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STRATIGRAPHY AND PALEONTOLOGY OF THE McPHERSON EQUUS BEDS (SANDAHL LOCAL FAUNA), McPHERSON COUNTY, KANSAS

BY

HOLMES A. SEMKEN, JR.

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VOLUME XX

1. Upper Devonian and Lower Mississippian Pectinoid Pelecypods from Michigan, Ohio, Indiana, Iowa, and Missouri, by Thomas W. Hutchinson and Erwin C. Stumm. Pages 1–48, with 7 plates.
2. Two New Middle Devonian Species of the Starfish *Devonaster* from Southwestern Ontario, by Robert V. Kesling and Jean D. Wright. Pages 49–61, with 4 plates.
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4. *Proctothylacocrinus esseri,* a New Crinoid from the Middle Devonian Silica Formation of Northwestern Ohio, by Robert V. Kesling. Pages 75–87, with 5 plates.
5. Additions to and Revision of the Oligocene Ruby Paper Shale Flora of Southwestern Montana, by Herman F. Becker. Pages 89–119, with 6 plates.
6. Stratigraphy and Paleontology of the McPherson Equus Beds (Sandahl Local Fauna), McPherson County, Kansas. Pages 121–178, with 7 figs., 1 map.

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ABSTRACT

Pleistocene rocks in northwestern McPherson County, Kansas, which were collectively designated McPherson *Equus* beds in the past, are divided into the lower Pleistocene Meade Group and the upper Pleistocene McPherson and Loveland Formations of the Sanborn Group.

Kansan age deposits of the Meade Group, identified by the Pearlette Ash Member, were dissected by fluvial processes and subsequently buried by sand and gravel deposits of the McPherson Formation (redefined). Silts of the Loveland Formation later covered the surface of the area. Re-entrenchment during late Wisconsin time again dissected the area, exposed the stratigraphic sequence, and allowed deposition of topographically low terrace deposits.

Examination of the geologic section revealed that the bulk of the fossil vertebrates recovered in the area were from deposits of the McPherson Formation. Vertebrate remains are very rare from other lithic units in the area. Thus, the term "McPherson *Equus* beds" should apply only to deposits of the McPherson Formation.

A micro-vertebrate fauna collected from the McPherson Formation is designated the Sandahl local fauna and is the basis of paleoecological interpretations on the McPherson *Equus* beds. The Kentuck assemblage, a mixed fauna known from northern McPherson County, is not related to the McPherson Formation or the Sandahl local fauna.

Age of the McPherson Formation is considered to be Illinoian on stratigraphic, paleoecological, and evolutionary evidence. The McPherson *Equus* beds rest unconformably upon the late Kansan Pearlette Ash member of the Meade Group and are stratigraphically below Wisconsin terrace deposits. Paleoecological interpretations, based on the area of sympatry (overlap area) of extant species from the Sandahl local fauna, suggest that climatic conditions in central Kansas during time of deposition of the

McPherson Formation were 10°F cooler with approximately 5 inches less rainfall per year than at present. This suggests a glacial rather than interglacial period of deposition. Measurements of fossil muskrat teeth from the High Plains indicate a chronocline of gross size increase and an increase in dentine tract height through time. Muskrats from the Sandahl local fauna compare best with other specimens taken from Illinoian deposits. In addition, all fossil rodents and insectivores from the Sandahl local fauna have been recovered from other Illinoian deposits.

CONTENTS

INTRODUCTION

Deposits of the *Equus* beds were first recorded from McPherson County, Kansas, in 1891. The age, concept, and general stratigraphy of the deposits as well as *Equus* bed deposits from other parts of the United States, have been in dispute since they were recognized. Various authors have considered these deposits either Pliocene or early, middle, or late Pleistocene. Examination of fossil megavertebrates collected from classic localities in northwest McPherson County revealed Pleistocene forms.

New interest in these deposits developed when a microvertebrate fauna, with a number of mammal species, was discovered in the area. Small mammals, because of rapid evolution during the Quaternary and more limited ecological tolerances than the larger mammals, are fairly good

biostratigraphic and paleoecological indicators when studied as a fauna. The purpose of this paper is to revise and map the stratigraphy of the McPherson *Equus* beds, refine the age of the deposits on the basis of the new faunal data, and to interpret the paleoecology of the microfauna.

ACKNOWLEDGMENTS

I am most grateful to Clayton and Caroline Griggs of McPherson for collecting and donating many valuable specimens to the Museum of Paleontology, University of Michigan, and for their general support of my work in McPherson County, Kansas. Sincere appreciation also is extended to the numerous property owners who permitted me to examine exposures on their land, and especially to John and Leland Akers, Miss Frances Flohr, and the Sandahl family who allowed fossils to be removed from their property.

Financial support for travel expenses was made available from the Graduate Student Research Fund of the Horace H. Rackham School of Graduate Studies. A research grant from the National Science Foundation (G 19458) to Dr. C. W. Hibbard provided the services of Margaret Skeels Stevens and Janet A. Walerstein, artists, and defrayed the costs of field work in 1963. Members of the field party were William Melton, Kenneth Campbell, Michael Clark, Clifford Prentice, and Richard Zakrzewski. A Lotta B. Backus predoctoral fellowship, University of Michigan, also is deeply appreciated.

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LOCATION AND GENERAL DESCRIPTION OF AREA

Outcrops of the "McPherson *Equus* beds" are located in the northwest corner of McPherson County, Kansas, and in neighboring southeastern Ellsworth County, Kansas. The area investigated for this report is confined to portions of Marquette Township (T.17S., R.5W.), South Sharps Creek Township (T.18S., R.5W.), Union Township (T. 17S., R.4W.), Harper Township (T.18S., R.4W.) and New Gottland Township (T.18S., R.3W.)

in northwestern McPherson County, Kansas. The city of Marquette lies in the center of the area. Highway access is illustrated on Map I.

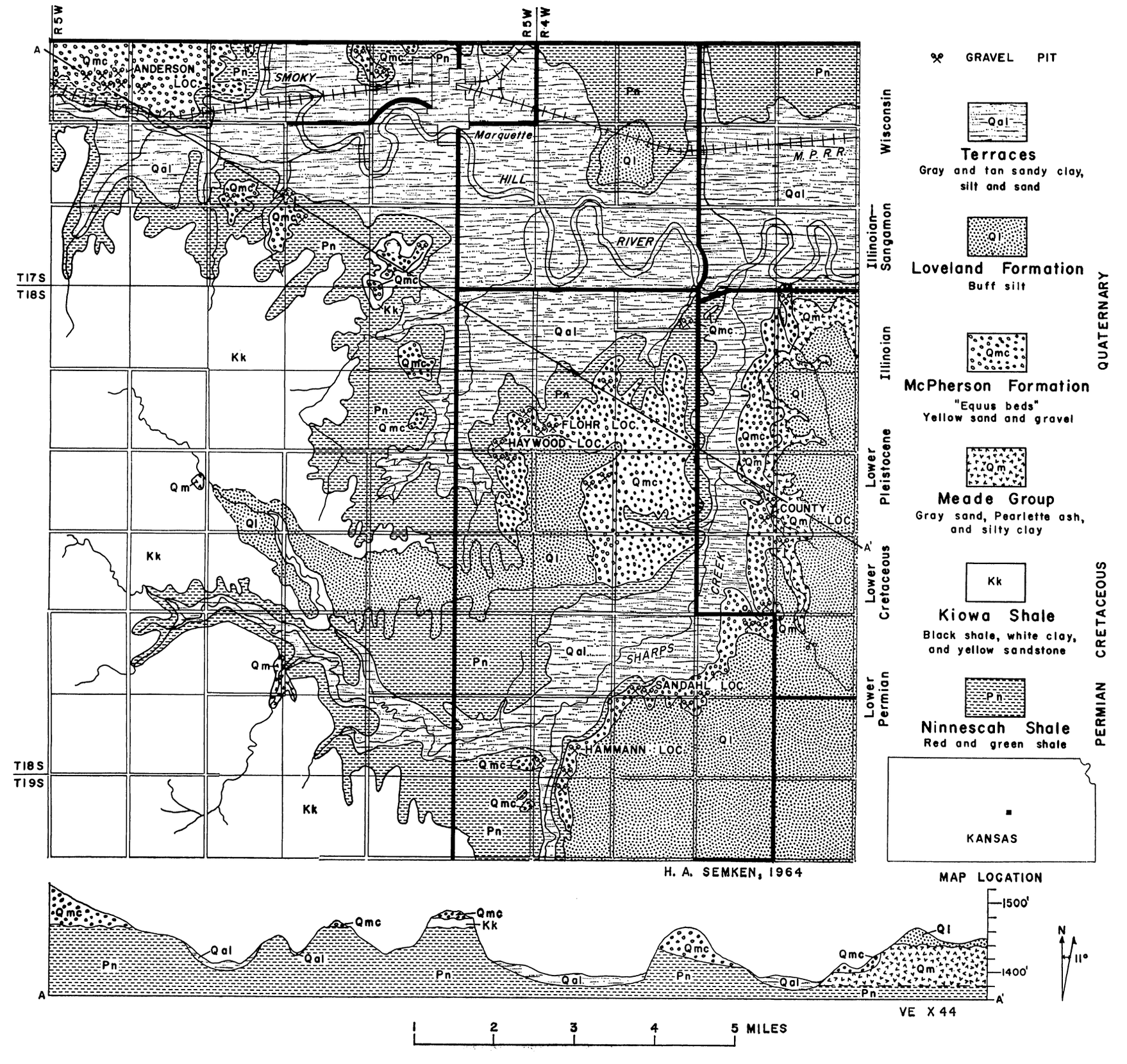
The study area is in the extreme northwestern portion of the Osage plains that has undergone dissection by the Smoky Hill River, which loops through northwestern McPherson County before flowing north to join the Kansas River. The breaks above the Smoky Hill valley and its tributary Sharps Creek provide the exposures utilized in this study. Topographic relief in the area is approximately 150 feet. The topography is relatively flat south of the Smoky Hill valley breaks, but rises approximately 30 feet in elevation toward a topographic high (McPherson ridge) in the vicinity of McPherson. McPherson ridge is the divide between the present Smoky Hill and Arkansas River drainage systems.

HISTORY OF THE *Equus* BEDS

Equus *beds of North America.*—Prior to 1877 the geologic column of North America essentially was cut off at the top of the Pliocene section. Any superimposed units were informally referred to as the Post-Pliocene, the surficial formation, or rarely to the Quaternary.

In 1877, O. C. Marsh wrote on the succession of vertebrate life in America and formally named a number of biostratigraphic units, e.g. *Coryphodon* beds, for rock units characterized by a predominant fossil. Marsh (1877, p. 26) did not break the Pliocene or the Post-Pliocene into smaller units because he thought that the Pliocene consisted of an essentially continuous series of deposits in which "the upper beds may be distinguished from lower by the presence of a true *Equus*." Marsh added that *Equus* continued into Post-Pliocene deposits but he, like Cope (1874) did not consider *Equus* a major element of the Quaternary fauna. While Marsh (1877) did not officially sanction or use the term "*Equus* beds" for his "upper Pliocene beds," most subsequent authors referred any deposits with a quantity of fossil *Equus* to the *Equus* beds. Thus, by 1879, the name evolved into a biostratigraphic term for any lithic unit containing *Equus*, the consensus being that the *Equus* beds were upper Pliocene in age.

Cope (1879), enticed by the discovery of ancient man in Europe, correlated North American and European vertebrate horizons, looked at later Tertiary deposits with a more critical eye, and compared the late Tertiary fauna of eastern and western North America. He noted that the fauna of "the Pliocene formations" of the west had fewer species and was different in many respects from the fauna of eastern deposits. However, both the western *Equus* beds and the late Tertiary eastern fauna correlated best with the same Pliocene deposits of Europe and South America



GEOLOGIC MAP AND SECTION OF NORTHWESTERN MCPHERSON COUNTY, KANSAS

(Pampean). Cope (1879, p. 48) formally named the eastern fauna, primarily derived from cavern deposits, the *Megalonyx* beds after the giant ground sloth. The *Megalonyx* beds, *Equus* beds, and Pampean deposits were enough alike, Cope noted, that the differences might be geographic rather than stratigraphic.

During the 1880's, Cope (1883, 1884, 1889*a, c*), Marsh (1886), and Shufeldt (1892) published on the *Equus* beds but did not substantially alter either the concept or the age of the deposits. While G. K. Gilbert was working in the Lake Lahontan area, he found remains of *Equus,* an ox, and a llama. Marsh identified these as being from the *Equus* beds and correlative with classic Fossil Lake deposits of Oregon. Gilbert (1890, p. 393–402) pointed out that the fossils were collected from a beach deposit which was cut into a mountain moraine. Therefore, the *Equus* beds definitely were Pleistocene rather than Pliocene. Besides, the characteristic species of the *Equus* beds, as stated by Marsh (1886), continued into Post-Pliocene time and were of no value as an indicator of time.

J. A. Udden (1891) investigated old stream deposits in McPherson County, Kansas, and noted the occurrence of *Megalonyx* sp. and *Equus major* in the same deposit. This proved Cope's idea that the *Equus* beds and *Megalonyx* beds were contemporaneous, at least in part.

Cope (1895) reviewed the *Equus* beds in relation to the antiquity of man and came to the conclusion that there was considerable probability that man was a contemporary of the *Equus* fauna. He added, however, that biologically the European Pleistocene fauna was even more modern than the North American fauna.

In 1893, after studying fossils from the Llano Estacado, Cope redefined the *Equus* beds on the presence of *Elephas* (= *Mammuthus*) *primigenius* and on the absence of *Mastodon* (= *Mammut*) from the Texas localities. Apparently, Cope was attempting to narrow down the *Equus* beds to an interval smaller than the full stratigraphic range of *Equus*.

E. J. Dumble (1894) studied the Cenozoic deposits of Texas and recognized the *Equus* beds, established by *Elephas* and *Equus* remains, as lying unconformably upon Pliocene and Blanco beds. Describing the *Equus* beds as channel fillings, Dumble demonstrated that the *Equus* beds were not conformable with all Pliocene deposits as Marsh (1886) had observed.

Scott (1897, p. 532) named the Sheridan stage as the surface formation of fine, calcareous, sandy clay that lies unconformably on older strata over the Great Plains. He equated this unit with the *Equus* beds. Matthew (1899) classified the Tertiary of the west and considered the Sheridan as a lithic division and the *Equus* beds as an equivalent faunal division. However, by 1902, Matthew was using "Sheridan or *Equus* beds" together.

Henry F. Osborn (1909) listed the *Equus zone* (italics mine) as lower Pleistocene and included the Sheridan, Hay Springs, and Rock Creek beds within the faunal unit.

The first person to devote a large portion of his time to the Pleistocene was O. P. Hay (1924) who briefly summed up the problem of the *Equus* beds and because of the confusion, ambiguity, and multiple meaning of "*Equus* beds" said that the term should be abolished. In general, this suggestion has been followed.

From the above discussion, the definition of *Equus* beds would be any deposit, regardless of origin, which contained fossils of the genus *Equus*. *Equus*, in a strict sense, is recorded first in Kansan age deposits of the High Plains (Hibbard, 1958*b*). If the classification of Simpson (1945) is followed, where *Plesippus* is considered a subgenus of *Equus* rather than a genus, the *Equus* beds would be essentially synonymous with the Pleistocene but would include all Blancan deposits. Since *Plesippus* was separated from *Equus* by Matthew in 1924, the early concept of the *Equus* beds doubtless included some plesippine horses. Thus, the *Equus* beds may include upper Pliocene units.

McPherson Equus *beds*.—Professor J. A. Udden (1891) published a geologic summary of the McPherson *Equus* beds after a skull of a giant ground sloth from these deposits was brought to his attention in 1887. Cope (1889*b*) figured the skull and identified it as *Megalonyx*. The sloth skull was fully described by Josua Lindahl (1891) and named *Megalonyx leidyi*. Lindahl did not give a geologic age for the specimen but included a letter from Professor Udden which described the deposits as in "old river bed" cut prior to Pleistocene deposition.

Udden (1891) published a more detailed account of the "*Megalonyx* beds" from McPherson County and noted that the area offered proof that the *Equus* and *Megalonyx* beds were, to some extent, contemporaneous because *Megalonyx* and *Equus* were found associated there. The McPherson *Megalonyx* beds were described as deposits in a troughlike depression several miles wide, extending south from Salina to approximately 15 miles south of McPherson, connecting the Saline River of the Kansas River drainage with the Arkansas River drainage. Udden noted several large boulders of Cretaceous clay in the vicinity of McPherson that did not occur naturally within 30 miles. He deduced that they must have been deposited by floating ice from northern glaciers drifting down the dammed Kansas River, through the McPherson Channel, to the Arkansas River.

In 1894 S. Z. Sharp enlarged on Udden's idea and added that large quartzite boulders on Battle Hill in McPherson County were not common

to the area and must have been ice-rafted across a lake. According to Sharp, the lake was caused by glacial ice damming the Kansas River which raised the water level, leaving McPherson Channel the lowest outlet for the lake.

Erasmus Haworth and J. W. Beede (1897) reviewed the situation and came to the conclusion that the quartzite of Sharp (1894) was a cross-bedded Dakota sandstone remnant common to the area. In addition, the boulders were 500 feet higher than the terminal moraine, so the lake could not have been high enough to ice-raft the boulders to that level. Haworth and Beede (1897) agreed with Udden (1891) that the deposits were fluvial, but they could not resolve the problem of the deposits making up McPherson Ridge. McPherson Ridge, the divide between the Smoky Hill and Arkansas Rivers, lies some 200 to 300 feet above the present level of the Smoky Hill River. If the *Equus* bed deposits were fluvial, then the stream must have been flowing 200 to 300 feet above the present course. However, they could not find evidence of a stream at this level either up or down stream and admitted that they could not offer a satisfactory explanation for the beds.

No work was published on the area between 1900 and 1939 except for references to individual fossils or general geologic maps of the state, although R. C. Moore (1920) mapped the McPherson *Equus* beds as the McPherson Formation.

An investigation of ground water for the city of Wichita led to a more thorough study of local channel deposits. J. C. Frye (1939) identified the upper 110 feet of McPherson Ridge as loess and added that this placed the top of the fluvial *Equus* beds at a level compatible with up-stream terraces.

Lohman and Frye (1940) enlarged on the geology of the McPherson *Equus* beds and recognized three distinct units. The basal part of the McPherson *Equus* beds was removed on lithologic and paleontologic criteria and named the Emma Creek formation, distinguished by a Pliocene fauna; the presence of reworked Permian and Cretaceous rock fragments of quartz, chert, shale, and Dakota sandstone; and on the absence of igneous rock fragments. The second unit removed from the McPherson *Equus* beds included all deposits of eolian origin that covered both the Emma Creek and Pleistocene channel deposits. The loess, with a basal layer of volcanic ash, was considered correlative of the Loveland loess. The name McPherson Formation (restricted) was retained for fluvial deposits of glacial outwash. Lithologically, the McPherson Formation was distinguished from the Emma Creek Formation by the presence of feldspar grains, igneous rock fragments, and red quartzite. The associated fauna was Pleistocene in age.

Lohman and Frye (1940) pictured the McPherson trough as forming

in Pliocene time by solution and collapse of underlying Permian salt beds. This trough then filled with small stream and lake deposits of the Emma Creek Formation. With the advent of the Kansan ice advance, the Kansas River was blocked with ice and the "McPherson Valley" formed the lowest outlet for meltage. When the ice retreated, the Kansas River recaptured the Smoky Hill River and "McPherson Valley" was abandoned. Loess then blanketed the area.

Frye and Hibbard (1941), Frye, Leonard, and Hibbard (1943), and Hibbard (1943) enlarged on and debated the lithology and paleontology of deposits up the Smoky Hill valley (Rezabek local fauna) that were correlated with McPherson deposits.

C. C. Williams and S. W. Lohman (1949) investigated the ground water resources of south-central Kansas and placed special emphasis on the McPherson Formation because of its vast water supply. A detailed investigation of the Emma Creek Formation revealed that some Emma Creek sediments were above the volcanic ash, not below as originally described; that some Emma Creek sediments (channel phase) can be traced physically and paleontologically into the McPherson Formation (restricted); and that recently discovered fossil vertebrates from the type locality of the Emma Creek Formation were Pleistocene, not Pliocene, in age. A lithologically distinct portion of the Emma Creek Formation on the northeast side of McPherson Valley was found to be Pliocene in age and was named the Delmore Formation. All other Emma Creek sediments were returned to the McPherson Formation. The Delmore differs from the McPherson Formation in having a much finer grain size, gray color, and a lower percentage of igneous and metamorphic rock fragments.

Williams and Lohman (1949) also noted fluvial cross-bedding in the "loess" of Lohman and Frye (1940) and returned these deposits, except for a thin layer of loess on McPherson Ridge, to the McPherson Formation. Fluvial deposits of the McPherson Formation (restricted) were found to be entrenched into the ash and therefore younger, and not older, than the loess as defined by Lohman and Frye (1940).

FIELD WORK

No additional work was done in this area until Clayton Griggs discovered a *Mylohyus* palate in one of the gravel pits. Dr. C. W. Hibbard investigated this find in 1962 and discovered a snail and microvertebrate horizon in the *Equus* bed deposits. Subsequent collecting by the washing technique (Hibbard, 1949*a*) the following summer resulted in the collection of the Sandahl local fauna and other local faunules of the Sandahl

local fauna described in the systematic portion of this paper. Field mapping was completed in the summer of 1964 with the aid of U. S. Department of Agriculture air photographs.

STRATIGRAPHY

Late Cenozoic deposits in northwestern McPherson County lie in a collapse structure known as McPherson Valley and in paleotopographic lows cut by streams. At the present time, the Smoky Hill River is dissecting the northwest corner of the buried McPherson Valley and exposing pre-Tertiary bedrock, McPherson Valley deposits, and superimposed fluvial and eolian sediments. Although slope wash and vegetation obscure the beds and contacts over most of the area, numerous gravel, ash, and silt pits, as well as limited natural exposures, provide enough stratigraphic control for interpretation of regional stratigraphy.

Pre-Pleistocene stratigraphy was thoroughly reviewed and discussed by Williams and Lohman (1949), so these units are only briefly described for field identification and convenience in interpreting the geologic map of the area (Map I).

Pre-Tertiary

Lower Permian

Wellington Formation.—This calcareous gray and blue-gray shale does not crop out in the mapped area but is exposed along the Smoky Hill River approximately 4 miles to the east. The Wellington dips approximately 3 degrees to the west and is only known from the subsurface of the mapped area.

Ninnescah Shale.—The variegated brick-red, gray, and green Ninnescah Shale, which conformably overlies the Wellington Formation, is readily identified by its "red-bed" nature. A typical exposure can be located in the NW¼ NW¼ sec. 4, T.18S., R.4W. at the junction of county roads 1064 and 1065. This is the major bedrock unit in the area studied.

Lower Cretaceous

Kiowa Shale.—Marine and non-marine sandstones and shales of the Kiowa rest unconformably on Permian rocks in northwestern McPherson County. Kiowa Shale members in the area are predominantly black and white fissile shales or semiconsolidated to consolidated sandstones. Imposing caprock ledges and erosional remnants in the area are supported by Kiowa sandstones. Typical Kiowa Shale can be examined in a road cut in

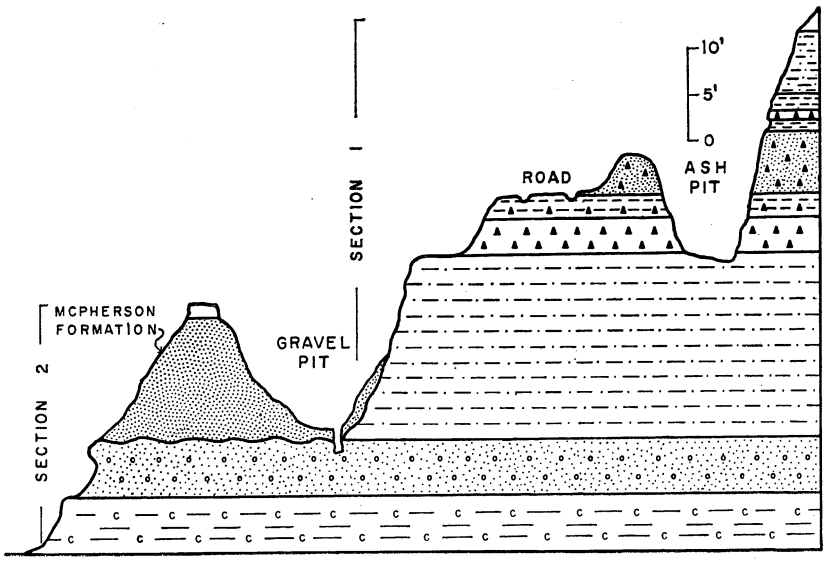


FIG. 1. Composite stratigraphic column showing Meade Group with entrenched McPherson Formation.

the SW¼ SE¼ sec. 9, T.17S., R.5W. Interbedded Kiowa sandstone is readily accessible on erosional remnants in the W½ of sec. 33, T.17S., R.5W.

Tertiary

Pliocene

Delmore Formation.—The Delmore Formation was named by Williams and Lohman in 1949 to include deposits of calcareous, gray to buff clay, silt, fine-to-coarse-grained dominantly quartz sand with some gravel. The Delmore Formation is distinguished from Pleistocene units in the area by a light gray color, generally finer grain size, and a much lower percentage of igneous rock fragments. Fossils from the Delmore Formation, including *Amebelodon, Tetralophodon* (= ?*Amebelodon*), *Neohipparion, Nannippus, Pliohippus,* and *Teleoceras* establish Pliocene age for these deposits (Hibbard, 1952).

Quaternary

Meade Group

Meade Group (undifferentiated).—The Meade Group was defined by Hibbard (1958*a*) to include all Pleistocene deposits above the base of the David City Formation (Nebraskan) up to the base of the Crete Formation

(Illinoian). In southwestern Kansas this includes the Pearlette Ash Member of the Crooked Creek Formation and the older Ballard Formation. Presence of the Pearlette Ash Member in northwestern McPherson County is the basis for correlation of the rocks in measured sections 1 and 2 with other Meade Group deposits in central and southwestern Kansas.

MEASURED SECTION 1: Section measured across the road from Measured Section 2 in an ash pit in the NW¼ SW¼ sec. 15, T.18S., R.4W.

Unit	*Feet*
Top Soil	2.7
Meade Group–undifferentiated	
8. Clayey silt, buff, crumbles into small irregular blocks when dry, one-foot band of nodular caliche disseminated at base	7.0
7. Reworked ash and silty sand, buff with bands of red-brown clay partings, bands of caliche nodules	1.8
6. Reworked ash with some silt	0.6
5. Clayey silt, red brown, concave weathered surface, slightly adhesive when wet, band of nodular caliche at top and bottom	0.9
4. Silty ash, white to tan, erodes into rounded columns with vertical entrenched streamlets, caliche nodule bands spaced 1–3 feet apart, blocky fracture	7.7
3. Reworked ash blocks and silty ash, white and tan	2.6
2. Pearlette ash, pure, white	3.2
1. Silty clay, dark brown, homogeneous, tough, blocky fracture	19.5
Total	46.0

Other than the Pearlette volcanic ash (a widespread, distinct, late Kansan ash that was deposited over much of the High Plains surface) there is not enough lithologic continuity to identify deposits above and below the ash as either Crooked Creek Formation or Grand Island-Sappa Members. However, the type section of the Crooked Creek Formation (Hibbard, 1949*b*), Grand Island-Sappa Members (Frye and Leonard, 1952), and McPherson County Meade Group deposits share (1) a basal sand and gravel that grades up into a silt, (2) the Pearlette ash, and (3) post-Pearlette deposits of reworked ash, silt, and clay with caliche nodules. Sediments of the Meade Group are the primary deposits that fill the buried McPherson Valley to the east of the study area.

The geologic relationship of the Meade Group to the overlying McPherson Formation of the Sanborn Group and the composite of measured sections 1 and 2 is illustrated in Figure 1. A left maxillary, lacking M^3 (KUMNH 6878), of *Equus scotti* was recovered from unit 2 of measured section 2.

MEASURED SECTION 2: Section measured on the east bank of a tributary to Sharps Creek in the NE¼ SE¼ sec. 14, T.18S., R.4W. A quantity of the McPherson Formation has been removed for road construction.

Unit	*Feet*
Topsoil	1.8
Sanborn Group–McPherson Formation	
3. Gravely sand, yellow, particles predominantly quartz with feldspar and igneous rock fragments, limonitic	13.1
Unconformity	
Meade Group–undifferentiated (units 1 and 2)	
2. Pebbly sand, white-gray, few igneous rock fragments, local calcareous cementation into ledge-forming sandstone	6.3
Unconformity	
1. Silty clay, mottled light gray and buff, disseminated stringers and nodules of caliche, tough when dry with polygonal mud cracks, sticky and dark when wet	5.9
Total	27.1

A small sand pit in the SW¼ SW¼ section 20, T.18S., R.4W., contains deposits of a fairly well-sorted sand with sheets of primary caliche in the planes of cross-bedding. Farther west, beyond the mapped area, thick units of caliche in gray-buff silts and clays are common. These deposits, which also contain ash, are considered units of the Meade Group.

Sanborn Group

The Sanborn Group was named by C. W. Hibbard in 1952 to include the Kingsdown and Vanhem formations of southwestern Kansas, and deposits of the central Kansas Sanborn Formation of Frye and Fent in 1947 (Hibbard, 1958*a*, p. 55). The Sanborn Group includes deposits of Illinoian, Sangamon, and Wisconsin ages (Frye and Leonard, 1952).

McPherson Formation (redefined).—The McPherson Formation was originally described by Haworth and Beede (1897) as the McPherson *Equus* beds. R. C. Moore (1920, p. 93) cited and mapped the deposits described by Haworth and Beede (1897) as the McPherson Formation. Until restricted by Lohman and Frye (1940) this included all unconsolidated deposits in the area. Numerous lithologic differences and the presence of fossils that ranged from middle Pliocene (Hemphillian) to Wisconsin in age prompted many revisions during the next ten years. Williams and Lohman (1949, p. 59) summed up these reports, as discussed earlier in this

paper, and defined the McPherson Formation to include "all the unconsolidated stream and slope deposits of Pleistocene age which occur in this area." They recognized "upper" and "lower" units in the McPherson Formation but did not name them. Their "lower" McPherson Formation, which contains Pearlette ash, properly belongs with the Meade Group and is placed there in this report.

Units of the Sanborn Group rest unconformably on or are entrenched in Meade Group deposits (Figure 1). Sanborn Group deposits consist of a lower sand and gravel overlain by a buff, calcareous, loess-like silt. The lower Sanborn sand and gravel unit, which contains reworked Permian, Cretaceous, and Pliocene, is the deposit which has produced the quantity of fossil vertebrates, including *Equus,* from McPherson County. These are the beds to which the term "McPherson *Equus* beds" should be applied. Fossils of any kind are rare from underlying and overlying Pleistocene units. Therefore, the term McPherson Formation is restricted here to serve as a local term for post-Meade Group sand and gravel containing abundant fragments of fossil vertebrates. Sand and pebble constituents are made up of quartz, chert, limestone, pink and white feldspar, basic igneous rock, caliche, and reworked particles and fossils identifiable as Permian and Cretaceous. The sands usually have a yellow hue. Lenses of white and blue clay and boulder beds of reworked Permian are locally common. The term Crete Formation has been applied to these deposits by Frye and Leonard (1952) on the basis of their stratigraphic position. The Crete Formation was proposed by Condra, Reed, and Gordon (1947) for channel fill deposits in Nebraska which rest unconformably on the Upland (Sappa) or older Pleistocene deposits. While deposits of the McPherson Formation fit the stratigraphic and broad lithologic criteria of the Crete, so do all Illinoian and many Wisconsin sand and gravel deposits. As yet, these terrace deposits have not been physically correlated. For this reason, the McPherson Formation is retained to facilitate discussion of local sand and gravel between the Meade Group and Loveland Formation in McPherson and Ellsworth counties.

The following measured section, measured section 3, was taken in the northwest corner of the Sandahl gravel pit, SE¼ SW¼ sec. 29, T.18S., R.4W., and is designated the type section of the McPherson Formation as defined in this report. The Flohr pit, NE¼ SW¼ sec. 7, T.18S., R.4W., and Hammann pit, NE¼ SW¼ sec. 31, T.18S., R.4W., are considered reference localities to the McPherson Formation. The Sandahl local fauna, Illinoian in age, was taken from unit 3 of measured section 3.

MEASURED SECTION 3: Section measured in the northwest corner of the Sandahl gravel pit, SE¼, SW¼, sec. 29, T.18S., R.4W. Type locality of the McPherson Formation as defined in this paper.

Unit	*Feet*
Topsoil	3.9
Sanborn Group	
Loveland Formation	
8. Loess-like silt with disseminated caliche nodules, blocky fracture, tubules, no shells	1.7
McPherson Formation	
7. Clay, dark brown, concoidal fracture	0.4
6. Sand, fine to coarse, soft, friable, shells and bone	0.5
5. Clayey sand, fine, some reworked caliche, rectilinear fracture, shells common	1.9
4. Sandstone, sporadic induration, coarse	0.4
3. Sand, medium to coarse, shells and bone (Sandahl local fauna), clay lens at base	0.6
2. Gravelly sand, fine to coarse, cross-bedded, particles of quartz, chert, limestone, caliche, pink and white feldspar, volcanics, basic igneous rock and bone fragments; lenses of blue clay up to 3 feet thick; boulders of reworked Ninnescah at base	34.3
1. Ninnescah Shale (Permian)	1.0
Total	44.7

The top of the McPherson Formation is conformable with overlying silts of the Loveland Formation.

Loveland Formation.—South of Sharps Creek, a buff, fairly homogeneous "loess-like" silt with bands of caliche conformably overlies the McPherson Formation and supports the tableland topography in this area. Much of this unit was described by Frye (1939) as loess; however, fluvial cross-bedding is present in several sections. A large quantity of reworked loess is present in the unit.

Following the classification of Hibbard (1958*a*), all pre-Wisconsin, post-Yarmouth, loess and silt is included in the Loveland Formation. As this unit is lithologically similar to deposits described as Loveland in other areas, the term is retained in northwestern McPherson County.

Wisconsin terraces.—Alluvium of clay, silt, sand, and gravel forms the fertile bottom land of the entrenched Smoky Hill River. At least 3 terraces can be observed in this unit. Wisconsin age is established on stratigraphic position and on the remains of *Bison bison* observed in alluvium along the streams.

Fossil Localities and Faunas

Vertebrate and invertebrate fossils have been collected from numerous localities in northwestern McPherson County. In years past most of these were attributed to the McPherson *Equus* beds with little or no additional data. H. H. Nininger (1928) discussed the specimens located in the McPherson College Museum and H. J. Harnly (1934) supplemented the work of Nininger by listing additional fossils collected in the Hammann gravel pit. These specimens and additional Pliocene and Pleistocene fossils were reviewed by Hibbard (1952). In 1952, Hibbard also named and discussed the Kentuck assemblage from a locality approximately 7 miles east of the area under investigation. The Kentuck assemblage was recovered from channel sediments that are entrenched into deposits of the Meade Group. Rocks of the Meade Group are readily identified by the presence of thick deposits of Pearlette ash about 100 yards west of the Kentuck locality. Channel deposits of the Kentuck locality are topographically lower than the ash, contain an unusual combination of fossils, and are not lithologically related to the McPherson Formation. The presence of warm and cool indicator species and a combination of primitive and advanced species led C. W. Hibbard (1952) to designate the fossil accumulation an assemblage rather than a local fauna. This assemblage is reviewed here in relation to the new Sandahl local fauna of the McPherson *Equus* beds.

The assemblage was collected from the bank of a road cut on the east side of a section line road in the NW¼ sec. 13, T.18S., R.4W., McPherson County, Kansas. E. C. Galbreath (1964 personal communication) called attention to his incorrect locality listing (Galbreath, 1955).

The Sandahl local fauna consists of a number of local faunules that were collected from the McPherson Formation as defined in this paper. The local faunules were given the name of the present owner of the property because geographic names are too scarce to facilitate accurate reference to the locality. Established as contemporaneous on stratigraphic and paleontological data, local faunules of the McPherson Formation are collectively designated the Sandahl local fauna. Pliocene deposits were not identified in the mapped area.

Localities

Anderson gravel pit—SW¼ NE¼ sec. 19, T.17S., R.5W., property of J. E. Anderson.
County gravel pit—NW¼ SE¼ sec. 16, T.18S., R.4W., leased by McPherson County.
Flohr gravel pit—NE¼ SW¼ sec. 7, T.18S., R.4W., property of Miss Frances Flohr.
Hammann gravel pit—NW¼ SE¼ sec. 31, T.18S., R.4W., property of L. W. Hammann, leased by John and Leland Akers.
Haywood gravel pit—SE¼ SW¼ sec. 12, T.18S., R.5W., property of Rufus Haywood.
Sandahl gravel pit—SE¼ SW¼ sec. 29, T.18S., R.4W., property of Sandahl and Sons' Dairy.

The following abbreviations are used when referring to collections: AMNH, American Museum of Natural History; BCM, Bethany College Museum; KUMNH, Kansas University Museum of Natural History; MCM, McPherson College Museum; TMM, Texas Memorial Museum; UMMP, University of Michigan Museum of Paleontology; UMMZ, University of Michigan Museum of Zoology.

SYSTEMATIC PALEONTOLOGY

Mollusca

Fresh water mollusks are being studied by Barry B. Miller of Kent State University, Kent, Ohio.

Vertebrata

Class Osteichthyes

Fishes of the Sandahl local fauna and the Kentuck assemblage have not been fully studied, but numerous fossil specimens were recovered.

Family Lepisosteidae

Genus *Lepisosteus*

Lepisosteus sp.

Geologic range.—Cretaceous to Recent.

Habitat.—Quiet streams and lakes from Guatemala north to the Great Lakes.

Material.—Sandahl locality: UMMP 50456, isolated scales.

Remarks.—Gar scales recovered from the Sandahl locality are not sculptured, so they may represent any of the smooth-scaled gars or an immature alligator gar.

Family Ictaluridae

Genus *Ictalurus*

Ictalurus sp.

Geologic range.—Miocene to Recent.

Habitat.—Catfishes and bullheads occupy most drainage and lake systems in North America.

Material.—Sandahl locality: UMMP 50457, pectoral spines.

Remarks.—Pectoral spines from the Sandahl may represent 2 species.

Family Percidae
Genus *Stizostedion*
Stizostedion vitreum (Mitchill)

Geologic range.—Illinoian to Recent.

Habitat.—The walleye is common in lakes and streams between the Appalachians and Nebraska from northern Alabama to the Great Slave Lake in Canada. It is found only north and east of McPherson County today.

Material.—Flohr locality: UMMP 50483, parasphenoid.

Remarks.—This specimen was identified by Ted Cavender, University of Michigan Museum of Zoology. This constitutes a chronologic and geographic range extension for the species.

Genus *Perca*
Perca flavescens (Mitchill)
(Figure 3K)

Geologic range.—Illinoian to Recent.

Habitat.—Usually in clear cold lakes and ponds from northern Missouri, Iowa, Illinois, and Ohio north to the Mackenzie and Hudson Bay drainages. South to South Carolina on the Atlantic slope (Smith, 1963).

Material.—Sandahl locality: UMMP 50455, right opercle. Donated by Clayton Griggs.

Remarks.—This specimen was identified by Gerald R. Smith. The Recent yellow perch is now restricted well to the north of McPherson County on the plains.

Class Amphibia

Numerous frog and salamander remains from the Sandahl fauna and the Kentuck assemblage have not been studied.

Class Reptilia

Snake vertebrae are common in the Sandahl fauna and Kentuck assemblage but other remains of fossil reptiles are rare.

Family Trionychidae
Genus *Trionyx*
Trionyx sp.

Geologic range.—Kansan to Recent.

Habitat.—Softshell turtles are powerful swimmers, completely aquatic, and, except for the Florida softshell, mainly inhabit streams. Both species of *Trionyx* are found in McPherson County at present.

Material.—Anderson locality: UMMP 50919, hypoplastron fragment. Donated by Clayton Griggs.

Remarks.—These turtles imply a continuous supply of water.

Family Emydidae
Genus ? *Pseudemys*

Geologic range.—Pliocene to Recent.

Habitat.—Abundant in ponds and streams. The genus is present in McPherson County today.

Material.—Flohr locality: UMMP 50945, left hypoplastron.
Hammann locality: UMMP 50946, right hypoplastron fragment.

Remarks.—The specimens favorably compare with a large *Pseudemys*. Neither element is arched as in observed specimens of *Chrysemys*.

Class Aves

Fossil birds from the Kentuck assemblage were identified by E. C. Galbreath (1955), who listed the following species:

Family Anatidae

Anas carolinensis Gmelin, green-winged teal
Lophodytes cucullatus (Linnaeus), hooded merganser

Family Scolopacidae

Bartramia longicauda (Bechstein), upland plover
Numenius borealis (Forster), Eskimo curlew

Family Icteridae
Euphagus cyanocephalus (Wagler), Brewer's blackbird

All of the above species presently inhabit the High Plains and do not show any changes in the avifauna.

A few bird bones recovered from the Sandahl fauna have not been identified.

Class MAMMALIA
Order INSECTIVORA
Family Soricidae
Genus *Sorex*
Sorex cf. cinereus Kerr

Geologic range.—Kansan to Recent.

Habitat.—The genus *Sorex* does not occur in Kansas today. *Sorex cinereus* ranges south into central Nebraska from the north and east. Another species, *S. longirostris* Bachman, the southeastern shrew, extends westward across northern Arkansas from the east. Almost all species of *Sorex* are found in a variety of habitats but usually prefer moist situations in either woods, marshes, or open areas.

Material.—Sandahl locality: UMMP 50387, fragment of the left mandible with the talonid basin and posterior portion of the protoconid and entoconid of M_1 present.

Kentuck assemblage: KUMNH 7344, fragmentary mandible without teeth. Species not implied.

Remarks.—This fragmentary specimen of *Sorex* is sufficient to separate it from other genera on morphology and size, but is not complete enough for positive specific identification. The ramus is much too delicate for *S. arcticus* Kerr or *S. palustris* Richardson, but it compares favorably with *S. cinereus*. Long-tailed shrews are not present in Kansas today but are common in late Pleistocene deposits of the state.

Genus *Blarina*
Blarina sp.

Geologic range.—Upper Pliocene to Recent.

Habitat.—Short-tailed shrews inhabit forests, grasslands, marshes, and brushy areas of the eastern United States.

Material.—Kentuck assemblage: UMMP 51248, left lower incisor and fragment of mandible.

Remarks.—This tooth is assigned to *Blarina* on the basis of its large and massive size. *Blarina* is the largest North American shrew.

Order EDENTATA
Family Megalonychidae
Genus *Megalonyx*
Megalonyx leidyi Lindahl

Geologic range.—Illinoian, McPherson *Equus* beds.

Habitat.—The genus *Megalonyx* usually is considered to have been a forest dweller because of its past abundance in forested regions of the Pacific slope and eastern North America.

Material.—Hammann locality: BCM, no number, holotype, a nearly complete skull without mandible. UMMP 51146, cast of the holotype.

Remarks.—*Megalonyx leidyi* was described by Josua Lindahl in 1891 and formed the basis of Udden's (1891) correlation of the *Megalonyx* and *Equus* beds.

Museum labels in Bethany College indicate that this specimen was recovered from a gravel pit in the southwest corner of Harper Township. Presently, there are 4 gravel pits (Map I) in section 31, one in section 29, and one pit in section 6 T. 19S., R.4 W., that may have produced this specimen. All of these pits are south of Sharps Creek and are in stratigraphically equivalent deposits. The Sandahl locality (section 29) was not dug early enough, according to local inhabitants, to be the source of the specimen. Hibbard (1952) reviewed the literature and also examined the above pits, and concluded that the most likely locality is the old Hammann gravel pit, NW¼ SW¼ sec. 31 (T. 18S., R.4 W.), which is north of the old cemetery. He based his conclusion in part on the presence of a snail-clay horizon immediately above the sand and gravel, recorded by Udden in Lindahl (1891) and Udden (1891). Udden (1891, p. 342) states that the *Megalonyx* was taken from the bottom of the gravel and the mollusks were from the top of the sand. If this applies to a specific pit, then the locality cited by Hibbard (1952) is the only possible locality. If Udden intended his description to be general for the area, then the skull may have come from any of the old southwest Harper Township localities.

Megalonyx leidyi is being reviewed presently by Jay Lillegraven at the University of Kansas (W. A. Clemens, personal communication, 1964).

Megalonyx sp.

Geologic range.—Upper Pliocene to Wisconsin.

Material.—County pit locality: UMMP 50930, a terminal phalange.

Remarks.—The phalange is 51.5 mm deep at the posterior portion of

the subungual base and 19.1 mm wide across the base at this point. A terminal phalange, BCM 4088, is referable to this genus.

Family Mylodontidae
Paramylodon cf. *harlani* (Owen)

Geologic range.—Kansan to Wisconsin.

Habitat.—Stock (1925) suggested that *Mylodon* and related genera were inhabitants of open country, pampas, or steppes because of their association with open country forms in many fossil localities.

Material.—Hammann gravel pit: MCM 50, caudal vertebra.

Remarks.—This specimen was identified by Stock in Nininger (1928) and was listed by Hibbard (1952). A large, rounded ungula, BCM 4202, may belong to this genus.

Order RODENTIA
Family Sciuridae
Genus *Cynomys*
Cynomys ludovicianus (Ord)

Geologic range.—Illinoian to Recent.

Habitat.—The blacktail prairie dog lives in colonies on flat expanses of short-grass prairie. It ranges north to southern Saskatchewan and south to northern Mexico.

Material.—Sandahl locality: UMMP 45355, a right mandible with P_4 (3.0 mm length × 4.1 mm width), M_1 (2.8 × 4.8) and M_2 (3.1 × 5.1). Length P_4–M_2 is 9.7 mm.

Flohr locality: UMMP 50466, right maxillary with M^1 (3.0 × 4.3) and M^2 (3.1 × 4.4); UMMP 50467, right mandible with M_1 (2.8 × 4.5), M_2 (2.7 × 4.8) and M_3 (4.7 × 5.0). Length M_1–M_3 is 10.6 mm.

Remarks.—The blacktail prairie dog is distinguished from other species of *Cynomys* by its larger teeth, relatively long occlusal length of P_4–M_2 in relation to M_3, and greater tooth row length and width. The above specimens fall well within the range of 46 adult specimens of *C. ludovicianus* in the UMMZ collection. Figure 2, scatter diagram of width M_1 *vs.* length P_4–M_3 is representative of the distribution found in scatter diagrams of 4 other dental combinations.

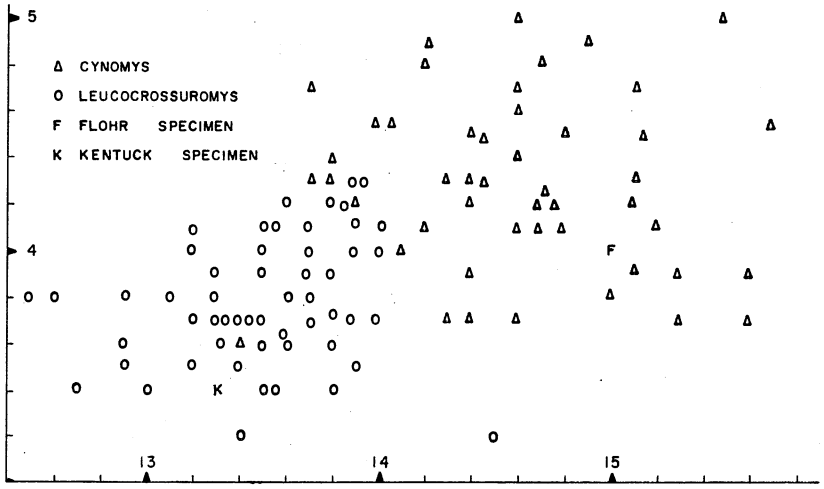


FIG. 2. Scatter diagram of lower molar series length *vs.* first lower molar width (mm.).

Cynomys cf. *gunnisoni* (Baird)

Geologic range.—Illinoian to Recent.

Habitat.—The whitetail prairie dog prefers high country and is found 5000 feet above sea level in mountain valleys and parks.

Material.—Sandahl locality: UMMP 50388, left M_3 (4.6 × 3.7).

County pit locality: UMMP 50463, left mandible with P_4 (2.9 × 3.5), M_1 (2.6 × 4.0), and M_2 (3.0 × 4.5).

Kentuck assemblage: UMMP 50494, left mandible with P_4 (2.9 × –), M_1 (2.6 × 3.9), M_2 (2.7 × 4.1) and M_3 (4.3 × 3.7), length P_4–M_3 is 13.2 mm.; UMMP 50495, right M_3 (3.9 × 3.8).

Remarks.—The whitetail prairie dog was identified on the basis of overall smaller size, smaller width to length of the molars, relatively short P_4–M_2 series in relation to length of M_3, and on the pattern of M_3.

The third lower molar of the subgenus *Cynomys* (including *C. ludovicianus* and *C. mexicanus* Merriam) can usually be distinguished from the subgenus *Leucocrossuromys* (including *C. gunnisoni, C. leucurus* Merriam, and *C. parvidens* Allen) in that the ectolophid is separated from the talonid basin by an anterior-posterior valley. In *Leucocrossuromys* a stylid on the talonid basin abuts the ectolophid and with wear joins the ectolophid, thus dividing the anteroposterior valley. This character is variable but evident in 53 out of 58 examined Recent specimens of *Leucocrossuromys*. The

anteroposterior valley was not divided in 45 out of 50 examined specimens of *C. ludovicianus*.

The two M_3's from the Kentuck assemblage exhibit a divided valley. No third lower molars are available from the County pit locality, therefore, identification is based on size and molar proportions. The Sandahl third lower molar contains the divided anteroposterior valley, is relatively narrow, and is the small size of *C. gunnisoni*.

The specimens from the *Equus* beds constitute a chronological extension to Illinoian time and a past range extension of the subgenus *Leucocrossuromys* into Kansas. Although blacktail and whitetail prairie dogs are not locally sympatric at present, regional sympatry is recorded. The presence of whitetail prairie dogs at a lower elevation than at present is evidence of a cooler climate and strengthens the assignment of the *Equus* beds to a glacial age.

Genus *Citellus*

Citellus tridecemlineatus (Mitchill)

Geologic range.—Illinoian to Recent.

Habitat.—Prairies and grasslands in wooded regions of the midwest. Thirteen-lined ground squirrels are living in McPherson County at present.

Material.—Sandahl locality: UMMP 50394, 8 isolated lower teeth; UMMP 50395, one left upper molar; UMMP 50396, right mandible without teeth.

Flohr locality: UMMP 50470, 2 lower P_4's.

Kentuck assemblage: UMMP 50497, right M^2; KUMNH 7347, in part, isolated cheek teeth.

Remarks.—The thirteen-lined ground squirrel was separated from other ground squirrels on its small size, a discontinuous metaloph on the upper molars, and a prominent sulcus between the protocone and metacone.

Citellus richardsoni (Sabine)

Geologic range.—Illinoian to Recent.

Habitat.—Moister situations in sagebrush and grasslands of the northern plains. Prefer sandy soils that are suitable for burrowing.

Material.—Sandahl locality: UMMP 50398, right ramus with P_4 (2.1 mm length × 2.4 mm width), M_1 (1.8 × 2.7) and M_2 (2.0 × 2.7), total length P_4–M_2 is 5.8 mm.; UMMP 50399, isolated teeth.

Flohr locality: UMMP 50471, left mandible without teeth.

Kentuck assemblage: UMMP 50498, isolated upper teeth; UMMP 50499, isolated lower teeth; KUMNH 7347, in part, isolated teeth.

Remarks.—Specimens from the above McPherson localities are assigned to the subgenus *Citellus* on the basis of relatively high-crowned teeth which are much broader than long, more closely spaced transverse ridges and the abrupt change of direction in which the parastyle joins the protocone. The preceding description separates the McPherson specimens from the subgenus *Poliocitellus*, including *C. franklini* (Sabine) according to Howell (1938). The specimens resemble *C. richardsoni* and several other western species. Richardson's ground squirrel is the only plains species that compares favorably with the fossils, so they are attributed to this species. Fossil ground squirrels from Doby Springs, UMMP 38648, attributed to *C. richardsoni*, compare closely with fossils from the McPherson *Equus* beds.

Family Geomyidae
Genus *Geomys*
Geomys bursarius (Shaw)

Geologic range.—Illinoian to Recent.

Habitat.—Grasslands where the substratum is friable and deep enough to permit burrowing. The plains pocket gopher, *Geomys bursarius*, is living in northwest McPherson County at the present time.

Material.—Sandahl locality: UMMP 50400, anterior portion of a skull with incisors and RP^4 (2.1 mm length × 1.9 mm width); UMMP 50401, isolated P^4's; UMMP 50402, isolated molars.

County pit locality: UMMP 50461, right ramus with P_4 (2.5 × 2.2), M_1 (1.4 × 2.6) and M_2 (1.4 × 2.4), length P_4–M_2 is 6.2 mm.

Kentuck assemblage: UMMP 50501, left ramus with P_4 (2.5 × 2.1); UMMP 50502, 13 isolated P_4's; UMMP 50503, 6 isolated P_4's; UMMP 50504–50506, isolated incisors and molars; KUMNH 7346, left mandible with P_4 (2.6 × 2.0) and M_1 (1.1 × 2.4), figured by Hibbard (1952, p. 7); KUMNH 7345, isolated dental elements.

Remarks.—Pocket gophers from the Sandahl and Kentuck localities are inseparable from *Geomys bursarius*. *G. tobinensis* (Hibbard) from the Cudahy fauna, as reported by Paulson (1961, p. 137), has a longer diastema, a deeper infraorbital canal, and there is a tendency for the premolar enamel folds to be less compressed as in *Thomomys*. These features were not observed in the pocket gopher sample from any of the above localities.

Family Heteromyidae
Genus *Perognathus*
Perognathus hispidus Baird

Geologic range.—Illinoian to Recent.

Habitat.—Open grassland with friable soils for burrowing. Absent from timbered and bushy areas. This species is living in McPherson County at present.

Material.—Flohr locality: UMMP 50473, right P^4 (1.1 mm length × 1.5 mm width) and M^2 (1.1 × 1.4).

Kentuck assemblage: KUMNH 7427, left mandible with P_4 (1.0 × 1.0), M_1 (1.1 × 1.3), M_2 (1.0 × 1.2) and M_3 (0.8 × 0.9) length P_4–M_3 is 4.1 mm, figured by Hibbard (1952); KUMNH 7363, worn lower molar (1.3 × 1.4); and KUMNH 7362, right mandible without teeth is also referred to *P. hispidus*.

Remarks.—The presence of *Perognathus hispidus* in the Flohr locality suggests that *P. hispidus* should be present in the Sandahl locality as the two localities are stratigraphic equivalents.

Perognathus sp.

Geologic range.—Miocene to Recent.

Habitat.—Adapted for areas of sparse vegetation, usually associated with soft substrata.

Material.—Sandahl locality: UMMP 50403, right mandible with P_4 (0.6 mm length × 0.7 mm width).

Remarks.—The pocket mouse mandible from the Sandahl locality is much smaller than *Perognathus hispidus* and compares in size with a large *P. flavescens* (Merriam). The diastemal region of the Sandahl specimen is much shorter and broader than in observed fossil specimens of *P. pearlettensis* Hibbard. The masseteric ridge extends up to the top of the diastema as in Recent species of *Perognathus*. As there are several modern species in the size range of the Sandahl specimen that cannot be distinguished on the morphology of the P_4, assignment of a specific name must await additional material.

Family Castoridae
Genus *Castor*
Castor canadensis Kuhl
(Figure 3A–F)

Geologic range.—Illinoian to Recent.

Habitat.—Ponds, streams, and lakes with wooded areas on the banks. In some areas, including Kansas, beavers more commonly burrow into stream banks than build twig houses. *Castor canadensis* was originally common in most Kansas waterways before the arrival of white men.

Material.—Sandahl locality: UMMP 50927, right M^3 (5.7 mm length × 6.3 mm width), collected and donated by Caroline Griggs.
County pit locality: UMMP 50929, left M^3 (6.3 × 6.4).

Remarks.—*Castor* teeth from the McPherson *Equus* beds are extremely hyposodont and have 3 external striae and one internal stria. All striae extend to the base of the tooth in the Sandahl specimen and to 5 mm of the external base in the County pit specimen. The material is indistinguishable from Recent *C. canadensis*.

Genus *Castoroides*
(Figure 3G)
Castoroides cf. *C. ohioensis* Foster

Geologic range.—Late Kansan to late Wisconsin.

Habitat.—Giant beavers have been recorded from deposits of bogs, marshes, lakes, and larger rivers from Minnesota to Texas.

Material.—Sandahl locality: UMMP 51166, enamel chip from an incisor.
Anderson locality: UMMP 50921, left astragalus.

Remarks.—The chip of enamel with large striae is a perfect match for either *Castoroides* or *Burosor effossorius* Starrett.

The astragalus from the Anderson locality has not been compared with a specimen of *Castoroides*, but it compares favorably with the astragalus of *Castor canadensis*, except for size. The specimen from the *Equus* beds measures 41.4 mm greatest anteroposterior length and has a maximum width of 38.5 mm. Identification is confirmed by almost perfect articulation of the specimen with UMMP 29009, a tibia of *Castoroides* from the Berends local fauna of Beaver County, Oklahoma. Two diagnostic facets on the proximal surface of the astragalus match similar surfaces on the tibia.

Family Cricetidae
Genus *Onychomys*
Onychomys sp.

Geologic range.—Late Pliocene to Recent.

Habitat.—Inhabit prairies and brushy areas on friable soil. Frequently live in burrows of other animals. These carnivorous mice are found in McPherson County today.

Material.—Sandahl locality: UMMP 50404, right M^1 (2.2 mm length × 1.4 mm width).

Flohr locality: UMMP 50474, right M_2 (1.5 × 1.2).

Kentuck assemblage: KUMNH 13458, left M_1 (2.0 × 1.2).

Remarks.—Measurements of 30 M^1's of *Onychomys leucogaster* (Maximilian) and *O. torridus* (Coues) indicate that the size of the Sandahl specimen is comparable to *O. leucogaster* rather than the other Recent species. Two specimens of *O. jinglebobensis* Hibbard (1955), on the other hand, are also comparable to the Sandahl specimen in all respects. As *O. jinglebobensis* is based on mandibular characteristics and a reduced M_3, it will be impossible to assign the Sandahl grasshopper mouse to specific status until additional material is obtained. The Sandahl M_1 has a shallow anterior median fold and appears slightly heavier than most specimens of Recent *O. leucogaster*.

The grasshopper mouse M_1 from the Kentuck locality falls in the size range of *Onychomys leucogaster, O. jinglebobensis,* and *O. fossilis* Hibbard. A mandible and a more complete dentition is required to distinguish between the above species. The Kentuck specimen is peculiar in that it has a well-developed cingulum across the major median fold. Stephens (1960) implied that *O. fossilis* can be distinguished from other species on the presence of a cingulum surrounding the tooth. Examination of 38 *O. fossilis* M_1's revealed cingula in the median fold of only 4 individuals. This character, therefore, is not too reliable.

One specimen of *Onychomys fossilis,* UMMP 35765A, a right mandible with M_1, is very unusual in that it has a mesostylid connected to the entoconid by a narrow mesolophid. Stylids and lophids were not observed in any other individuals of fossil or Recent specimens in this study.

Genus *Reithrodontomys*

Reithrodontomys cf. *montanus* (Baird)

(Figure 3J)

Geologic range.—Illinoian to Recent.

Habitat.—Predominantly an upland species that prefers well-drained areas. Often sympatric with *Reithrodontomys megalotis* (Baird) which prefers taller grass, more moist areas (Hooper, 1952). Both species are present in McPherson County today.

Material.—Sandahl locality: UMMP 50405, left mandible with I, M_1 (1.4 mm length × 0.9 mm width) and M_2 (1.1 × 0.9).

Remarks.—The above specimen is referred to *Reithrodontomys montanus* on the presence of a labial cingulum on the side of M_1 and M_2 and the broad, relatively massive diastemal region of the mandible. There is no anteromedian fold on the anteroconid and lophids are absent. The cingulum is well developed across the labial folds, thickens in the position of the ectostylid, but is faint around the protoconid.

Hooper (1952, p. 36) states that *Reithrodontomys montanus* and *R. megalotis* are not easily distinguished, particularly on the Great Plains where some characters tend to be parallel. Characters of the Sandahl specimen more often favored *R. montanus* than *R. megalotis* in a series of 50 specimens examined. Unfortunately, the diagnostic M_3 is missing and definite assignment of this species is dependent on the discovery of additional material.

Genus *Peromyscus*

Peromyscus cf. *progressus* Hibbard

(Figure 3H and I)

Geologic range.—Illinoian to Sangamon.

Habitat.—Known only in fossil form but is apparently related to *Peromyscus leucopus* (Hibbard and Taylor, 1960, p. 175).

Material.—Sandahl locality: UMMP 50406, right mandible with M_1 (1.5 mm length × 0.9 mm width), figured; UMMP 50407, left mandible with I and M_1 (1.4 × 0.9); UMMP 50408, left mandible with M_1 (1.3 × 0.9); UMMP 50409, right maxillary with M^1 (1.5 × 1.1); UMMP 50410, right maxillary with M^1 (1.6 × 1.2); UMMP 50411, left maxillary with M^2 (1.2 × 1.0) and M^3 (0.7 × 0.8); UMMP 50412–50414, maxillaries with M^2 (1.3 × 1.0, 1.3 × 1.1, and 1.3 × 1.1); and UMMP 50415, isolated teeth.

Remarks.—The lower dental elements listed above resemble *Peromyscus progressus* in size, presence of a cingulum in the labial re-entrant valleys

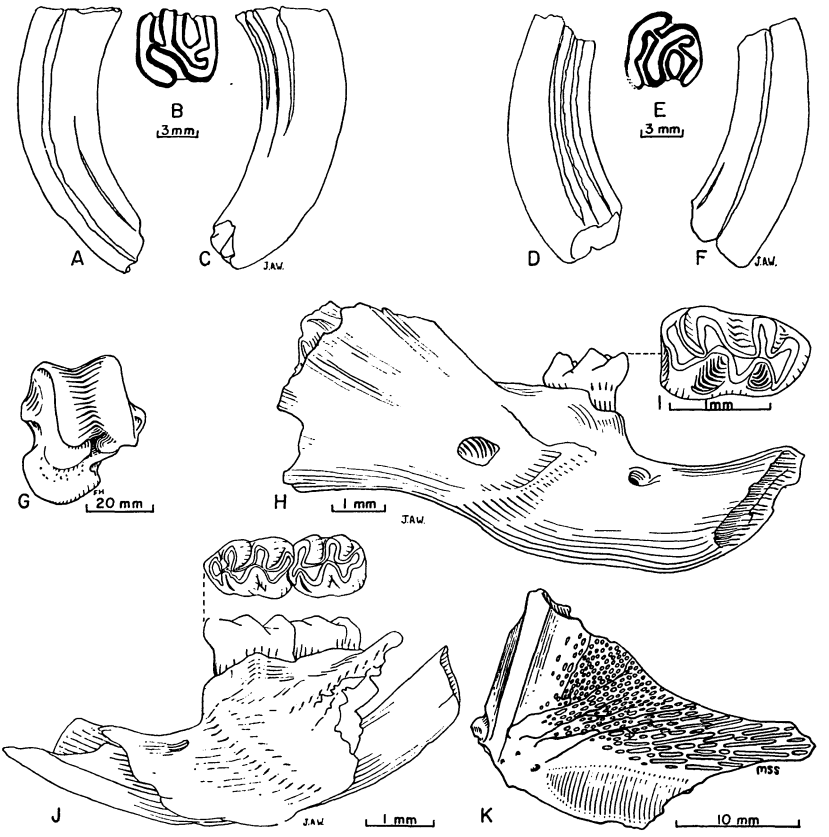


FIG. 3. Fossils from the Sandahl local fauna. (A–F) *Castor canadensis*: (A–C) UMMP 50929, LM^3; (A) lingual view; (B) occlusal view; (C) labial view. (D–F) UMMP 50927, RM^3; (D) labial view; (E) occlusal view; (F) lingual view. (G) *Castoroides* cf. *C. ohioensis*: UMMP 50921, left astragalus. (H–I) *Peromyscus progressus*: UMMP 50406, right mandible and occlusal view of M_1. (J) *Reithrodontomys* cf. *R. montanus*: UMMP 50405, left mandible and occlusal view of M_1 and M_2 (K) *Perca flavescens*: UMMP 50455, right opercle.

of M_1, broader re-entrant valleys than most Recent specimens, and are comparable to type specimens of *P. progressus*. Hibbard and Taylor (1960) observed a wide range of variation in the lower molars of the *P. progressus* sample from Cragin Quarry. In view of this they set up 3 groups to describe the population: (1) individuals with well-developed stylids and lophids, (2) individuals that have only stylids, and (3) individuals without lophids or stylids. Material recovered from the Sandahl locality falls in group 3 because stylids and lophids are absent in all specimens.

Upper dental elements from Cragin Quarry assigned to *P. progressus* also exhibit considerable variation in style and loph development. External re-entrant valleys in specimens from the type locality (Cragin Quarry) range from completely open, to valleys with mesostyles, and to valleys with mesolophs. Well-developed mesolophs are present in all upper molars from the Sandahl locality. More complicated upper molars are not surprising. Hooper (1957, p. 51) observed that M^1 is usually the most complicated tooth. This is followed by M^2. Lower molars may be similar to the uppers but frequently are simpler in nature.

Peromyscus berendsensis Starrett falls within the size and loph development range of *P. progressus*. However, *P. berendsensis* is only known from a single mandible with a M_1. Until a sample of this species can be obtained and its variability diagnosed, it cannot be determined whether or not *P. berendsensis* is conspecific with *P. progressus* and the Sandahl specimens. In view of the wide range of individual and geographic variation in living populations of *Peromyscus*, large samples of fossil specimens are essential for accurate determination of specific affinities.

Peromyscus sp.

Geologic range.—Lower Pliocene to Recent.

Material.—Sandahl locality: UMMP 50416, right mandible with M_1 (1.5 mm length × 1.0 mm width).

Kentuck assemblage: KUMNH 7385, right mandible with M_1 (1.5 × 0.9), figured by Hibbard, 1952.

Remarks.—The above specimens are excluded from *Peromyscus progressus* because (1) the re-entrant valleys are too narrow, like modern species in this respect, (2) the mandibles are heavier and deeper, and (3) the first molars are larger. Both specimens have a mesostylid, taper anteriorly, and do not have lateral cingula.

The Kentuck specimen contains a conspicuous anteromedian groove on the anteroconid and has a rudimentary lophid between the anteroconid and the protoconid. These features are absent in the Sandahl specimen.

The advanced, more complicated *Peromyscus* sp. first molar from Mt. Scott (Hibbard, 1963) is 0.3 mm longer than either of the above specimens and has an ectolophid as well as the mesolophid. The above specimens from McPherson County may or may not be the same species, but they are not the same as the advanced *Peromyscus* sp. from Mt. Scott.

Genus *Neotoma*
Neotoma sp.

Geologic range.—Upper Pliocene to Recent.

Habitat.—Woodrats or "packrats" occupy a number of habitats, depending on the species. On the plains they construct houses out of plant debris or live around rock ledges. *Neotoma floridana* (Ord) is presently found in McPherson County. *N. micropus* Baird is recorded about 40 miles to the west.

Material.—Flohr locality: UMMP 50475, left M_2 (3.0 mm length × 2.1 mm width).

Kentuck assemblage: UMMP 24509, right M^1 (4.1 × 2.7); KUMNH 7359, 3 worn or damaged molars.

Remarks.—The Flohr molar was indistinguishable from young individuals of *Neotoma micropus* and *N. floridana.*

Hibbard and Taylor (1960, p. 176) distinguish *Neotoma floridana* from *N. micropus* on the shape of the posterior (lingual) triangle of M^1. They report that in *N. micropus* this triangle is rounded and that it is flattened in *N. floridana.* The 2 tooth patterns are illustrated by Patton (1963, p. 30). Examination of 40 individuals of each species suggested that while the flattened lingual triangle was characteristic of *N. floridana* with one exception, UMMZ 109926, the rounded triangle is present in both species. Twenty-five per cent of the *N. floridana* sample had a rounded triangle. The criteria of a flattened triangle of *N. floridana* was fairly consistent in plains individuals.

The Kentuck M^1 exhibits a rounded lingual triangle of *N. micropus.* However, a larger sample is necessary to evaluate the Kentuck woodrats.

Genus *Sigmodon*
Sigmodon cf. *hispidus* Say and Ord

Geologic range.—? Kentuck assemblage to Recent.

Habitat.—Found in grasslands and meadows where the grasses provide a dense, overhead cover. Cotton rats, primarily southern in distribution, reach their northern range limit in southeastern Nebraska.

Material.—Kentuck assemblage: KUMNH 7361, right mandible with M_1 (2.4 mm length × 1.7 mm width), M_2 (1.9 × 1.8), and M_3 (1.6 × 1.7), length M_1–M_3 is 6.5 mm, figured by Hibbard (1952, p. 8).

Remarks.—The right mandible was thoroughly described by C. W. Hibbard (1952). Additional material from the Kentuck assemblage consists of a fragmentary lower first molar with the anterior and posterior loops

missing. The valleys of the fragmentary specimen appear to be more compressed than those in KUMNH 7361, reinforcing assignment of the Kentuck cotton rat to *S. hispidus*. The valleys of the Kentuck specimens are much too compressed for *S. hilli* Hibbard from the Borchers local fauna and are comparable to individuals of the modern *Sigmodon* population.

Genus *Ondatra*

Ondatra annectens (Brown)

Fiber annectens Brown (1908, p. 197).
Ondatra kansasensis Hibbard (1944, p. 732).
Ondatra annectens, Stephens (1960, p. 1695).

Geologic range.—Kansan–? (Cudahy fauna, Kansas; Conard Fissure, Arkansas; and Cumberland Cave, Pennsylvania).

Habitat.—Probably similar to the modern muskrat.

Material.—Kentuck assemblage: UMMP 24508 RM_1 (5.3 mm length $\times$ 2.4 mm width).

Remarks.—Stephens (1960), after examination of the type of *O. annectens* and a larger sample of *O. kansasensis* Hibbard, synonymized the 2 species. Examination of the same and additional material for this study strongly supports the conclusions reached by Stephens.

The right molar compares favorably with *Ondatra annectens* in size and height of the dentine tracts.

A left molar, KUMNH 7350, described by Hibbard (1952), is considerably larger than observed specimens of *Ondatra annectens*, but the dentine tract height is much lower than *O. nebracensis* (Hollister) and comparable to *O. annectens*. The difference in length as recorded by Hibbard (1952), 5.9 mm, and in this paper, 6.1 mm, is a result of an occlusal measurement as opposed to a measurement at the girth of the tooth to reduce variation resulting from wear. Although the dentine tract height of *O. nebracensis* from the type locality is not known, KUMNH 7350 is assigned to *O. nebracensis* because of their much larger size. Relationships of *O. nebracensis* to *O. annectens* and *O. zibethicus* (Linnaeus) is discussed under the remarks on *O. nebracensis*.

Ondatra nebracensis (Hollister)

(Figure 6B and D)

Fiber nebracensis Hollister (1911, p. 32).
Ondatra zibethicus, Stephens (1960, p. 1693)

Geologic range.—Illinoian.

Habitat.—Probably very similar to the modern muskrat. Fossils known from Kansas and Nebraska.

Material.—Flohr locality: UMMP 50519, RM_1 (6.3 mm length × 2.6 mm width).

Anderson locality: UMMP 50520, left mandible with M_1 (6.6 × 2.6) and M_2 (3.3 × 2.2).

Kentuck assemblage: UMMP 34712, left mandible with M_1 (6.2 × 2.4), M_2 (3.1 × 2.2) and M_3 (2.6 × 1.8); KUMNH 7350, left M_1 (6.1 × 2.3) and isolated teeth; UMMP 50931, left M_1 (6.4 × 2.3).

Remarks.—Muskrats, known from late Kansan to Recent time, make up a very interesting but somewhat confusing group. Recovery of several first lower molars from the *Equus* beds led to a general review of muskrats from fossil localities on the Central Plains and to a study of the taxonomic value of muskrat lower first molars.

Hollister (1911) summed up fossil and modern muskrats and recognized 3 fossil species, *O. nebracensis, O. oregonus* (Hollister), and *O. annectens*. Apparently, he considered *Arvicola hiatidens* Cope and *Sycium cloacinum* Cope as distinct genera. Hibbard (1947) recognized these as muskrats and placed *A. hiatidens* and *S. cloacinum* into synonymy as *Ondatra hiatidens* (Cope).

In 1944, Hibbard named *O. kansasensis* from the Cudahy fauna of Kansas and applied this name to specimens from the Kentuck assemblage. Stephens (1960), with better muskrat material from the Cudahy fauna, compared *O. kansasensis* with *O. annectens*-type material from the Conard Fissure and concluded that *O. kansasensis* was the same as *O. annectens*. Data collected during this study is in complete agreement with Stephens. Size, dentine tract development, and interstitial cement are very similar in the 2 species.

Stephens (1960, p. 1693) also examined the type material of *O. nebracensis* and Recent muskrat specimens and concluded that the skull (type) of *O. nebracensis* was separated from Recent individuals on characters of old age and added that "all of the other specimens (lower jaws and partial maxillaries) are as measured by Hollister and cannot be distinguished from Recent species."

Interpretation of data gathered from first lower molars does not support Stephens' (1960) conclusions that *O. nebracensis* is conspecific with *O. zibethicus*. First lower molar measurements of 92 Recent muskrats (63 *O. z. zibethicus* and 29 *O. z. cinnamoninus*) demonstrate that these 2 Recent subspecies are larger in size than the sample of *O. nebracensis* (AMNH 2702–2710) from Hay Springs, Nebraska (Figure 4, solid circles). The only exception to this generalization is the Recent sample from Isle Royal, Michigan (Figure 4, open triangles). This island sample is smaller than the over-all sample of the Recent population and is comparable in size to the

O. nebracensis sample. Island populations are frequently bizarre because of selection and restricted gene pools; therefore, the Isle Royal sample is not necessarily representative of the Recent population. The island sample, however, does support the close relationship of *O. nebracensis* with Recent muskrats.

Starrett (1956) described *O. triradicatus* from the Illinoian Berends local fauna. *O. triradicatus* was described as larger than *O. nebracensis,* smaller than *O. zibethicus,* and with 3 well-developed roots on M^1 as opposed to 2 roots on Recent M^1's. In 1960, Stephens obtained a series of 654 Recent M^1's and found that 3-rooted M^1's appeared up to 56.2 per cent of the time in older individuals. On this basis Stephens considered *O. triradicatus* as synonymous with *O. zibethicus.* In terms of size, *O. triradicatus* is the size of a small *O. zibethicus* or a large *O. nebracensis,* the size of the 2 specimens falling within the range of *O. zibethicus* from Miller's Cave (Wisconsin age) as well (Figure 4). Since only 2 upper first molars are available from the Berends, the value of 3-rooted M^1's must await larger sample size to determine if a progressive reduction of roots is a taxonomic criterion.

Figure 4, a scatter diagram of length *versus* width of lower first molars, was constructed to illustrate the size relationship of the various species of

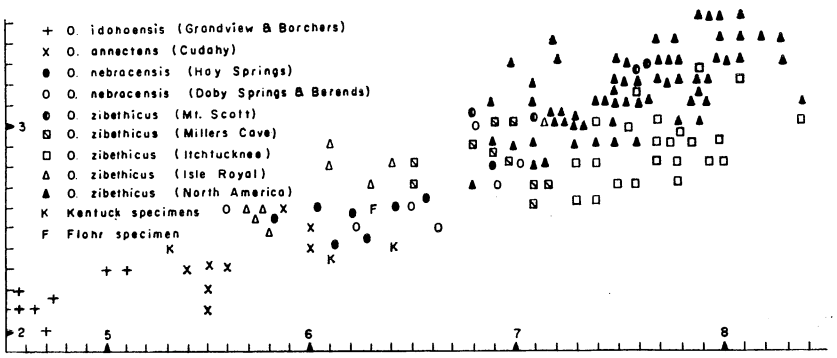


FIG. 4. Scatter diagram of length *vs.* width of M_1 (mm) in fossil and Recent *Ondatra.* X's, Kansan age; +'s, Yarmouth age; circles, Illinoian age; boxes, Wisconsin age; and triangles, Recent age.

muskrats. Measurements were made at the girth of the tooth to reduce error owing to wear, and teeth worn below the girth were not used.

A chronocline of size increase is readily apparent from *O. annectens* (x's) through Illinoian (circles) and Wisconsin (boxes) to Recent (triangles) individuals, with the Isle Royal exception. Overlap is evident for

each sample. Since the Hay Springs sample (*O. nebracensis*) fits best with specimens from deposits considered to be Illinoian in age, and is smaller than the late Illinoian Mt. Scott sample (taken in known stratigraphic position), the Illinoian specimens may be referred to *O. nebracensis* on size. Tract height, discussed later, does not always fit this interpretation.

Muskrats from the Yarmouth age Borchers and Grandview local faunas (Hibbard, 1959) do not fit into the chronocline in their stratigraphic position. Hibbard (1959) considered *O. idahoensis* Wilson (Grandview local fauna) less advanced than *O. annectens,* and thought that *O. idahoensis* compared favorably with the Borchers *Ondatra* sp., a single first lower molar. Stephens and the author agree with this interpretation. *O. idahoensis,* known only from Yarmouth deposits, may have been living to the south during Kansan time and advanced north with the retreat of Kansan ice. Or, there may have been a difference between forest and plains species at that time, however, morphological differentiation is not evident between forest and plains muskrats today. More probably *O. idahoensis* was a primitive muskrat that was able to compete with the more modern *O. annectens–O. zibethicus* line until Illinoian time.

Figure 5, a bar graph of dentine tract height, illustrates the increase in tract height from *O. idahoensis* to *O. zibethicus.* Measurements were made from the base of the crown posterior to the tract. Since first lower molars

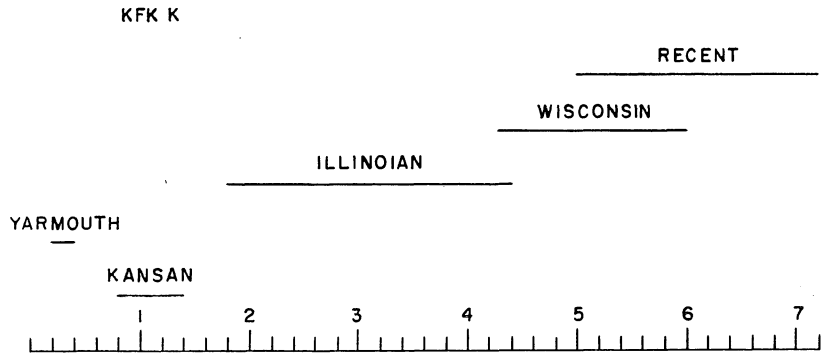


FIG. 5. Bar graph of the first dentine tract height of M_1 in fossil and Recent *Ondatra.* K, Kentuck assemblage; F, Flohr locality. Measurements in millimeters.

imbedded in jaws cannot be used, the sample size is small but is suggestive of a progressive increase of tract height with time. In general, tract height of the anterior and posterior loops increases more rapidly than gross size so that enamel patterns of Illinoian muskrats are interrupted earlier in life than in Kansan specimens, and modern specimens are interrupted still

earlier than in Illinoian groups. This generalization does not apply to the first lingual dentine tract, which increased relatively slowly with time (Figure 5). The molars from the Kentuck assemblage (except UMMP 24508—*O. annectens*) and the Sandahl fauna are comparable in size with the Illinoian muskrats but have a dentine tract height comparable with *O. annectens* of Kansan age. Since these deposits are stratigraphically above the Kansan Pearlette ash, selection for size increase must have taken place more rapidly than selection for tract height increase of the first lingual dentine tract. This tract height-size relationship would place the Kentuck assemblage (in part) and the Sandahl fauna as earlier than the Berends, Doby Springs, and Mt. Scott local faunas but later than the Kansan Cudahy fauna.

Genus *Synaptomys*

Synaptomys (*Mictomys*) *kansasensis* Hibbard

Geologic range.—Known only from the Kentuck assemblage.

Habitat.—The subgenus *Mictomys* is presently confined to boreal forests, wet meadows, and muskeg of the Canadian and Hudsonian life zones of North America, extending into the United States in western New England and northern Washington and Montana.

Material.—Kentuck assemblage: UMMP 50509, right mandible with I, M_1 (2.7 mm length × 1.3 mm width), M_2 (1.7 × 1.1), and M_3 (1.5 × 1.0), total length is 6.0 mm; UMMP 50510, left mandible with I and M_2 (1.9 × 1.2); UMMP 50511, right mandible with M_2 (1.7 × 1.2); UMMP 50512, right mandible with M_1 (3.1 × 1.3) and M_2 (1.8 × 1.2); UMMP 50513, right mandible with M_2 (1.8 × 1.2); UMMP 50514, right mandible with M_3 (– × 1.0); and UMMP 50515, isolated molars including 15 left M_1's and 10 right M_1's; KUMNH 7425, 7426, 7365–7379, dental elements described by Hibbard (1952). Additional collecting since 1950 raises the number of isolated right M_1's (7378) to 55 and left M_1's (7377) to 51.

Remarks.—Presently, this bog lemming is known only from the Kentuck assemblage, the type locality. It was described by Hibbard (1952) and compared with *Synaptomys* (*Mictomys*) *meltoni* Paulson (1961).

Synaptomys meltoni, known only from the pre-Pearlette ash Cudahy fauna, is distinct from but closely related to *S. kansasensis*. The latter species are alike with (1) a poorly developed, cementless, labial re-entrant angle on M_3, (2) thinner enamel walls on the posterior wall of lower molar prisms, (3) advanced state of enamel reduction, and (4) convex rather than concave posterior wall of the first triangle on M_1. *S. meltoni* and

S. kansasensis differ in the much larger size and a more posterior position of the capsular process in the latter. Paulson (1961, p. 144) presents more detailed data on the relationship of the 2 species. In general, the 2 fossil species are more closely related to each other than either is to *S. borealis* which has (1) less enamel reduction, (2) a strong, cement filled labial re-entrant angle on M_3, and (3) equal enamel thickness on the anterior and posterior prism walls.

Genus *Microtus*
Microtus (Pedomys) llanensis Hibbard

Geologic range.—Late Kansan (Cudahy fauna) and the Kentuck assemblage.

Habitat.—The modern member of this subgenus, *Microtus (Pedomys) ochrogaster* (Wagner), the prairie vole, requires a dense cover of grass on open, usually dry, prairie situations. Since *M. llanensis* is associated with the cool Cudahy fauna, it would suggest cooler conditions where it is found.

Material.—Kentuck assemblage: UMMP 24505, left mandible with M_1 (3.1 mm length × 1.0 mm width) and M_2 (1.8 × 1.0); UMMP 34707A, left ramus with M_1 (3.1 × 1.2) and M_2 (1.7 × 1.0); UMMP 34707B, right ramus with M_1 (2.8 × 1.1); UMMP 34710, left mandible with M_1 (3.1 × 1.2) and M_2 (1.7 × 1.0); UMMP 50516, isolated molars including 5 right and 9 left M_1's; KUMNH 7351, left ramus with M_1 (2.7 × 1.1) and M_2 (1.6 × 1.0); KUMNH 7380, right mandible with M_1 (3.2 × 1.3) and M_2 (1.9 × 1.1); KUMNH 7381, right ramus with M_1 (2.8 × 1.3) and M_2 (1.7 × 1.1); KUMNH 7382, right mandible with M_1 (3.3 × 1.3) and M_2 (2.0 × 1.1); KUMNH 7383, 30 isolated left M_1's and KUMNH 7384, 35 isolated right M_1's.

Remarks.—Specimens of *Microtus llanensis* from the Kentuck locality, described by Hibbard (1952), are almost identical with specimens of *M. llanensis* from the Cudahy fauna. As stated by Hibbard (1952), the Kentuck series of M_1's of *M. llanensis* are broader across the anterior loop than those from the Cudahy series. The 3 additional rami from the Kentuck locality, however, reveal that the pit labial to M_3 varies in depth, and in UMMP 34710 is as deep as in the type series. The fourth lingual and the third labial re-entrant angles of the Cudahy series tend to be deeper and not as longitudinally broad as in the Kentuck sample.

Recent species of *Pedomys* are distinguished from *M. llanensis* on the presence of small sixth and seventh confluent triangles which are not present in *M. llanensis*.

Microtus (*Pedomys*) *ochrogaster* (Wagner)
(Figure 6E)

Geologic range.—Illinoian to Recent.

Habitat.—The prairie vole is found in moist grassland habitats where the grass is tall enough to conceal their runways. The species is found presently in McPherson County. It ranges south to south-central Oklahoma and north to southern Alberta, Canada. *M. ochrogaster,* when regionally sympatric with *M. pennsylvanicus,* will be found in a higher, less moist, situation.

Material.—Sandahl locality: UMMP 44764, left mandible with M_1 (3.0 mm length × 1.2 mm width), M_2 (1.7 × 1.1) and M_3 (1.5 × 0.9), tooth row length is 6.3 mm; UMMP 50420, left mandible with M_1 (2.7 × 1.2) and M_2 (1.6 × 1.0); UMMP 52610, isolated M_1's including 6 right and 4 left.

Flohr locality: UMMP 50476, 4 right and 6 left M_1's.

Remarks.—Specimens from the Sandahl and Flohr localities could not be distinguished from Recent specimens of *M. ochrogaster.* One of the Sandahl left M_1's is unusual in that the second and third triangles are confluent rather than closed. The constriction between the third and the fourth triangle was normal. All other specimens have a posterior loop, 3 alternating closed triangles, and confluent fourth and fifth triangles opening into the anterior loop.

Microtus (*Pedomys*) from the Sandahl is advanced over the Kentuck species, *M.* (*P.*) *llanensis,* in the possession of rudimentary sixth and seventh triangles.

Microtus (*Microtus*) *pennsylvanicus* (Ord)
(Figure 6C)

Geologic range.—Illinoian to Recent.

Habitat.—Meadow voles inhabit grasslands, meadows, and low moist areas in the southern part of their range, occasionally extending their range into forests during periods of high population density. The only Kansas record of Recent *M. pennsylvanicus* is from Jewell County in the north-central part of the state (Fleharty and Anderson, 1964). This is approximately 100 miles north of McPherson County.

Material.—Sandahl locality: UMMP 45356, right mandible with M_1 (3.1 mm length × 1.2 mm width) and M_2 (1.6 × 1.0); UMMP 50421, 8 right and 7 left M_1's (Range 2.8– 3.3 × 1.0–1.3, Ave.—3.0 × 1.1).

Flohr locality: UMMP 50477, 4 right and 2 left M_1's (Range 2.8–3.4 × 1.0–1.2).

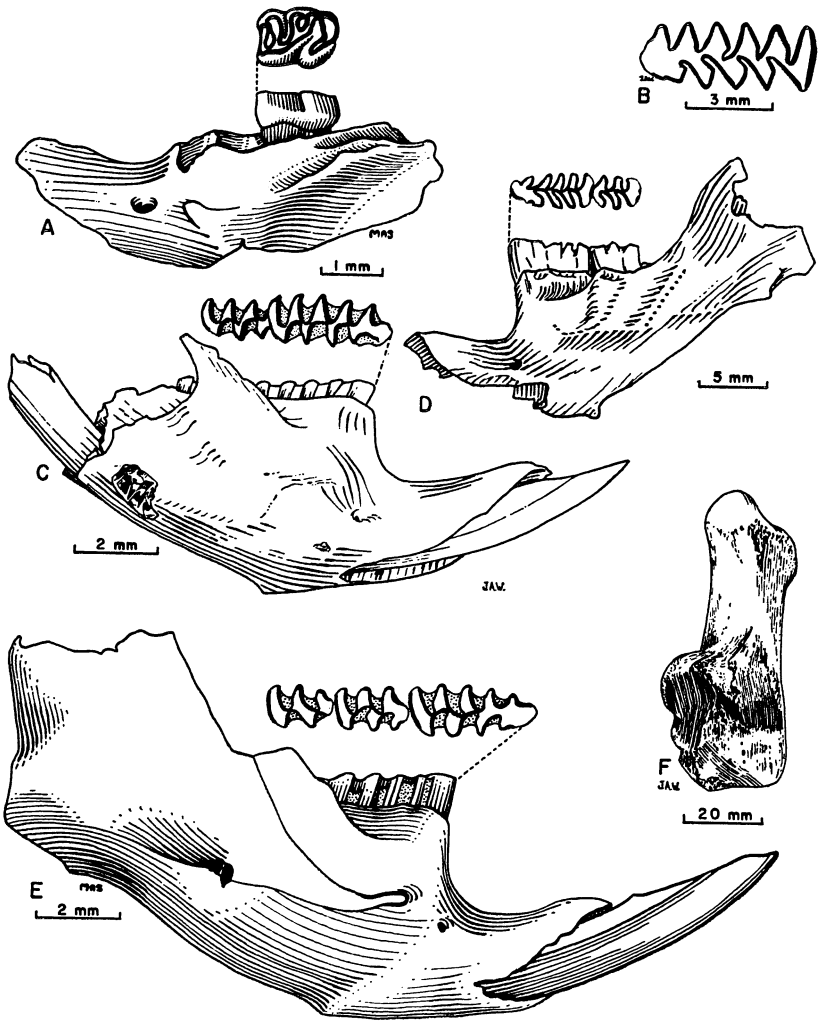


FIG. 6. Fossils from the Sandahl local fauna. (A) *Zapus hudsonius*: UMMP 45357, left mandible and occlusal view of M_2 (B) *Ondatra nebracensis*: UMMP 50519, RM_1, occlusal view. (C) *Microtus pennsylvanicus*: UMMP 45356, right mandible and occlusal view of M_1 and M_2. (D) *Ondatra nebracensis*: UMMP 50520, left mandible and occlusal view of M_1 and M_2. (E) *Microtus* (*Pedomys*) *ochrogaster*: UMMP 44764, left mandible and occlusal view of M_1, M_2, and M_3. (F) *Dinobastis serus*: UMMP 50909, left calcaneum.

Remarks.—The fossil specimens of *Microtus pennsylvanicus* fall within the size range of Recent *M. pennsylvanicus* and resemble the modern species in dental morphology. All M_1's (100 per cent) from the above localities have a posterior loop, 5 closed triangles, and sixth and seventh triangles that open broadly into the anterior loop. The same condition is observed in UMMP 34740 from the Illinoian Butler Spring local fauna (Hibbard and Taylor, 1960). Hibbard (1955, p. 216) observed that the sample of *M. pennsylvanicus* from the Sangamon Jinglebob local fauna contained 27 M_1's (64 per cent) with 5 closed triangles and 15 M_1's (36 per cent) with 6 closed triangles. The M_1 sample from the late Illinoian Mt. Scott local fauna had 190 (74 per cent) specimens with 5 closed triangles, 66 (25 per cent) specimens with 6 closed triangles, and 3 (1 per cent) specimens with 7 closed triangles (Hibbard, 1963). This sequence suggests a gradual increase in the number of closed triangles with time.

Examination of 398 M_1 pairs (right and left lower jaws) of Recent *M. pennsylvanicus* from 16 states revealed 239 pairs (60 per cent) with 5 closed triangles, 120 pairs (31 per cent) with 6 closed triangles, 23 pairs (6 per cent) with 5 closed triangles on one side and 6 on the other, and 5 pairs (1 per cent) with 7 closed triangles on both sides. Four specimens (1 per cent) had 6 closed triangles on one side and 7 on the other. The remaining specimens were either forms with 4 closed triangles or aberrant dentitions.

The relation of the number of closed triangles with geographic distribution is interesting. Of 128 specimens from the northeastern United States (mainly Ohio and Massachusetts) only 6 (5 per cent) had 6 closed triangles. In Virginia 8 of 37 (22 per cent) specimens had 6 closed triangles. In the plains states of Montana, Iowa, North Dakota, and South Dakota, where samples of at least 30 individuals from each was avilable, 51 per cent to 70 per cent of each sample had 6 closed triangles. Four specimens from South Dakota had 7 closed triangles. This brief survey indicates that there is a tendency for an increased number of triangles in populations from the plains over those in eastern forested regions.

The data are too fragmentary to give any positive results but there are several explanations for the significance of 5 closed triangles in the Sandahl fauna. First, a chronocline for an increased number of closed triangles may be present on the plains from Illinoian to Recent time with little change occurring in the eastern forests. Second, the number of closed triangles may be an ecological factor with selection favoring an increased number of triangles on the plains. This would be compatible with a general increase in enamel found in many grazing forms that consume the tough, siliceous, plains grasses. And third, the samples may reflect a general population

variation from locality to locality or different stocks. Only a much more extensive study of larger samples will settle the question. If the number of triangles is an ecological factor, then the Sandahl specimens represent a woodland situation and the Mt. Scott sample represents a plains population.

Family Zapodidae
Genus *Zapus*
Zapus hudsonius (Zimmermann)
(Figure 6A)

Geologic range.—Illinoian to Recent.

Habitat.—Grasslands and wet meadows. The eastern jumping mouse enters eastern Kansas and was recorded from Trego County in the western part of the state (Hall, 1955). Generally to the north and east of McPherson County.

Material—Sandahl locality: UMMP 45357, left mandible with M_2 (1.5 × 1.0).

Remarks.—Klingener (1963) revised the North American fossil jumping mice and recognized 2 successional subspecies of *Zapus hudsonius, Z. h. transitionalis* and *Z. h. adamsi,* separated from each other and Recent subspecies on size and anteroconid characters of M_1. In addition, the M_2 of *Z. h. adamsi* has a greater width anteriorly than posteriorly.

The Sandahl specimen has its greatest width posteriorly and is comparable with the smaller size of *Z. h. transitionalis.* Therefore, the Sandahl specimen is attributed to the latter. *Z. h. transitionalis* is recorded from the Mt. Scott and Doby Springs local faunas. Both of these local faunas are assigned to Illinoian time (Hibbard, 1963).

Order CARNIVORA
Family Felidae
Genus *Dinobastis*
Dinobastis serus Cope
(Figure 6F)

Geologic range.—Illinoian to Wisconsin.

Habitat.—Probably wide ranging in meadow and forested areas.

Material.—Anderson locality: UMMP 50918, left calcaneum.

Remarks.—The calcaneum was compared with a calcaneum of *Dinobastis serus* (TMM 933–1079) from Friesenhahn Cave, Bexar County, Texas, and was found to be almost identical in size and morphology. The calcaneum is as Meade (1961) described, with the articular facets broadly

similar to *Smilodon*. However, there is a considerable difference in size and relative proportions of the various facets. The outer facet for the astragalus is proportionally one-third larger in the examined *Smilodon* specimen than in either *Dinobastis* specimen.

Dinobastis is smaller than *Smilodon*; maximum length UMMP 50918, 77.4 mm; TMM 933–1079, 83.4 mm; as opposed to 94.3 mm for the same measurement in UMMP 48647, *Smilodon californicus* Bovard.

A large feline braincase, MCM9, from the Hammann gravel pit, listed by Harnly (1934) and Hibbard (1952) as *Smilodon,* has been identified as *Dinobastis* by C. S. Churcher, Royal Ontario Museum, University of Toronto (Churcher, personal communication 1964).

Genus *Felis*

Felis sp.

Geologic range.—Pliocene–Recent.

Habitat.—Cats are wide ranging and found in most environments.

Material.—Kentuck assemblage: KUMNH 7349, left M_1. Identified by Hibbard (1952).

Remarks.—Hibbard described this cat as the size of *Felis lacustris* Gazin, but noted that the carnassial notch was completely closed.

Order PROBOSCIDEA

Family Mammutidae

Genus *Mammut*

Mammut americanus (Kerr)

Geologic range.—Illinoian to Wisconsin.

Habitat.—Mastodons were forest animals that browsed on woody vegetation in stands of timber. Several fossil specimens have been recovered with half-masticated twigs, leaves, and reeds preserved in the position of the stomach (Skeels, 1962).

Material.—Haywood locality: KUMNH 4929, right M_3 (187.0 mm length × 96.2 mm width). Listed and measured by Hibbard (1952).

Remarks.—Mastodons are rare in the McPherson *Equus* beds. This is the only known specimen from the area. This animal undoubtedly lived in a gallery forest along the Illinoian drainage.

Family Elephantidae
Genus *Mammuthus*
Mammuthus columbi (Falconer)

Geologic range.—Illinoian to Wisconsin.

Habitat.—Mammoths, which are very closely related to modern elephants, were grazers and probably remained in open grasslands. Grasses from stomach contents of frozen remains of the woolly mammoth, *Mammuthus primigenius* Blumenbach, help confirm the grazing habit of *Mammuthus.*

Material.—Hammann locality: MCM 65, upper molar. Listed by Hibbard (1952).

Remarks.—Columbian mammoth remains without locality data are common in local museums and private collections in McPherson County.

Mammuthus imperator (Leidy)

Geologic range.—Illinoian to Wisconsin.

Habitat.—The imperial mammoth was a grazer as was *Mammuthus columbi,* but it is a much larger species. The differences of habitat are not known.

Material.—Locality unknown: BCM 896, molar, reported by Hibbard (1952) as taken approximately 10 miles west of Lindsborg.

Remarks.—Several molars of the imperial mammoth, one from the Sandahl locality, are in private collections in McPherson County.

Order LAGOMORPHA
Family Leporidae
Genus *Lepus*
Lepus sp.

Geologic range.—Kansan to Recent.

Habitat.—Species of *Lepus* range over all but the southeastern part of the United States and occupy a variety of habitats.

Material.—Sandahl locality: UMMP 50947, left P_3 (3.8 mm length × 3.6 mm width).

Kentuck assemblage: UMMP 50948, left P^2 (1.5 × 3.0) and 3 isolated upper teeth; KUMNH 7348, right P_3 (3.7 × 3.0) and 3 isolated teeth, figured by Hibbard (1952).

Remarks.—Specimens of *Lepus* from both localities belong to a large hare the size of *L. townsendi* Bachman or a large *L. americanus* Erxleben, but do not have the crenulated posterior wall of the P_3 re-entrant angle present in *L. californicus* Gray. The P^2, with 3 anterior re-entrant angles,

is smaller than most observed adult *L. townsendi,* but it belongs to a young individual. Conversely, the P_3's are large and represent either an extremely large *L. americanus* or an average size *L. townsendi.* Measurements and tooth patterns are compatible with both species.

Order ARTIODACTYLA
Family Tayassuidae
Genus *Mylohyus*
Mylohyus nasutus (Leidy)

Geologic range.—Illinoian to Wisconsin.

Habitat.—Lundelius (1960) inferred that *Mylohyus* was a close ecological equivalent of the European hog *Sus* because of its long rostrum and bunodont teeth. *Mylohyus* is commonly associated with the *Megalonyx* fauna of the eastern forests.

Material.—Sandahl locality: UMMP 44763, partial palate with incisors, premolars, M^2 and M^3. Collected and donated by Clayton Griggs.

Remarks.—Long-nosed peccaries from the McPherson *Equus* beds were discussed by Semken and Griggs (1965). The record of this species from the *Equus* beds helps confirm that the differences between the *Equus* and *Megalonyx* faunas were geographic rather than stratigraphic. This is the first record of this peccary from Kansas Pleistocene faunas.

Family Camelidae
Genus *Gigantocamelus*
Gigantocamelus sp.

Geologic range.—U. Pliocene–Kansan.

Habitat.—Presumably open country.

Material.—Kentuck assemblage: KUMNH 7340, calcaneum with distal end missing. Recorded by Hibbard (1952).

Remarks.—This damaged specimen is larger than any other late Pleistocene camel calcaneum observed during this study. Its minimum proximal-distal height is 167 mm and its maximum depth (anteroposterior) is 98 mm. Measurements in millimeters on 4 Illinoian and post-Illinoian *Camelops* calcanei are: UMMP 44688, 146 × 69; UMMP 35738, 142 × 60, and UMMP 29024, 138 × 70 from the Butler Springs area and UMMP 46336, 159 × 86 from Doby Springs.

Gigantocamelus is recorded from Kansan age deposits of Frederick, Oklahoma (Hibbard, 1958, p. 21), and is considered one of the Kansan elements in the Kentuck assemblage.

Genus *Camelops*
Camelops sp.

Geologic range.—Nebraskan to Wisconsin.

Habitat.—Open country, associated with cool and warm faunas.

Material.—Sandahl locality: UMMP 50431, tooth fragments.
Flohr locality: UMMP 50492, lower tooth.
County pit locality: UMMP 50464, tooth fragments.

Remarks.—Teeth and limb bones of camels are common *Equus* bed fossils and are in numerous local museum and private collections. None of the material was complete enough to warrant specific comparisons.

Family Cervidae
Genus *Odocoileus*
Odocoileus sp.

Geologic range.—Late Pliocene to Recent.

Habitat.—Predominantly a browser and usually associated with wooded or brushy areas.

Material.—Anderson locality: UMMP 50920, right ramus with P_3–M_3 (total length dental series is 83.7 mm), diastema and ascending ramus missing, teeth are badly worn. Collected and donated by Clayton Griggs.

Remarks.—Measurements of the McPherson specimen fall within the range of *Odocoileus virginianus* (Zimmermann) and *O. hemionus* (Refinesque). The specimen is not sufficiently complete to distinguish between the two species on morphology.

Order Perissodactyla
Family Equidae
Genus *Equus*
Equus scotti Gidley

Geologic range.—Late Kansan to Wisconsin.

Habitat.—Troxell (1915) stated that this horse was probably too large for rapid movement and therefore was confined to grassy valleys with luxuriant vegetation.

Material.—Recovered from an indurated Meade Group sand ledge exposed in the SE¼ NE¼ sec. 16 T. 18S. R.4 W.): KUMNH 6878, left maxillary lacking M^3. Figured by Hibbard (1952, p. 13).

Remarks.—The specimen, listed above, described and measured by Hibbard (1952), was recovered from a sand ledge stratigraphically below the Pearlette Ash.

Local private collections from the McPherson Formation contain a few teeth of a large horse referable to *E. scotti.*

Equus cf. *niobrarensis* Hay

Geologic range.—Illinoian to Sangamon. May be in Kansan deposits (Paulson, 1961).

Habitat.—A grazer that probably ranged over most of the High Plains.

Material.—Flohr locality: UMMP 50618, right protoconid.

County pit locality: UMMP 50617, left M_3, damaged; UMMP 50465, right M_2 (31.5 mm length × 17.8 mm width).

Anderson locality: UMMP 50523, right M^3 (28.6 × 21.3).

Hammond locality: MCM 42, right mandible with P_2–M_3.

Remarks.—The teeth mentioned above, and the majority of teeth in the Griggs collection are comparable to *Equus niobrarensis.* In addition, postcranial elements commonly found in the area are the size of material referred to *E. niobrarensis.*

Equus cf. *conversidens* Owen

Equus leidyi Hay. Harnly (1934, p. 151).
Equus cf. *francisci* Hay. Hibbard (1952, p. 12).

Geologic range.—Illinoian to Wisconsin.

Habitat.—Probably open grasslands and dry, semiarid areas.

Material.—Hammann locality: MCM 7, left upper molar.

Remarks.—This tooth is 5.0 mm shorter and 6.3 mm narrower across the width of the enamel borders than any other tooth observed from the McPherson Formation. It compares favorably with a sample of *Equus conversidens,* an ass-like horse, from Cragin Quarry.

Equus sp.

Geologic range.—Kansan to Recent.

Habitat.—A grazing animal usually associated with open country.

Material.—Kentuck assemblage: UMMP 50949, left lower premolar; KUMNH 7342, lower tooth.

Remarks.—The above specimens, in addition to a number of specimens from the McPherson Formation, cannot be assigned to any species. A long, slender, proximal phalange (UMMP 52087, 107 mm long by 42 mm proximal width), collected by Clayton Griggs from a gravel pit in the SE¼ sec. 21, Harper Township, suggests the presence of the stilt-legged horse in McPherson Formation deposits.

PALEOECOLOGY

Paleoecological interpretations are based on the assumption that physiological and ecological adaptions of animals evolve at the same rate as the gross anatomy of the animal. Thus, a fossil animal with osteology comparable to an extant species is considered to be that species and to occupy the same environmental station. Fossil species with morphology similar to extant species are considered to have lived under conditions similar to their modern counterparts. Exotic and extinct forms require interpretation based on homologous and analogous structural comparison. The validity of the uniformitarian approach is confirmed when the various elements of a local fauna, flora, or both are compared and give "consistent and harmonious results" (Taylor and Hibbard, 1959, unpublished manuscript).

A local fauna may represent one or more of the microenvironments of an area, with the relative abundance of the various species reflecting selective sorting, differential preservation, population density of an accessible microhabitat, or the regional fauna of the area. As a rule, several microhabitats can be identified within a local fauna and the sum of these ecological associations give a fairly accurate picture of regional ecology.

Sandahl Local Fauna

Several communities are apparent in the Sandahl local fauna. These include: (1) a permanent stream community, (2) a stream border community, (3) a gallery forest community, (4) a lowland meadow-savanna community, and (5) an upland prairie community (after Stephens, 1960).

Permanent stream community.—The presence of permanent water is verified by the yellow perch (*Perca flavescens*), walleyed pike (*Stizostedion vitreum*), gar (*Lepisosteus* sp.), catfish (*Ictalurus* sp.), and the soft-shelled turtle (*Trionyx* sp.). According to Rostlund (1952, p. 13), presence of the gar alone indicates that the fish fauna was very rich. These voracious fish-eaters, which consume a tremendous quantity of fish, could not exist in an impoverished or intermittent stream. The yellow perch suggests clear, cold, quiet streams. At present, the yellow perch is restricted to the Great Lakes and northern waterways, its range extending southward to northeastern Nebraska (Smith, 1963). The walleye is not living in the Smoky Hill River today but does extend into northeastern Kansas from the North. Taken together, the aquatic fauna indicates a clear, cold, quiet, permanent waterway with an abundance of fish. As the water was much colder than at present, a cooler climate is indicated.

Stream border community.—Characteristically linked to the permanent stream association is the stream border community represented in the

Sandahl local fauna by the muskrat (*Ondatra nebracensis*), a giant beaver (*Castoroides* cf. *C. ohioensis*), and the modern beaver (*Castor canadensis*). These animals require a permanent water supply and, since *Castor* feeds on bark, twigs, and tree branches, a quantity of brush or standing timber must have been present in the area.

Gallery forest community.—Stands of brush or timber, implied by the presence of the beavers and browsing animals, are interpreted as part of a gallery forest extending west from eastern forest biomes along the Illinoian drainage system. This does not necessarily imply that an optimum Austroriparian forest extended west into McPherson County. However, a corridor of either timber, chaparral, or brush with sufficient timber to support a population of browsing animals doubtless streaked across the plains along the Smoky Hill River valley. This gallery forest probably served as a "filter bridge," allowing some eastern forest forms to penetrate the plains environment. Members of the gallery forest association from the McPherson *Equus* beds include a saber-toothed cat (*Dinobastis serus*), the long-nosed peccary (*Mylohyus nasutus*), the American mastodon (*Mammut americanus*), a giant ground sloth (*Megalonyx leidyi*), and a deer (*Odocoileus*).

Kapp (1965) stated, "There is no convincing palynological evidence that the deciduous forest extended across the grasslands as far as western Kansas during Illinoian glacial time. Nevertheless, gallery forests of deciduous trees no doubt extended westward along major rivers during many intervals of the Pleistocene; these could have served as migration routes for the vertebrates and mollusks."

Gallery forest vertebrates from the *Equus* beds indicate that a gallery forest undoubtedly did extend west at least as far as Central Kansas during Illinoian time. Faunal elements of this association have not been found in intensively studied Illinoian deposits in southwestern Kansas and western Oklahoma, suggesting that the gallery forest was greatly reduced or absent in western Kansas during this period. The Smoky Hill and other central Kansas rivers support gallery forests of eastern deciduous trees across the plains today, but none of these extend to western Kansas.

Lowland meadow-savanna community.—Surrounding and mixed with the gallery forest association was the lowland meadow-savanna association consisting of the meadow vole (*Microtus pennsylvanicus*), the jumping mouse (*Zapus hudsonius*), Harlan's ground sloth (*Paramylodon harlani*), mammoths (*Mammuthus* sp.) and the large Scott's horse (*Equus scotti*). All of these animals probably ranged out onto the upland prairie, particularly during more moist seasons. *Geomys bursarius,* the plains pocket gopher would also be found in this community.

Upland prairie community.—By far the largest association, at least in terms of the number of species, was the upland prairie community. Mammals in this association include: the prairie vole (*Microtus ochrogaster*), the thirteen-lined ground squirrel (*Citellus tridecemlineatus*), Richardson's ground squirrel (*C. richardsoni*), the hispid pocket mouse (*Perognathus hispidus*), the plains harvest mouse (*Reithrodontomys montanus*), a grasshopper mouse (*Onychomys* sp.), camels (*Camelops* sp.), and the smaller horses (*Equus* cf. *niobrarensis* and *E.* cf. *conversidens*).

Two of the most distinctive mammals of this association are the blacktail prairie dog (*Cynomys ludovicianus*) and the whitetail prairie dog (*C.* cf. *gunnisoni*). The presence of these two species in the same area is confusing until the various soil groups in the area are investigated. Soils on top of the Cretaceous caprock are shallow compared with soils on Cenozoic deposits. In addition, the substrata of the Cenozoic deposits are friable and permit easy digging. Blacktail prairie dogs are presently found in deeper soil zones of terrace deposits on the high plains and prairie dogs from the whitetail group inhabit higher areas with more shallow soil zones. Extensive zones of both deep and shallow soils in northwestern McPherson County provide two entirely different environments to support two species of *Cynomys*.

The accumulation of a variety of small upland species in the fluvial deposits of the *Equus* beds is probably a result of the feeding habits of owls. Owls frequently hunt their prey over large open areas, feed, and then return to timbered areas to roost, subsequently regurgitating the remains of their meal around their roost or nest. Trees of the gallery forest along the Illinoian waterway would have provided excellent roosting and nesting sites where the pellets easily could have dropped in or near the stream. Owls, thus, could have served to sample the regional fauna.

Regional paleoecology.—The present-day area of sympatry of all 11 extant mammal species from the Sandahl local fauna (Figure 7, solid area), derived in the manner described by Stephens (1960), lies in the High Plains of southeastern Wyoming and northcentral Colorado. If one of the limiting species, *Citellus richardsoni,* is removed from the group the area of regional sympatry would include most of eastern Wyoming (Figure 7, heavy stripes). The whitetail prairie dog is restricted to the area of sympatry by thin soil zones. If this species were not present in the population, the area of sympatry would expand to include southern South Dakota and northern Nebraska (Figure 7, thin stripes). Taken in general or as a whole, the Sandahl local fauna represents a population living under climatic conditions which exist today in the southeastern plains of Wyoming. All of the animals included in Illinoian fauna which are not presently living in McPherson

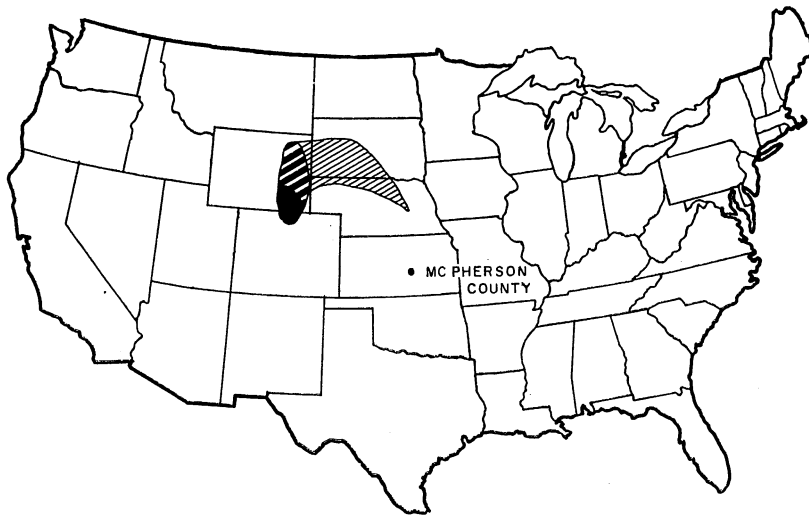


FIG. 7. Present area of sympatry of extant mammals from the Sandahl local fauna. Solid area—all extant mammals (11); heavy bars—10 extant mammals; light bars—9 extant mammals.

County have the southern limits of their range north of McPherson County. Thus, cooler and probably glacial time was present when the Sandahl fauna was deposited. Climatic conditions of McPherson County today and the area of modern sympatry are compared in Table I.

The area of sympatry of the Sandahl local fauna is unique in comparison with other Illinoian local faunas. Vertebrates and mollusks from the Illinoian Berends, Doby Springs, Adams, Butler Spring, and Mt. Scott local faunas have been compared by Stephens (1960), Hibbard (1963), and Miller (1965) with the eastern Dakotas, Nebraska, Iowa, or more eastern points, while the Sandahl fauna compares with southeastern Wyoming. This appears incongruous with the other Illinoian localities until the palynological studies of R. O. Kapp (1965) are considered. Kapp found that the pollen of Illinoian localities in southwestern Kansas and western Oklahoma indicated cooler, more glacial conditions but that the pollen represented a western, not eastern, flora common to central Colorado. Kapp (1965) analyzed the fossil and Recent floras and faunas in relation to climate and found that climatic conditions in central Colorado and in the eastern Dakotas are very similar at present. Therefore, the flora and fauna indicated identical climatic conditions but from two different areas. The Sandahl local fauna area of sympatry, less the western species *Cynomys* cf. *C. gunnisoni* and *Citellus richardsoni* (Figure 7, thin bars) overlaps the area of sympatry of the other Illinoian faunas.

TABLE I

SUMMARY OF CLIMATIC DATA FOR MCPHERSON COUNTY, KANSAS AND SOUTHEASTERN WYOMING

(Area of Sympatry, Sandahl Local Fauna.) After Vishner (1954).

Temperature	McPherson County	Southeastern Wyoming
Normal annual	55°–60°F	45°–50°F
Normal winter	25°–35°F	15°–25°F
Normal summer	75°–80°F	65°–70°F
Normal daily maximum in July	90°–93°F	80°–87°F
Norman daily minimum in January	10°–20°F	10°–20°F
Normal annual number of days with temperature continuously below freezing	15–30 days	30–60 days
Normal annual number of days with daily maximum temperatures above 85°	80–100 days	30–60 days
Precipitation	**Inches**	**Inches**
Normal annual	20–30	10–20
Normal spring	8–10	4–6
Normal summer	10–12	6–8
Normal fall	6–8	2–4
Normal winter	2–4	1–2

The small mammals from the Sandahl local fauna are common to the northern plains and, with the exception of the whitetail prairie dog and Richardson's ground squirrel, are either ubiquitous or eastern in affinity. However, the large mammals of the gallery forest association are not quite as regional. *Megalonyx* and *Mammut* are common to both eastern and western forests. *Mylohyus* has been recorded only from the east. *Dinobastis*, on the other hand, is known only from the San Francisco Bay region, California, Friesenhahn Cave, Texas, and western Oklahoma (Meade, 1961). It has not been found in the eastern forests of the United States. The combination of a central Colorado-type flora in southwestern Kansas deposits of Illinoian age (Kapp, 1965), *Dinobastis*, and the southeastern Wyoming area of sympatry for the small mammals of the Sandahl local fauna, make it a distinct possibility that gallery forests crossed the High Plains during some part of the Pleistocene.

Kentuck Assemblage

The enigma of the Kentuck assemblage was discussed by Hibbard (1952). Additional collecting at this locality further demonstrates that fossils from two different Pleistocene environments have been mixed. Hibbard (1952) pointed out that the occurrence of the cotton rat (*Sigmo-*

don hispidus), primarily southern in distribution, with a large sample of bog lemming (subgenus *Mictomys*), primarily northern in distribution, could not be natural and therefore the mixed faunas were designated an assemblage rather than a local fauna.

Many of the species identified from the assemblage are extinct, but extant species from the assemblage are indicative of open grassy areas for both the warm and cool elements of the fauna. The grassland species include *Cynomys* cf. *C. gunnisoni, C. ludovicianus, Citellus tridecemlineatus, Citellus richardsoni, Geomys bursarius, Perognathus hispidus, Onychomys* sp., and *Sigmodon hispidus*. The fossil remains of two species of muskrat, *Ondatra annectens* (Kansan age) and *Ondatra nebracensis* (Illinoian? age) indicate a stream border community for two of the source areas of the assemblage. Birds from this locality are all presently living on the High Plains (Galbreath, 1955). Evidence of mixing, also implied by the stratigraphic range of the component species, is considered under the "age and correlation" of the deposits.

AGE AND CORRELATION

Sandahl Local Fauna

Information derived from paleoecology, stratigraphic relationships, and faunal comparison points to Illinoian age of the Sandahl local fauna and consequently the McPherson *Equus* beds (McPherson Formation).

As illustrated in Figure 1, the McPherson Formation is stratigraphically above the Late Kansan Pearlette ash member of the Meade Group. Topographically lower terrace deposits of Wisconsin age, dated by *Bison bison,* are entrenched into the McPherson Formation. Thus, stratigraphic evidence places the McPherson Formation somewhere in time between late Kansan and late Wisconsin. Paleoecological interpretations of the Sandahl local fauna further limit deposition of the McPherson Formation to a glacial period, eliminating Yarmouth and Sangamon times as possible ages.

Comparison of the Sandahl local fauna with other Illinoian local faunas from the plains in Table II suggests a very close relationship because all small mammals, except *Cynomys* cf. *gunnisoni,* are represented in at least one other Illinoian fauna (Hibbard, 1943, and 1963; Schultz, 1965; Starrett, 1956; and Stephens, 1960).

Additional evidence is furnished by the muskrats. Muskrat samples taken from known glacial age deposits illustrate a chronocline for gross size and dentine tract height through time (Figure 4). The two specimens from the McPherson Formation are too small to be Wisconsin age muskrats, too large for a Kansan age population, but favorably compare with most other Illinoian muskrat samples. The sample from the late Illinoian Mt.

TABLE II

COMPARISON OF SEVEN ILLINOIAN VERTEBRATE LOCAL FAUNAS AND THE KENTUCK ASSEMBLAGE

	Central Kansas			Southwestern Kansas and Western Oklahoma				
	Sandahl	Rezabek	Kentuck	Berends	Doby Springs	Adams	Butler Spring	Mt. Scott
Scalopus aquaticus (Linnaeus) ...		x						
Sorex cinereus Kerr	x	x		x	x		x	x
S. arcticus Kerr					x			x
S. palustris Richardson					x			x
Blarina b. brevicauda (Say)				x	x			
Blarina b. carolinensis (Bachman)								x
Blarina b. fossilis Hibbard		x						
Blarina sp.			x					
Cryptotis parva (Say)								x
Lasiurus cinereus (Beauvois)								x
Megalonyx leidyi Lindahl	x							
Megalonyx sp.	x					x		
Paramylodon harlani (Owen)	x						x	
Cynomys ludovicianus (Ord)	x						x	
C. cf. *C. gunnisoni* (Baird)	x		x					
Cynomys sp.								x
Citellus tridecemlineatus (Mitchill)	x		x		x			
C. cf. *C. tridecemlineatus* (Mitchill)							x	x
C. richardsoni (Sabine)	x		x				x	
C. cf. C. richardsoni (Sabine)					x			
Citellus sp.		x				x		x
Thomomys sp.					x			
Geomys bursarius (Shaw)	x		x		x		x	
Geomys sp.		x		x		x		x
Dipodomys ordi Woodhouse							x	
Perognathus hispidus Baird	x		x				x	
P. cf. *P. hispidus Baird*				x				
Castoroides cf. *C. ohioensis* Foster	x	x		x	x	x		
Paradipoides stovalli Rinker and Hibbard				x				
Burosor effossorius Starrett				x				
Castor canadensis Kuhl	x							
Castor sp.				x				
Paradipoides or *Castor* sp.								x
Onychomys cf. *O. leucogaster* (Wied-Neuweid)					x		x	
Onychomys sp.	x		x					

TABLE II—Continued

	Central Kansas			Southwestern Kansas and Western Oklahoma				
	Sandahl	Rezabek	Kentuck	Berends	Doby Springs	Adams	Butler Spring	Mt. Scott
Reithrodontomys cf. *R. montanus* (Baird)	x							
R. cf. *R. megalotis*							x	
Peromyscus berendsensis Starrett				x				x
P. progressus Hibbard	x							x
P. cf. *P. cochrani* Hibbard					x			
P. oklahomensis Stephens					x			
Peromyscus sp.	x		x					x
Neotoma cf. *N. floridana* (Ord)								x
Neotoma sp.	x	x	x					
Oryzomys fossilis Hibbard								x
Sigmodon hispidus Say and Ord			x					
Ondatra annectens (Brown)			x					
O. nebracensis (Hollister)	x	x	x	x	x			
O. zibethicus (Linneaus)								x
Synaptomys kansasensis Hibbard			x					
Synaptomys australis Simpson								x
Pedomys llanensis Hibbard			x					
P. ochrogaster (Wagner)	x	x		x			x	x
Microtus pennsylvanicus (Ord)	x	x		x	x	x	x	x
Neofiber leonardi Hibbard		x						
Zapus hudsonius (Zimmermann)	x				x			x
Canis cf. *C. latrans* Say						x		
Dinobastis serus Cope	x							
Felis sp.			x					
Mammut americanus (Kerr)	x							
Mammuthus columbi (Falconer)	x							
M. cf. *M. columbi* (Falconer)				x				
M. imperator (Leidy)	x							
Mammuthus sp.					x	x		
Lepus sp.	x		x		x			x
Sylvilagus sp.							x	x
Camelops kansanus							x	
Camelops sp.	x				x	x	x	
Odocoileus sp.	x	x						
Equus cf. *conversidens* Owen	x						x	
E. scotti Gidley	x					x		
E. cf. *E. niobrarensis* Hay	x	x			x		x	
Equus sp.	x		x		x	x	x	x

Scott local fauna is larger than other Illinoian muskrat samples and comparable in size to Wisconsin samples. This is in line with the late Illinoian age of the Mt. Scott fauna (Hibbard, 1963). Chronology based on the muskrat chronocline would then suggest either early or middle Illinoian age of the McPherson Formation. This agrees with conclusions reached by Bayne and Fent (1963).

The Sandahl local fauna cannot be correlated with any particular glacial advance because the Illinoian faunas and the number and complexity of glacial advances during this period are not well known. Comparison of areas of sympatry, however, does indicate a somewhat warmer period of time than the period of deposition of the Doby Springs local fauna of western Oklahoma.

Kentuck Assemblage

Fossil vertebrates from the Kentuck assemblage represent two distinct periods of time as well as two different ecological associations. Some muskrats from the assemblage can be assigned to *Ondatra annectens* (Kansan age in plains deposits) and others to *O. nebracensis* (Illinoian age). The species of the subgenus *Pedomys* from the Kentuck assemblage (*P. llanensis*) is known only from the late Kansan Cudahy fauna and it is not as advanced as *M. ochrogaster* from known Illinoian deposits. On the other hand, the species of *Sigmodon* from the assemblage is much more advanced than the Yarmouth age *S. hilli*. Thus, the Kentuck *Sigmodon* likely represents either Sangamon time or a post-Yarmouth interstadial.

The Kentuck assemblage was recovered from a small channel deposit, lithologically distinct from the McPherson Formation, that filled an older cut through a thick bed of Pearlette Ash and underlying deposits so mixing of fossils is not surprising. Kansan elements of the assemblage would have been accessible here and post Kansan elements probably are remains of species living at the time of deposition.

In summary, the Kentuck assemblage is a mixture of faunas from the late Kansan Cudahy fauna and from a post Yarmouth interglacial or interstadial period. It can not be associated in any respect with the Sandahl local fauna or the McPherson *Equus* beds.

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