippi. Boreus 11:47-52.

Lindsey, E. 2017. Mammals at Rancho La Brea: Canidae. Available at www.nhm.org/site/research-collections/rancho-la-brea/about-rlb-mammals. Accessed November 30, 2017.

Looper, L. 2006. Phytolith recovery from the tooth calculus of a giant ground sloth (*Megalonyx jeffersonii*). Available at http://www.cwreplicas.com/phytoliths. Accessed October 4, 2017.

Lorenzen, E. D., D. Nogués-Bravo, L. Orlando, J. Weinstock, J. Binladen, K. A. Marske, A. Ugan, M. K. Borregaard, M. T. P. Gilbert, R. Nielsen, S. Y. W. Ho, T. Goebel, K. E. Graf, D. Byers, J. T. Stenderup, M. Rasmussen, P. F. Campos, J. A. Leonard, K-P. Koepfli, D. Froese, G. Zazula, T. W. Stafford Jr., K. Aaris-Sørensen, P. Batra, A. M. Haywood, J. S. Singarayer, P. J. Valdes, G. Boeskorov, J. A. Burns, S. P. Davydov, J. Haile, D. L. Jenkins, P. Kosintsev, T. Kuznetsova, X. Lai, L. D. Martin, H. G. McDonald, D. Mol, M. Meldgaard, K. Munch, E. Stephan, M. Sablin, R. S. Sommer, T. Sipko, E. Scott, M. A. Suchard, A. Tikhonov, R. Willerslev, R. K. Wayne, A. Cooper, M. Hofreiter, A. Sher, B. Shapiro, C. Rahbek, and E. Willerslev. 2011. Species-specific responses of late Quaternary megafauna to climate and humans. Nature 479:359-365.

Lundelius, E. L., Jr. 1967. Late Pleistocene and Holocene faunal history of central Texas. pp. 287-319 in P. S. Martin and H. E. Wright (ed.), Pleistocene Extinctions: The Search for a Cause. Yale University Press, New Haven, Connecticut.

Lyons, S. K., P. J. Wagner, and K. Dzikiewicz. 2010. Ecological correlates of range shifts of Late Pleistocene mammals. Philosophical Transactions of the Royal Society B 365:3681-3693.

Martin, P. S. 1984. Prehistoric overkill: the global model. pp. 354-403 in Martin, P. S., and R. G. Klein, (eds.) Quaternary Extinctions: A Prehistoric Revolution. University of Arizona Press, Tucson, Arizona, 892 pp.

Martin, L. D., K. N. Whetsone, J. D. Chorn, and C. D. Frailey. 1979. Survey of fossil vertebrates from East-Central Kansas, Kansas River Bank stabilization study. Division of Vertebrate Paleontology, Museum of Natural History, University of Kansas, Lawrence, Kansas, 52 pp.

Martin, P. S. 1990. Who or what destroyed our mammoths. pp. 109-117 in L. D. Agenbroad, J. I. Mead, and L. W. Nelson (eds.), Megafauna and Man: Discovery of America's Heartland. Mammoth Site of Hot Springs, South Dakota, Inc.

Martin, P. S. 2005. Twilight of the Mammoths: Ice Age Extinctions and the Rewilding of America. University of California Press, Berkeley, California, 270 pp.

Mead, J. I. 2007. Late Pleistocene of North America. pp. 3150-3158 in S. Elias (ed.), Encyclopedia of Quaternary Science. Elsevier, Oxford, UK, 3576 pp.

Meltzer, D. J. 2015. Pleistocene overkill and North American mammalian extinctions. Annual Review of Anthropology 44:33-53.

Morgan, G. S., and R. C. Hulbert. 1995. Overview of the geology and vertebrate biochronology of the Leisey Shell Pit local fauna Hillsborough County, Florida. Bulletin of the Florida Museum of Natural History 37:1-92.

Morse, D. F., and P. A. Morse. 1983. Archeology of the Central Mississippi Valley, New World Archaeological Record. Academic Press, Inc., San Diego, California, 345 pp.

Nowak, R. M., 1979. North American Quaternary *Canis*. University of Kansas, Monograph of the Museum of Natural History 6:1-154.

Nunez, E. E., B. J. McFadden, J. I. Mead, and A. Baez. 2010. Ancient forests and grasslands in the desert: diet and habitat of late Pleistocene mammals from Northcentral Sonora, Mexico. Palaeogeography, Palaeoclimatology, Palaeoecology 297:391-400.

Nye, A. S. 2007. Pleistocene peccaries from Guy Wilson Cave, Sullivan County, Tennessee. M.S. thesis, East Tennessee State University, Johnson City, Tennessee, 118 pp.

Price, J. S., S. Allen, C. Faucheux, and T. Althnaian. 2005. Deer antlers: a zoological curiosity or the key to understanding organ regeneration in mammals. Journal of Anatomy 207:603-618.

Riddle, B. R. 1996. The historical assembly of continental biotas: late Quaternary range-shifting, areas of endemism, and biogeographic structure in the North American mammal fauna. Ecography 21:437-442.

Rittenour, T. M., M. D. Blum, and R. J. Goble. 2007. Fluvial evolution of the lower Mississippi River valley during the last 100 k.y. glacial cycle: response to glaciation and sea-level change. Geologic Society of America Bulletin 119:586-608.

Royall, P. D., P. A. Delcourt, and H. A. Delcourt. 1991. Late Quaternary paleoecology and paleoenvironments of the Central Mississippi Alluvial Valley. Geological Society of America Bulletin 103:157-170.

Ruddell, M. W., R. C. Brister, J. M. Connaway, C. Davenport, P. A. Delcourt, and R. T. Saucier. 1997. The Connaway Collection: a Quaternary vertebrate record of the Yazoo River Basin. Current Research in the Pleistocene 14:151-153.

Ruddell, M. W. 1999. Quaternary vertebrate paleoecology of the central Mississippi Alluvial Valley; implications for the initial human occupation. Ph.D. dissertation, the University of Tennessee, Knoxville, Tennessee, 183 pp.

Ruez, D. R. 2005. Earliest record of *Palaeolama* (Mammalia, Camelidae) with comments on "*Palaeolama*" *guanajuatensis*. Journal of Vertebrate Paleontology 25:741–744.

Schubert, B. W., R. C. Hulbert Jr., B. J. MacFadden, M. Searle, and S. Searle. 2010. Giant short-faced bears (*Arctodus simus*) in Pleistocene Florida USA, a substantial range extension. Journal of Paleontology 84(1):79-87.

Schubert, B. W., R. W. Graham, H. G. McDonald, E. C. Grimm, and T. W. Stafford Jr. 2004. Latest Pleistocene paleoecology of Jefferson's ground sloth (*Megalonyx jeffersonii*) and elk-moose (*Cervalces scotti*) in northern Illinois. Quaternary Research 61:231-240.

Stevens, W. K. 1997. Disease is new suspect in ancient extinctions. New York Times (Science section) April 29, 1997.

Tankersley, K. B., M. R. Waters, and T. W. Stafford Jr. 2009. Clovis and the American mastodon at Big Bone Lick, Kentucky. Society for American Archaeology 74:558-567.

Teale C. L., and N. G. Miller. 2012. Mastodon herbivory in mid-latitude late-Pleistocene boreal forests of eastern North America. Quaternary Research 78:72-81.

Teller, J. T., D. W. Leverington, and J. D. Mann. 2002. Freshwater outbursts to the oceans from glacial Lake Agassiz and their role in climate change during the last deglaciation. Quaternary Science Reviews 21:879-887.

Van Geel, B., A. Aptroot, C. Baittinger, H. H. Birks, I. D. Bull, H. B. Cross, R. P. Evershed, B. Gravendeel, E. J. O. Kompanje, P. Kuperus, D. Mol, K. G. J. Nierop, J. P. Pals, A. N. Tikhonov, G. van Reenen, and P. H. van Tienderen. 2008. The ecological implications of a Yakutian mammoth's last meal. Quaternary Research 69:361-376.

Yann, L. T. 2010. Rare earth elements as an investigative tool into the source, age, and ecology of late Miocene to late Pleistocene fossils from the Tunica Hills, Louisiana. M.S. thesis, Louisiana State University and Agricultural and Mechanical College, Louisiana State University, Baton Rouge, Louisiana, 91 pgs.

Yansa, C. H. and K. M. Adams. 2012. Mastodons and mammoths in the Great Lakes Region, USA and Canada: new insights into their diets as they neared extinction. Geography Compass 6:175-188.

Watts, W. A. 1980. The late Quaternary vegetation history of the Southeastern United States. Annual Review of Ecology and Systematics 11:387-409.

Williams, J. W, W. Thompson, III, P. H. Richard, and P. Newby. 2000. Late Quaternary biomes of Canada and the eastern United States. Journal of Biogeography 27:585-607.

Williams, M. E. and D. P. Domning. 2004. Pleistocene or post-Pleistocene manatees in the Mississippi and Ohio River valleys. Marine Mammal Science 20:167-176.