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DISCOVERIES of vertebrate remains from postglacial deposits in Michigan provide a picture of life prior to historic time. The seemingly random localities of these animal remains reflect past geologic features, such as the lakes, bogs, and swamps that would permit burial and thus preservation. These geomorphic features were but temporary at any one geographic position, particularly in the rapidly changing period following glaciation.

Normally the resident of Michigan discovers remains of the Pleistocene vertebrates on his property or at a nearby excavation. Remains of the larger vertebrates such as the mammoths and mastodons have a long history of discovery dating from the early

TABLE I

THE PLEISTOCENE GLACIAL PERIODS IN NORTH AMERICA *

Glacial Ages	Approximate Age in Years	Interglacial Ages
Wisconsin	10,000-50,000	
		Sangamon
Illinoian	300,000	
		Yarmouth
Kansan	700,000	
		Aftonian
Nebraskan	1,000,000	

* Hough (1958).

19th century. The specimens noted in this study and earlier reports represent donations of many years to the various museums throughout the state. This study deals only with the specimens that have been donated to and recorded by these museums prior to January 1965. Vertebrate material associated with human remains is not reported.

TABLE II

THE FIVE GLACIAL ADVANCES OF THE LATER WISCONSIN PERIOD IN MICHIGAN
(Hough 1958)

Glacial Event	Date, C-14 year B. P. (approx.)
Valders	11,000
Port Huron (Mankato)	13,000
Cary (Lake Border)	14,000
" (Tinley-Defiance)	
" (Valparaiso)	

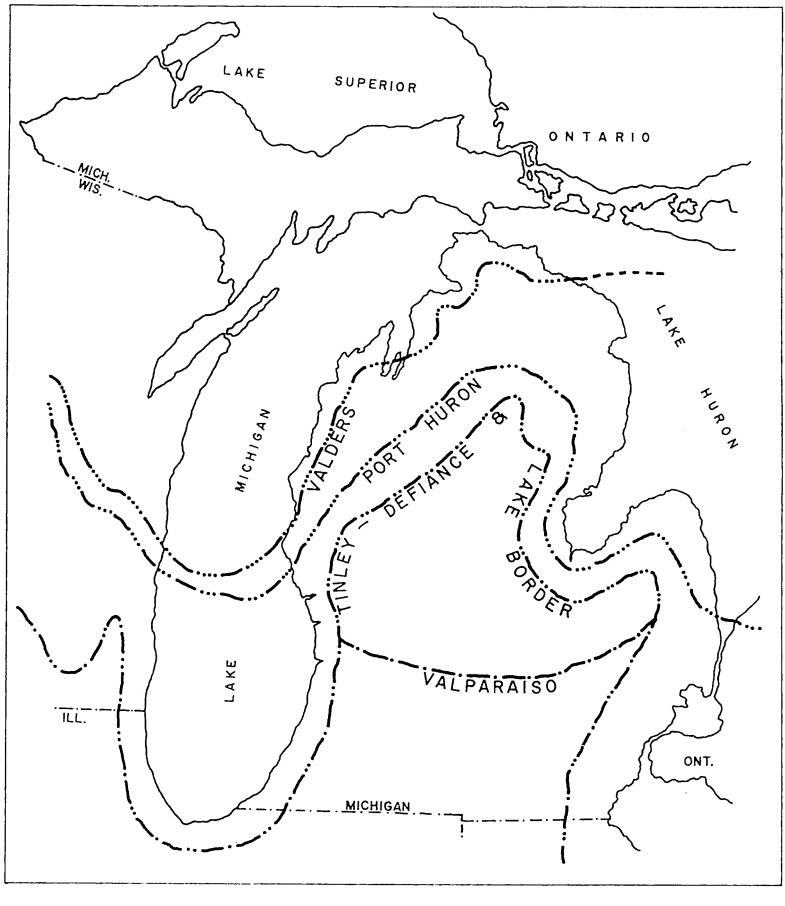

FIG. 1. Position of the approximate maximum advance of each fluctuation of the Late Wisconsin ice sheet. (For radiocarbon dates on two of these later advances, see Table II.)

Summary of Pleistocene Events

Four distinct Pleistocene glacial ages are recognized in North America. Each of these ages represents a southward advance of a continental sheet of ice (Table I). Ice probably covered the entire state of Michigan during each of these major advances and thus eliminated all vertebrate life from the state during these times. These glacial advances in effect erased the record of life of the preceding interglacial period. As the last continental ice sheet began to retreat the biota moved into the area formerly occupied by ice. The animals and plants that moved into the previously glaciated area furnished the specimens considered in this paleontological study. Much remains to be determined regarding such phenomena as the climate accompanying a glacial retreat, but studies in several fields of science have contributed to a better understanding of the postglacial interval.

The retreating Wisconsin ice sheet did not maintain a steady northward rate but pulsated in five fluctuations that have been termed the Valparaiso, Tinley-Defiance, Lake Border, Mankato, and Valders advances (Hough 1958; also Table II and Fig. 1). The form of the present Great Lakes represents the approximate shape of the retreating glacial ice when the central portion of the Lower Peninsula was free of ice and before the development of the present lakes (Fig. 1). The upper portion of the Lower Peninsula and the northern part of Michigan remained covered for a much longer time than the more southern regions (Hough 1958). This freedom from the ice sheet in southern Michigan (about 15,000 years ago) allowed the northward spread of plants and animals into this region.

Pleistocene vertebrates known from Michigan are restricted to the time that began with the retreat of the Valparaiso ice sheet. Different parts of the state became exposed at different times; there was a north-south variation caused by the direction of ice retreat and an east-west variation due to thicker ice in those areas now occupied by the Great Lakes. Details of the geologic history have been discussed in publications by many workers from the earliest comprehensive study by Leverett and Taylor (1915) to one of the latest by Hough (1958). Many specialists have dealt with individual areas or aspects of the Pleistocene in Michigan, including glacial geology, palynology, paleontology, limnology, and zoology.

Systematic Discussion

The following vertebrates from post-Valparaiso deposits in Michigan have been collected since the early 19th century to the present. Identification was by many experts from various fields of zoology and paleontology.

Abbreviations used:

sp.	species indeterminate
B.P.	Before the Present
CIPS	Cranbrook Institute Paleontological Series
GRPM	Grand Rapids Public Museum
KPM	Kalamazoo Public Museum
M-	Michigan Memorial-Phoenix Project radiocarbon date number
MSU	Michigan State University
MSU A. N.	Michigan State University Accession Number
UMMAA	University of Michigan Museum of Anthropology and Archeology
UMMP	University of Michigan Museum of Paleontology
UMMZ	University of Michigan Museum of Zoology
?	Indicates the genus is in doubt.

Class Osteichthyes

Ten genera of freshwater fishes have been recovered from Late Pleistocene bog deposits at three localities in Michigan. The first fossil fish specimen, a skull of the freshwater sheepshead, *Aplodinotus grunniens*, was found in 1940 (Hubbs 1940).

Robert A. Hard of Fenton, Michigan is responsible for the recovery of the remaining Pleistocene fishes. He has donated these to the Museum of Paleontology at the University of Michigan. All of the fish material collected by Hard, with the exception of the nearly complete skeleton of *Micropterus salmoides* (UMMP 44439), was dredged from the east side of Fenton Lake from a stratigraphic zone between the peat and marl (calcareous clay). The Fenton Lake locality is in the NE$\frac{1}{4}$ of Sec. 14, T. 5N, R. 6E. of Genesee County (Fig. 3; Tables III and IV).

FAMILY SALMONIDAE

Salmons, Trouts, Chars

Salvelinus namaycush (Walbaum). Common Lake Trout

Skeletal elements of the lake trout include the premaxilla, urohyal, ceratohyal, preopercular, palatine, and vertebrae (UMMP 51394). Ted M. Cavender identified the lake trout from deposits at Fenton Lake. The lake trout is confined to the main lakes and a few cold northern lakes in the Great Lakes region today (Hubbs and Lagler 1958).

FAMILY COREGONIDAE

Whitefishes

Coregonus clupeaformis (Mitchill). Lake Whitefish

The left dentary, right maxillary, right operculum, left hyomandibular, and a partial right dentary of the whitefish (UMMP 51399) were identified by Ted M. Cavender. These fossil skeletal parts of the lake whitefish are from the Fenton Lake locality.

FAMILY ESOCIDAE

Pickerels, Pikes, Muskellunges

Esox masquinongy Mitchill. Muskellunge

Several dentaries and skull parts (UMMP 33773) were identified by Reeve Bailey as bones of the muskellunge. These elements are from the Fenton Lake locality. Today the muskellunge is distributed throughout the Great Lakes region but is becoming quite scarce (Hubbs and Lagler 1958).

FAMILY CATOSTOMIDAE

Suckers

Moxostoma cf. *M. anisurum* (Rafinesque). Silver Redhorse

A right dentary (UMMP 51395) dredged from the Fenton Lake deposit was identified by Ted M. Cavender as that of a redhorse

sucker. Distribution of the redhorse, at present, is throughout the Great Lakes region (Hubbs and Lagler 1958).

Catostomus cf. *C. commersonnii* (Lacépède). White Sucker

Two elements, an operculum and maxillary (UMMP 51398), were referred to the white sucker by Ted M. Cavender. The white sucker is widespread throughout the streams and lakes in the eastern portion of the U.S. (Hubbs and Lagler 1958).

Catostomus catostomus (Forster). Longnose Sucker

Two maxillary bones (UMMP 51397) recovered at the Fenton Lake locality were identified by Ted M. Cavender. This species is common in the northern part of North America and *C. c. catostomus* is the only subspecies now occurring in the Great Lakes region. " Occurs through the Great Lakes proper, entering streams to spawn but resident in the interior only in the Lake Superior drainage. In colder lakes and streams " (Hubbs and Lagler 1958, p. 64).

Carpiodes cf. *C. cyprinus* (LeSueur). Quillback Carpsucker

One left dentary (UMMP 51396) was the only specimen of this genus recovered from the Fenton Lake deposits. The identification of the quillback carpsucker was by Ted M. Cavender. At present *C. cyprinus* is found throughout the Great Lakes region except in Lake Superior and the St. Lawrence River system (Hubbs and Lagler 1958).

FAMILY ICTALURIDAE

North American Freshwater Catfishes

Ictalurus punctatus (Rafinesque). Channel Catfish

Skeletal elements (UMMP 29403) of the channel catfish were collected by Pruitt from the Sleeping Bear Dune locality (Pruitt 1954).

FAMILY PERCIDAE

Perches and Darters

Stizostedion vitreum (Mitchill). Walleye

More than one individual is represented by parts of several dentaries, plus an operculum, epihyal, ceratohyal, metapterygoid,

lachrymal, lateral ethmoid, frontal and premaxillary (UMMP 51393). Reeve Bailey identified the skeletal elements belonging to *S. vitreum* recovered from Fenton Lake. Today the walleye is common in the Great Lakes and in many of the inland rivers and lakes of this region (Hubbs and Lagler 1958).

Family Centrarchidae

Sunfishes

Micropterus salmoides (Lacépède). Largemouth Bass

A nearly complete skeleton (UMMP 44439) is represented. This specimen is from an old lake deposit in the SW$\frac{1}{4}$ SW$\frac{1}{4}$ of Sec. 21, T. 6 N., R. 7 E. (60 yards south of Cook Road on the east side of new U.S. 10 expressway off the northbound lane) Genesee County, Michigan. Gerald R. Smith identified the bones of the largemouth bass. Present distribution of the largemouth bass is throughout the Great Lakes system.

Family Sciaenidae

Drums

Aplodinotus grunniens Rafinesque. Freshwater Drum

A skull (UMMZ 126289) was found and reported by Hubbs (1940). In this report Hubbs states that *A. grunniens* is absent today in equivalent waters but is common in the southern part of Lake Michigan, Saginaw Bay, and Lake Erie.

CLASS REPTILIA

The class Reptilia is represented by four species of turtles from the Pleistocene glacial deposits of Michigan. No previously published record exists of Pleistocene reptiles from the state. Those specimens listed have been found since 1956.

Family Chelydridae

Snapping Turtles

Chelydra serpentina (Linnaeus). Snapping Turtle

Two discoveries of fossil remains of the snapping turtle have been made in Michigan (Fig. 2).

Two fragments of a carapace (UMMP 33772) of *C. serpentina* were donated to the University of Michigan by Robert Hard in the spring of 1956. The fragments were discovered in a drainage ditch in Millington Township, Tuscola County, SE corner, NW$\frac{1}{4}$, NE$\frac{1}{4}$,

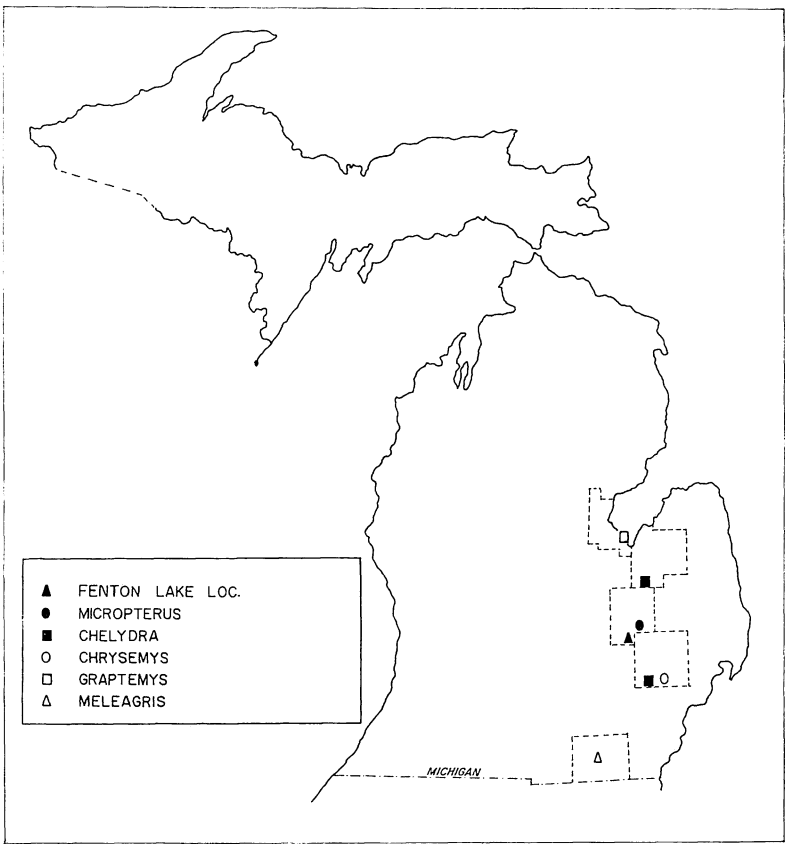

FIG. 2. Geographic position of the Fenton Lake locality and finds of the Osteichthyes, Reptilia, and Aves.

Sec. 31, T. 10 N., R. 8 E. These turtle shell fragments were located on a beach sand at the base of a peat deposit.

In 1958 five fragments (UMMP 44442) of the snapping turtle were taken from a peat layer at a depth of 15 feet by Robert J. Lutz. The locality is recorded as being halfway between 13 and 14 Mile roads, Farmington Township, in Oakland County. The

specimens were donated to the Museum of Paleontology, University of Michigan, by Richard Alde in September 1958.

Family Testudinidae

Terrestrial Turtles

Chrysemys sp. Gray. Painted Turtle

George Zug identified two fragments (UMMP 44443) of a carapace as belonging to the painted turtle, *Chrysemys*. The locality is the same as that of the snapping turtle, *Chelydra serpentina* (UMMP 44442). Only one species, *C. picta*, is present in Michigan today (Blair and others 1957).

Graptemys pseudogeographica (Gray). False Map Turtle

In the summer of 1962 Robert Hard discovered part of a plastron (UMMP 51249) belonging to the false map turtle from a dredging operation at the mouth of the Saginaw River (Wilson and Zug 1966). The locality is in Sec. 2, T. 14 N., R. 5 E. of Bay County. George Zug and Kraig Adler were responsible for the assignment of this fossil fragment. The false map turtle at present is found in very localized populations in Indiana, Ohio, and several states to the west. This fossil specimen supports other data suggesting that the false map turtle was present northeast of the present range before historic times (Conant and others 1964).

Family Trionychidae

Softshell Turtles

Trionyx cf. *T. spinifer* Le Suer. Eastern Spiney Softshell.

A xiphiplastron (UMMP 51412) of the softshell turtle was found by Robert Hard at the Fenton Lake locality. The eastern spiney softshell presently has a range that extends through the southern half of Michigan.

CLASS AVES

Birds

Fossils representing the Class Aves are rare in the postglacial deposits of Michigan. Three specimens have been recovered.

Family Anatidae

Ducks, Geese, Swans

Aythya sp.

The furcula (UMMP 33775) of a small duck has been assigned to the Aythya group. This specimen (wishbone) was dredged from Fenton Lake in the summer of 1956 and was collected by Robert Hard. According to Norman L. Ford the specimen most closely approximates *A. affinis* (Eyton), the lesser scaup or *A. collaris* (Donovan), the ring-necked duck.

Family Accipitridae

Hawks, Eagles, Old World Vultures

Haliaeetus leucocephalus (Linnaeus). Bald Eagle

A right femur (UMMP 33774) was recovered by Robert Hard from the Fenton Lake excavation (Fig. 2). P. S. Humphrey assigned this specimen to *H. leucocephalus*.

Family Meleagridae

Turkeys

Meleagris gallopavo Linnaeus. Wild Turkey

Gerald Larson recovered a left tibiotarsus (UMMP 51496) of a wild turkey from a dredging site near the SE corner of Sec. 28, (about 250 feet west and 350 feet north of the SE corner of Sec. 28) in Wolf Creek Valley, Adrian Township, Lenawee County. Harrison B. Tordoff identified the limb bone (Fig. 2).

CLASS MAMMALIA

The Class Mammalia has the largest number of post-Cary forms represented as fossils in Michigan. Size is perhaps one of the most important factors in the number of discoveries, for in this class the smaller forms are rarely collected from Late Pleistocene deposits.

ORDER INSECTIVORA

FAMILY SORICIDAE

Shrews

Blarina brevicauda (Say). Shorttail Shrew

Two left rami (UMMP 30092) were recovered by Jerome S. Miller from the Sleeping Bear Dune locality (Fig. 3) on July 28, 1951 (Pruitt 1954).

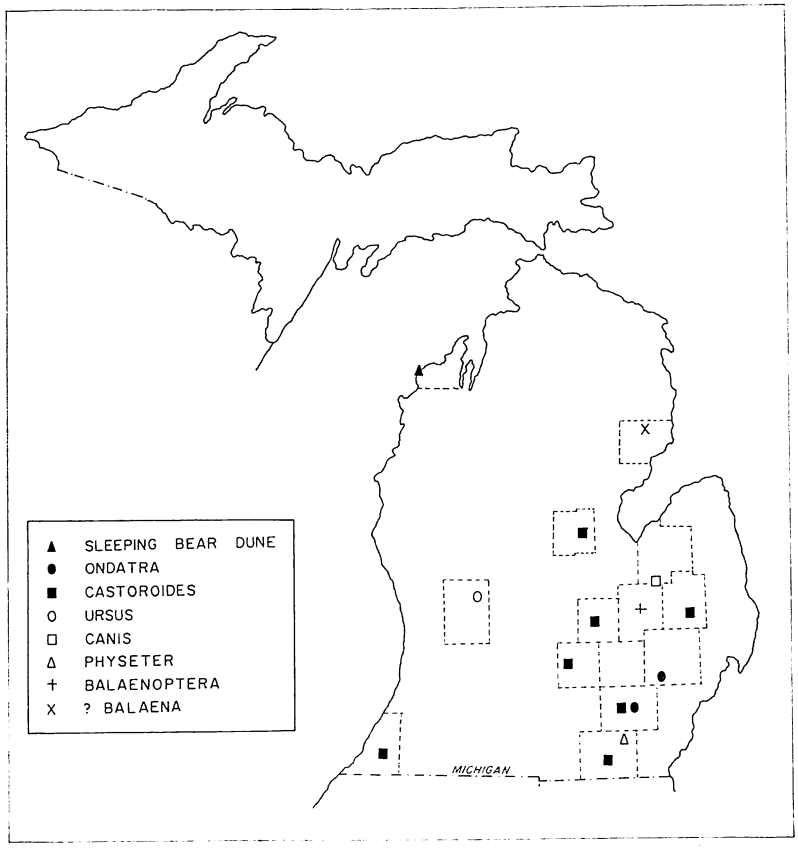

FIG. 3. Geographic position of Sleeping Bear Dune locality and the mammalian orders Rodentia, Carnivora, and Cetacea.

ORDER RODENTIA

Family Sciuridae

Squirrels

Marmota monax (Linnaeus). Woodchuck

One left ramus and one lower first molar (UMMP 29397) were taken from the Sleeping Bear Dune locality in 1951 (Fig. 3 and Pruitt 1954).

Tamias striatus (Linnaeus). Eastern Chipmunk

A left ramus, tibia, ilia, several teeth (UMMP 29398), and a left ramus with first molar (UMMP 30089) were recovered by Pruitt and Miller in 1951 from the Sleeping Bear Dune locality (Fig. 3 and Pruitt 1954).

Tamiasciurus hudsonicus (Erxleben). Red Squirrel

A left femur (UMMP 29394) was recovered from the Sleeping Bear Dune locality in 1951 (Pruitt 1954).

Sciurus carolinensis Gmelin. Eastern Gray Squirrel

A right ramus with P_4-M_1 (UMMP 29401) was taken from the Sleeping Bear Dune sediments (Pruitt 1954).

Glaucomys volans (Linnaeus). Southern Flying Squirrel

Pruitt recovered an ulna (UMMP 30117) in situ from the Sleeping Bear Dune locality (Fig. 3; Pruitt 1954).

Family Castoridae

Beavers

Castoroides ohioensis Foster. Giant Beaver

N. A. Wood (1914) reported on two specimens of the extinct giant beaver; a skull (UMMP 3110) which was found in Ann Arbor, Washtenaw County, and a lower jaw (UMMP 3109) from Owosso, Shiawassee County. Hay (1923) records three additional specimens from three separate localities in Berrien, Lenawee, and

Lapeer counties. Pilleri (1961) made comparisons of the brain of *Castoroides* with *Castor*, using the skull (UMMP 3110) from Ann Arbor.

Two new discoveries of the giant beaver from Michigan remain to be listed. One of these specimens is now on display at the Michigan State University Museum. It is the anterior portion of a skull with both upper incisors (MSU 2135) and was collected in 1892 by John Daft from the SE$\frac{1}{4}$ of Sec. 3, T. 3 N., R. 2 W., in Ingham County. The specimen was received April 7, 1962 by the Michigan State University Museum.

The second specimen, a right upper incisor (UMMP 32386) was collected in November 1951, by George F. Austin, in Midland County near the town of Midland. The specimen was taken from a sandy layer during excavation for a foundation.

Castor canadensis Kuhl. Beaver

One molar (UMMP 29402) of the beaver was recovered from the Sleeping Bear Dune locality by Pruitt in 1951 (Fig. 3; Pruitt 1954).

FAMILY CRICETIDAE

Mice and Rats

Peromyscus cf. *P. leucopus* (Rafinesque). White-Footed Mouse

Two left rami (UMMP 29400 and UMMP 30088) were collected by Pruitt and Miller from sediments of Sleeping Bear Dune area in 1951 (Fig. 3; Pruitt 1954).

Ondatra zibethica (Linnaeus). Muskrat

The first published record of a fossil muskrat from Michigan was by Pruitt (1954). It was taken from the Sleeping Bear Dune locality in Leelanau County (Fig. 3). Three later discoveries of *O. zibethica* (Fig. 3) from Pleistocene deposits in Michigan are as follows:

A partial skull with all six molars (UMMP 44444) was collected by Robert J. Lutz and donated to the University of Michigan by Richard Alde in September 1958. The darkly stained skull, taken from a peat deposit at a depth of 15 feet in Farmington Township, Oakland County, was associated with *Chelydra serpentina* (UMMP 44442; Fig. 3).

A muskrat femur and tibiofibula (UMMP 33776) were collected by Robert Hard from the east side of Fenton Lake. These elements were found in association with the fish material Hard collected in 1956 (Fig. 2).

Gerald Schultz collected a tibiofibula and four toe bones (UMMP 48421) in the summer of 1963, belonging to *O. zibethica*. These skeletal parts were dug from a position two feet below the surface at a location 0.7 mile north of Ann Arbor, Washtenaw County in the SW$\frac{1}{4}$ NE$\frac{1}{4}$, Sec. 36, T. 1 S., R. 7 E., of Salem Township.

Clethrionomys gapperi (Vigors). Boreal Redback Vole

Jerome Miller collected a right ramus (UMMP 30090) from the Sleeping Bear Dune locality in 1951 (Pruitt 1954).

Microtus ochrogaster (Wagner). Prairie Vole

A lower jaw with M_1-M_3 (UMMP 29399) found at the Sleeping Bear Dune locality in Leelanau County was assigned to *M. ochrogaster*. This specimen provides a range extension for the prairie vole of nearly 180 miles northward in Michigan (Fig. 3; Table IV). According to Burt (1957, p. 129), "This vole is restricted to open grassland, fence rows, and cultivated fields. It is seldom in wooded areas."

Microtus pennsylvanicus (Ord). Meadow Vole

A right ramus (UMMP 30091) and a lower first molar (UMMP 30107) were collected by J. Miller from the Sleeping Bear Dune locality in 1951.

Pitymys pinetorum (Le Conte). Pine Vole

In July 1952 Miller collected a left ramus (UMMP 30108) of the pine vole from sands of the Sleeping Bear Dune locality (Pruitt 1954).

ORDER CARNIVORA

Family Ursidae

Bears

Ursus americanus Pallas. Black Bear

In November 1963, Wayne Mol of Greenville, Michigan donated a fossil lower jaw (GRPM 12542) of a bear to the Grand Rapids

Public Museum. This specimen was discovered in a marl layer during the digging of a drainage ditch through a swamp near the NE corner of Big Wabasis Lake in Kent County.

The bear was reported by Weldon Frankforter (1966) of the Grand Rapids Public Museum.

Family Procyonidae

Raccoons

Procyon lotor (Linnaeus). Raccoon

A left ramus with P_3-M_1 (UMMP 29391) was collected from the Sleeping Bear Dune locality in 1951 (Pruitt 1954).

Family Mustelidae

Weasel-like Mammals

Martes americana (Turton). Marten

Pruitt (1954) collected a left ramus and ulna (UMMP 29395) and a right and left ramus (UMMP 30109) from deposits at Sleeping Bear Dune.

Family Canidae

Dogs and Foxes

Vulpes fulva (Desmarest). Red Fox

Several metacarpals and metatarsals (UMMP 29392) were collected by Pruitt in 1951 from the Sleeping Bear Dune locality (Fig. 3; Pruitt 1954).

Canis lupus Linnaeus. Gray Wolf

The lower jaws, several vertebrae, a rib, upper incisor, radius, ulna, humerus, and several foot elements (UMMP 33770) were collected in 1956, by Robert Hard between a peat layer and the basal beach sand of an old lake in the $NW\frac{1}{4}$ $NE\frac{1}{4}$, Sec. 31, T. 10 N., R. 8 E., Tuscola County, Michigan (Fig. 3). This partial skeleton was found in association with parts of the turtle *Chelydra serpentina,* (UMMP 33772).

The wolf was probably a very early resident of Michigan after the retreat of glacial ice. Bands of 3 to 12 individuals may occupy areas of 20 to 60 miles in diameter (Burt 1957). The single discovery of *C. lupus* would reflect the solitary habits of this form. The wolf is still a resident of Michigan, but its range is restricted to the wilderness of the Upper Peninsula (Burt 1957).

Canis sp.

On July 24, 1948 William O. Pruitt, Jr., discovered a vertebra (UMMP 30115) belonging to the genus *Canis* at the Sleeping Bear Dune locality (Pruitt 1954).

ORDER PINNIPEDIA

Family Odobaenidae

Walruses

Odobenus sp.

Two specimens representing the walrus have been found in Michigan deposits; a baculum (UMMAA 490) was reportedly found by Ezra Smith, 7 miles northwest of Gaylord, Michigan in 1914 (Hinsdale 1925), and a skull (UMMP 32453) was reported by Handley (1953). The exact locality from which the latter specimen was taken is not known, but it was reported to have come from a gravel deposit on Mackinac Island.

ORDER CETACEA

Whales

Five bones of whales from three localities are deposited in the Museum of Paleontology at the University of Michigan. Hussey (1930) was the first to publish on the Cetacea remains after they were donated to the University of Michigan. Handley (1953) studied the marine mammals from Michigan and assigned the four ribs and single vertebrae to the following categories (Fig. 3).

Physeter sp. Sperm Whale

A lumbar vertebra and two ribs (UMMP 14102) were reportedly found in a swamp deposit in the NE corner of Lenawee County (Handley 1953).

Balaenoptera sp. Rorquals

A single rib (UMMP 14101) was found in a cellar excavation in Genesee County. It was standing upright in a sand believed to be of Arkona age (Handley 1953).

? *Balaena* sp. Bowhead Whale

In 1927 a single rib (UMMP 11008) was found at Oscoda in Iosco County during excavation for a new schoolhouse. Handley (1953) compared it with the genus *Balaena,* the bowhead whale, but definite assignment was not made.

The presence of specimens representing these large marine mammals in the Pleistocene deposits of Michigan support those who propose the existence of an open seaway from a coastal area during some part of the later Pleistocene. Handley (1953) discusses the possible reasons for the occurrence of the large marine mammals in the Pleistocene beach deposits of Michigan.

ORDER PROBOCIDEA

Family Mammuthidae

Mastodons

Mammut americanum (Kerr). American Mastodon

Remains of the mastodon are the most numerous of Pleistocene vertebrate fossils in Michigan. The first reported specimen of the American mastodon from Michigan was by James H. Lanman in 1839. O. P. Hay (1923) summarized the discoveries of *M. americanum* made before this date, and MacAlpin (1940) recorded 117 discoveries in the state. Skeels (1962) lists 49 new finds, after 1940, from 26 counties of Michigan. Hatt (1962) described a partial mastodon skull (CIPS 827) from Pontiac in Oakland County. The published accounts from 1839 to the present appear in the bibliography.

Specimens of *M. americanum* unearthed or reported after the latest résumé by Skeels (1962) are:

1. A lower molar (GRPM 12540) was found by Larry Kramer of Grand Rapids on September 18, 1962. This specimen was found along Buck Creek in Paris Township, near the center of the $S\frac{1}{2}$, Sec. 29, T. 6 N., R. 11 W. in Kent County.

2. In Muskegon County, near Moorland several fragmentary mastodon teeth (GRPM 12469, 12471, and 12472) were found and donated to the Grand Rapids Public Museum. No locality data is available on these specimens except that they were found near Moorland. These teeth may have been part of the original discovery in 1905 at the time the skull of *Bootherium sargenti* (GRPM 11423) was recovered. A partial skeleton of *Mammut americanum* (GRPM 12533) is mounted at the public museum in Grand Rapids.

3. A right lower second molar and fragments of both lower jaws (UMMP 49425) of an American mastodon were found about 4 feet below the surface, directly above a layer of gravel and clay by Fred Berndt in May 1964 in Lincoln Township, Sec. 13, Berrien County.

4. 20 ribs and 16 vertebrae, a scapula and pelvis (UMMP 44433) were found 5 feet below the surface of a bog in Genesee County.

Discussions of the distribution and types of environment probably typical of the mastodon have been included in several reports. Skeels (1962) provides the latest account of *M. americanum* plus a brief discussion of this species in Michigan.

Family Elephantidae

Mammoths

Mammuthus jeffersoni (Osborn). Jefferson Mammoth

The first census of the species *M. jeffersoni* from the state of Michigan was published in 1962 by Skeels. O. P. Hay (1923) recognized two species and one indeterminate form of mammoth from Michigan. Specimens representing the Jefferson mammoth are considerably fewer than those of the American mastodon. From 1839 to 1962 32 discoveries of *M. jeffersoni* have been recorded in Michigan (Skeels 1962). Oltz and Kapp (1963) record a mammoth from Gratiot County found in 1962. Hatt (1963) reported a single molar from Oakland County.

One of the two new specimens of the Jefferson mammoth is a right upper third molar (UMMP 44381) collected by Larry Kickels in August 1961. This tooth was found in a gravel layer nearly 100 feet below the surface in the NE$\frac{1}{4}$, Sec. 17, T. 3 S., R. 17 W. near Watervliet, Berrien County.

A second discovery of a nearly complete skeleton of the Jefferson mammoth was made in Eau Clair, Berrien County. This specimen has a radiocarbon age of 8200 ± 300 B.P. (Table IV).

ORDER ARTIODACTYLA

Family Tayussuidae

Peccaries

Platygonus compressus (Le Conte). Peccary

In 1877, L. N. Tuttle uncovered the remains of five individual peccaries in a peat bog near Belding in Ionia County. Originally there were 294 bones (UMMP 7325) in the collection at the University of Michigan, but some of the elements have been exchanged for other specimens. Wagner (1903) described a skull belonging to this assemblage, and Hay (1923) gives a summary of this discovery.

A peccary found in Sandusky County, Ohio has been dated at 4290 ± 150 B.P. (Hoare 1964 and Table IV).

Family Cervidae

Deer

Cervus canadensis Erxleben. Elk

Hay (1923) reported two separate discoveries of remains of *Cervus canadensis*. In both cases these elk remains were associated with those of *Castoroides* and *Odocoileus*. Since this 1923 report many discoveries assigned to the elk have been reported and donated to one of the several museums in Michigan. Finds of skeletal material of *C. canadensis* are numerous, and detailed descriptions of each discovery will be omitted. In this as in other mammal groups it is very difficult to assign a specimen to the category of fossil or Recent. The following listing will be by county, and the map (Fig. 4) will illustrate the finds of the elk within the state.

BERRIEN COUNTY

1. Lower third premolar (UMMP 45865) collected in October 1949.

2. The base of a skull (UMMP 44692), posterior portion of skull (UMMP 44693), antler fragment (UMMP 44694), and a radius (UMMP 44701) were dredged from sediments at the mouth of the St. Joseph River. These specimens were recovered by Amos Green in the spring of 1957.

BRANCH COUNTY

1. The posterior portion of a skull (UMMZ 42528) was found near Union City.

GENESEE COUNTY

1. A fragment of a skull and antler (UMMP 44427) were collected by Richard Pohrt in 1930.

2. A lower jaw and other skeletal elements (UMMP 44431) were collected in North Flint by M. Salgat.

3. An antler fragment (UMMP 50995) was found near Flint in 1960.

4. A nearly complete skeleton (UMMZ 57713) was collected in 1926 by Paul McKeon.

INGHAM COUNTY

1. Antler (MSU 2598) collected in 1957 by P. Tack.

JACKSON COUNTY

1. An antler, right and left tibia, atlas vertebra, and the distal end of a femur (MSU A.N. 493) were unearthed near Fay Lake by Mr. Walkins in 1925.

KALAMAZOO COUNTY

1. An antler fragment (UMMZ 53078) was collected by Ernest T. Seton in 1899.

2. An antler (UMMP 42629) was unearthed from a marl layer near Scotts by Donald Haywood in 1959.

LEELANAU COUNTY

1. A partial skull (UMMP 29406) was collected at the Sleeping Bear Dune locality by W. O. Pruitt in 1950-51 (Pruitt 1954).

LIVINGSTON COUNTY

1. A radius ulna and metapodial (UMMP 44434, 44437) were collected from a marl deposit by Frank Sweeney in 1953.

2. A broken cervid antler (UMMP 22496) was donated by Harold Wallace in 1934. This specimen was found approximately 8 feet beneath the present surface in a peat layer.

OAKLAND COUNTY

1. A calcaneum (UMMP 44452); a thoracic and a cervical vertebra (UMMP 44450); and a metapodial (UMMP 38536) were

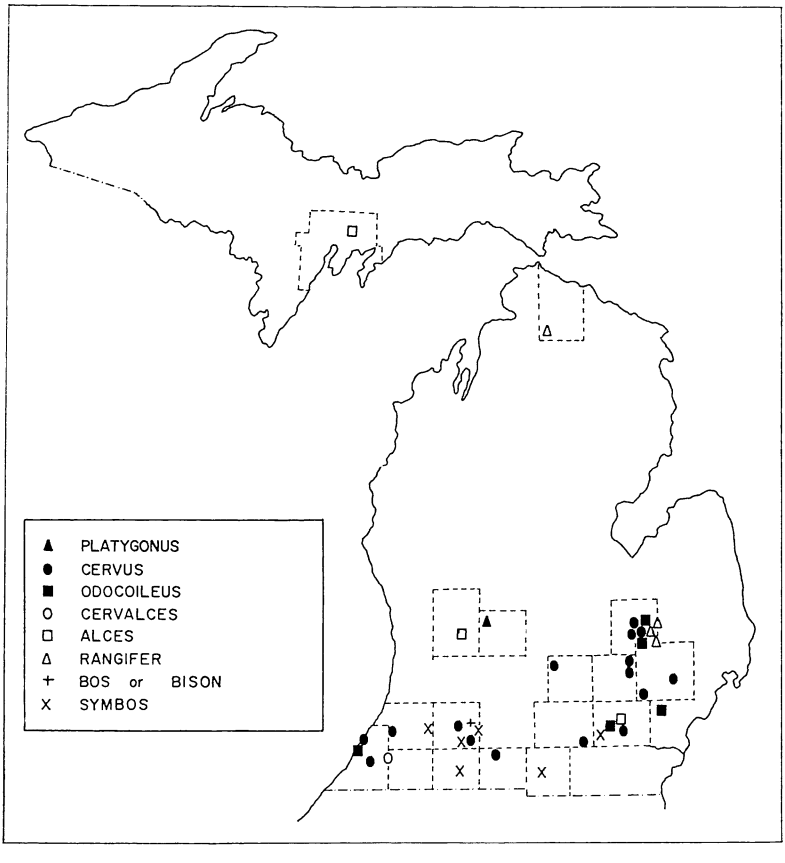

FIG. 4. Geographic position of the fossil discoveries of the order Artiodactyla.

dredged from a peat layer at a depth of 15 feet. These specimens were collected by Robert J. Lutz and were donated to the University of Michigan by Richard Alde in 1958 (Table III).

2. A maxillary and other skull fragments plus two antler frag-

ments (UMMP 44673) were collected by Arnold Luksche in 1960 from a bog deposit in South Lyon.

VAN BUREN COUNTY

1. A right palate and right antler fragment (MSU 2355) were taken from a peat bog about 5 feet below the surface in Hartford Township in July 1965, by R. Heusner.

WASHTENAW COUNTY

1. Six foot bones and four toe bones (UMMP 24379) were collected by John Dorr in September 1947. The specimens were from the NW$\frac{1}{4}$ NW$\frac{1}{4}$ Sec. 17, T. 3 S., R. 5 E. of Washtenaw County. They were taken from the same level as several mastodon elements (UMMP 24241; Table III).

2. A skull with attached antlers and atlas vertebra (UMMZ 113400) was collected a few hundred yards east of Maple Road in the NE$\frac{1}{4}$ Sec. 24, T. 2 S., R. 5 E. of Washtenaw County. The skull of this individual was injured as evidenced by the unusual ossified angle of attachment of the atlas to the skull.

Odocoileus virginianus (Zimmermann). Deer

The whitetail deer is as difficult to place in time as the elk. Associations of the deer, and the present distribution of this form, give some indication of the time at which it might have arrived in Michigan after the retreat of glacial ice (Fig. 5). The finds of *Odocoileus* will be listed by county (Fig. 4).

BERRIEN COUNTY

1. The posterior portion of a skull (UMMP 44695, 44696), parts of four antlers (UMMP 44697), radius (UMMP 44698), femur (UMMP 44699) and two vertebrae (UMMP 44700) were dredged from the mouth of the St. Joseph River. Amos Green collected these specimens in 1957.

2. A skull fragment with milk dentition (UMMP 22295) was collected from a soil horizon about 8 miles south of St. Joseph in 1941 by Dr. Belknap. J. T. Gregory identified the specimen.

GENESEE COUNTY

1. A shed antler (UMMP 44438) was dredged from Thread Lake in 1930. Mr. Pohrt was the collector.

2. A toe bone (UMMP 44441) was collected by Claude W. Hibbard from the SW¼ SW¼, Sec. 21, T. 6 N., R. 7 E., of Genesee County in November 1961.

LEELANAU COUNTY

1. An astragulus (UMMP 29404) was taken from the Sleeping Bear Dune deposits by Pruitt in 1951 (Pruitt 1954).

WASHTENAW COUNTY

1. Six vertebrae, three ribs, and a tibia (UMMP 22478) were discovered in an exposure nearly 25 feet below the surface in a marl layer by G. M. Ehlers in 1940. J. T. Gregory identified the specimens.

WAYNE COUNTY

1. A left antler (UMMP 24332) was dug from a bog deposit and collected by H. P. Zuidema in 1946.

Cervalces scotti Lydekker. Scott's Moose

In 1958, E. A. Hibbard assigned a proximal portion of a left antler (UMMP 33666) from Berrien County to the extinct moose *Cervalces scotti* (E. A. Hibbard 1958).

Alces alces (Linnaeus). Moose

Three specimens collected from glacial deposits in Michigan are considered to be fossil remains of the moose, *A. alces*.

1. A lumbar vertebra (UMMP 22477) was collected by M. H. Levy from a marl bed 8 miles west of Grand Rapids, Kent County.

2. In 1958, Art Slaughter recovered the proximal end of a humerus (UMMP 42628) belonging to *Alces alces*. This specimen was recovered 5-6 feet below the surface while excavating for a utility pole in Delta County, Michigan.

3. An incomplete skeleton (UMMP 48420) was collected by G. E. Schultz in the summer of 1963. This specimen was associated with several muskrat elements (UMMP 48421) which were taken 0.7 mile north of Ann Arbor, Salem Township, Washtenaw County in the SW¼, NE¼, Sec. 36, T. 1 S., R. 7 E.

Rangifer sp. Caribou

Remains of the caribou, genus *Rangifer*, are fairly numerous in the Pleistocene deposits of Michigan. Burt (1942) recorded a

caribou antler (UMMZ 84108) from Sanilac County. Hibbard (1951) assigned this specimen as well as another left antler (UMMP 26589) to the barren ground caribou, *R. arcticus*. Mikula (1964) described an antler fragment (MSU 7590) and assigned it to the woodland caribou *R. tarandus caribou*. The apparent discontinuity in the classification is due to the newest revision by Banfield (1961). Banfield has combined both *R. caribou* and *R. arcticus* into the single species *R. tarandus*. Individual authors use both specific names. There are, however, two distinct living populations of caribou and the controversy seems to be restricted to the classification.

Four other specimens, deposited in the museums at the University of Michigan remain to be recorded.

1. Two antler fragments (UMMP 44435 and 50994) were collected in 1960 by Robert Hard and Ed Hyde in the NW$\frac{1}{4}$, SW$\frac{1}{4}$, Sec. 27, T. 6 N., R. 8 E., of Genesee County.

2. A radius, ulna, distal end of a humerus, and a left antler (UMMZ 102458) were collected by Everett Howard in 1955. The specimens reportedly were found 50 feet below the present surface, south of Burt Lake, in Cheboygan County.

3. A fragment of a shed antler (UMMP 44440) was collected by Claude W. Hibbard in 1961 from the SW$\frac{1}{4}$, SW$\frac{1}{4}$, Sec. 21, T. 6 N., R. 7 E. in Genesee County.

4. Part of an antler (UMMP 44043) was collected by Frank Trecha in 1960, near Davison in the SE$\frac{1}{4}$, NE$\frac{1}{4}$, Sec. 11, T. 8 N., R. 8 E., of Genesee County. It has been assigned to *R. caribou*. This particular specimen has a radiocarbon age of 5870 $\pm$ 400 B.P. (M-294, Sci. 124 (3224); 664-672).

Family Bovidae

Bison and Cattle

Bison or *Bos*. Bison or Domestic Cow

A radius and ulna (UMMP 42630) assigned to *B. bison* is from post-glacial deposits near Scotts, in Climax Township, Kalamazoo County. This specimen was collected by Donald Haywood.

Until the horn cores or certain vertebrae are recovered, a more definite assignment of bison in a time sequence of Michigan Pleistocene deposits is not possible. Burt (1948) notes individual bison seen within historic times from Berrien, Jackson, Kalamazoo, Wayne, and Monroe counties.

Bootherium sargenti Gidley. Musk Oxen

Gidley (1908) described the skull (GRPM 11423) as belonging to a new species, *Bootherium sargenti.* The type, at the Grand Rapids Public Museum, consists of a nearly complete skull that was found lying beneath the pelvis of a mastodon, *Mammut americanum* (GRPM 12533). Hay (1923) gives the following locality: NE$\frac{1}{4}$ of Sec. 16, T. 10 N., R. 14 W., near Moorland, Muskegon County, on the farm of Charles McKay. E. R. Kalmbach, who discovered the skull of *B. sargenti,* places the date of this find in the fall of 1905 (correspondence of Kalmbach with Frank Du Mond of the Grand Rapids Public Museum, November 30, 1960).

The taxonomic position of this particular skull (GRPM 11423) is still in doubt. The following authors have attempted to assign this specimen at both the generic and specific levels: Allen (1913) designated the skull as that of a female *Symbos cavifrons* (woodland musk ox); Hay (1923) disagreed with Allen's determination and considered the skull to belong to the genus *Bootherium*; but Hibbard and Hinds (1960), agree with Allen.

Symbos cavifrons (Leidy). Woodland Musk Oxen

In 1908 an incomplete skull of *S. cavifrons* (UMMP 3450) was discovered on the farm of William J. Schlicht, 3 miles NE of Manchester in Washtenaw County (Case 1915 and 1921; Hay 1923). Hibbard and Hinds (1960) give the next published account of woodland musk oxen based on three vertebral elements discovered in 1956.

Semken and others (1964) give a description of the following discoveries of woodland musk oxen in Michigan: In 1919, part of a skull (UMMP 10567) was found in Hillsdale County; in 1942 another skull (UMMP 23113) was retrieved from a locality in Van Buren County; in August 1961, several skeletal elements were recovered near Scotts, in Kalamazoo County; on August 2, 1962 another skull and tibia (UMMP 50727) were dredged from Marl Lake in St. Joseph County.

Two previously unrecorded specimens of *Symbos cavifrons* are: (1) a skull (GRPM 12539) discovered by Ralph James of Croton on September 13, 1962; this weathered skull was taken from the marl bed between Croton Dam and Newaygo in Newaygo County; (2) a specimen donated to the University of Michigan by Frank Marsh on July 24, 1964; this fossil, part of an atlas vertebra (UMMP

48856), was assigned to *S. cavifrons*. The vertebra was discovered one foot below the surface, on top of a 60-foot bluff, along the St. Joseph River at the corner of Hill Crest Drive and Kimber Lane, in Berrien Springs.

Age Correlation

Associations.—At 10 localities in Michigan, including Sleeping Bear Dune, remains of different vertebrate species have been found together. These associated forms provide some evidence of contemporaneous existence. This evidence is based upon the amount of time available for burial at a particular site. However, this criterion must be used with caution for two reasons: the short time that has passed since the glacial retreat and the fast climatic transition after glaciation. In other words, Pleistocene vertebrates, although often separated because they lived during different time intervals, did occupy the same territories and probably shared the same burial sites. Conversely, many of the postglacial features, such as bogs, are very transitory and thus were available as a site of deposition for only a short time.

Vertebrate associations are useful in a study of Late Wisconsin biogeography to indicate the simultaneous existence of two or more species. Table III lists those localities where two or more vertebrates have been discovered.

Radiocarbon dating and pollen analysis.—Several of the vertebrates from the late Pleistocene deposits of Michigan have been dated using radioactive carbon and related to vegetative types by pollen analysis. Many radiocarbon dates and associated pollen profiles for these specimens are now recorded in the literature. Vegetational succession and the concordant faunal movements into a previously glaciated area will continue to be major considerations in the study of glaciated areas after the ice retreat.

Table IV summarizes the known data on radiocarbon dating and pollen associated with several of the Pleistocene vertebrates.

Biogeography

Following the retreat of the Late Wisconsin ice sheet, vegetation reoccupied the glaciated areas of North America. The sequence of plant types involved in this northward succession has been studied through the use of pollen profiles.

In Michigan the first major arboreal vegetation after glacial

retreat was spruce (Wright 1964a and 1964b; Zumberge and Potzger 1955 and 1956; Andersen 1954). The spruce forest was followed by a pine-dominated vegetation (Dansereau 1953). The rapid transition from spruce to pine at about 10,500 years B. P. was noted by Wright (1964a). The pine forest was then replaced by a more deciduous vegetation dominated by oak and elm, and this in turn is replaced by oak and hickory (Fig. 5, the xerothermic period). It is presumed that an invasion of grassland occurred which replaced the oak and hickory as the dominant vegetation (Fig. 5).

The flora as controlled by climate determined the vertebrate types which could inhabit an area after glaciation. A time of spruce domination is inferred as one of cool climate. The climate became warmer following the spruce-dominated period, reaching a relative maximum during the climatic optimum about 5000 years ago (Fig. 5). The rate of the vegetational succession was noted by Wright (1964b, p. 635): "The rapidity of the vegetational succession to a strictly temperate character following the retreat of the ice from the Great Lakes is by all odds the most striking feature of late post-glacial pollen diagrams. . . . [It is clear] that the climate change terminating the Pleistocene was as fast or faster than the forest succession itself."

If the vertebrate forms can be correlated with certain vegetational types they can be related to definite climatic periods that succeeded one another in this area after glaciation. In addition, if the ecological requirements of a particular vertebrate are known, a placement in time is also possible. Four means of correlation are used on the Michigan forms: association, radiocarbon dating of both the vegetation and vertebrates, viewing the morphology as a reflection of the animal's function, and treating the present distribution of living relatives as an indication of habitat preference. The vertebrate forms in Michigan after the retreat of the glacial ice, if not extinct, should have been living in the habitat for which they still are suited today. The present vertebrate distributions with respect to their habitat preference can be used in the interpretation of past distributions and environmental niches.

The high number of extinctions in late or post-Wisconsin time was the result of the inability of these vertebrates to adjust to or move with the rapidly changing environment. Competition from other vertebrates and restrictions imposed later by human occupation had their effects also, but the major factor in extinction was

TABLE III

KNOWN ASSOCIATIONS OF MICHIGAN PLEISTOCENE VERTEBRATES EXCLUSIVE OF THE SLEEPING BEAR DUNE LOCALITY (DESCRIBED BY PRUITT IN 1954).

	1	2	3	4	5	6	7	8	9 *
Fishes									
Salvelinus namaycush	X								
Coregonus clupeaformis	X								
Esox masquinongy	X								
Moxostoma cf. M. anisurum	X								
Catostumus catostomus	X								
Carpoides cf. C. cyprinus	X								
Stizostedion vitreum	X								
Turtles									
Chelydra serpentina		X							
Chrysemys sp.		X							
Trionyx cf. T. spinifer	X								
Birds									
Aythya sp.	X								
Haliaceetus leucocephalus	X								
Mammals									
Castoroides ohioensis									X
Ondatra zibethica	X	X	X						
Canis lupus									X
Mammut americanum				X				X	
Mammuthus jeffersoni				X		X			
Cervus canadensis					X				
Odocoileus virginianus					X		X	X	
Alces alces			X						
Bootherium sargenti						X			
Symbos cavifrons							X		

* Explanation of locality numbers:
1. Fenton Lake. 2 Farmington Twp., Oakland County. 3. Ann Arbor, Sec. 36, Washtenaw County. 4. Washtenaw County. 5. Thread Lake, Flint, Genesee County. 6. Moorland, Kent County. 7. White Pigeon, Sec. 17, St. Joseph County. 8. Adrian, Lenawee County. 9. Millington Twp., Tuscola County.

TABLE IV

VERTEBRATES WITH RADIOCARBON DATES AND POLLEN ANALYSIS

Specimen and Reference	State	County	C^{14}-B. P. Years	Pollen
Prairie Vole, M-208	Mich.	Leelanau	730 ± 250	Not studied
Mastodon, M-347	Mich.	Lapeer	5,950 ± 300	Not studied
Mastodon, M-281	Mich.	Lenawee	7,820 ± 450	Not studied
Mastodon, M-39	Ind.	Nobel	12,630 ± 1,000	Not studied
Mastodon, CIPS 827	Mich.	Oakland	11,900 ± 350	Spruce 83%, pine 8%
Mastodon; Oltz & Kapp, 1963	Mich.	Gratiot	10,700 ± 400	Not studied
Mastodon; Oltz & Kapp, 1963	Mich.	Gratiot	no date	Pine 59%, spruce 27%
Mammoth, M-507	Mich.	Jackson	12,200 ± 700	Not studied
Mammoth, M-1400	Mich.	Berrien	8,200 ± 300	Not studied
Peccary, M-1516	Ohio	Sandusky	4,290 ± 150	Not studied
Musk Oxen, M-639	Mich.	Kalamazoo	13,200 ± 600	Spruce 86.9%, pine 0.5%
Musk Oxen, M-1402	Mich.	Kalamazoo	11,100 ± 400	Pine 67%, spruce 5%
Musk Oxen; Semken, 1963	Mich.	St. Joseph	no date	Spruce 73%, pine 7%
Caribou, M-294	Mich.	Genesee	5,870 ± 400	Not studied

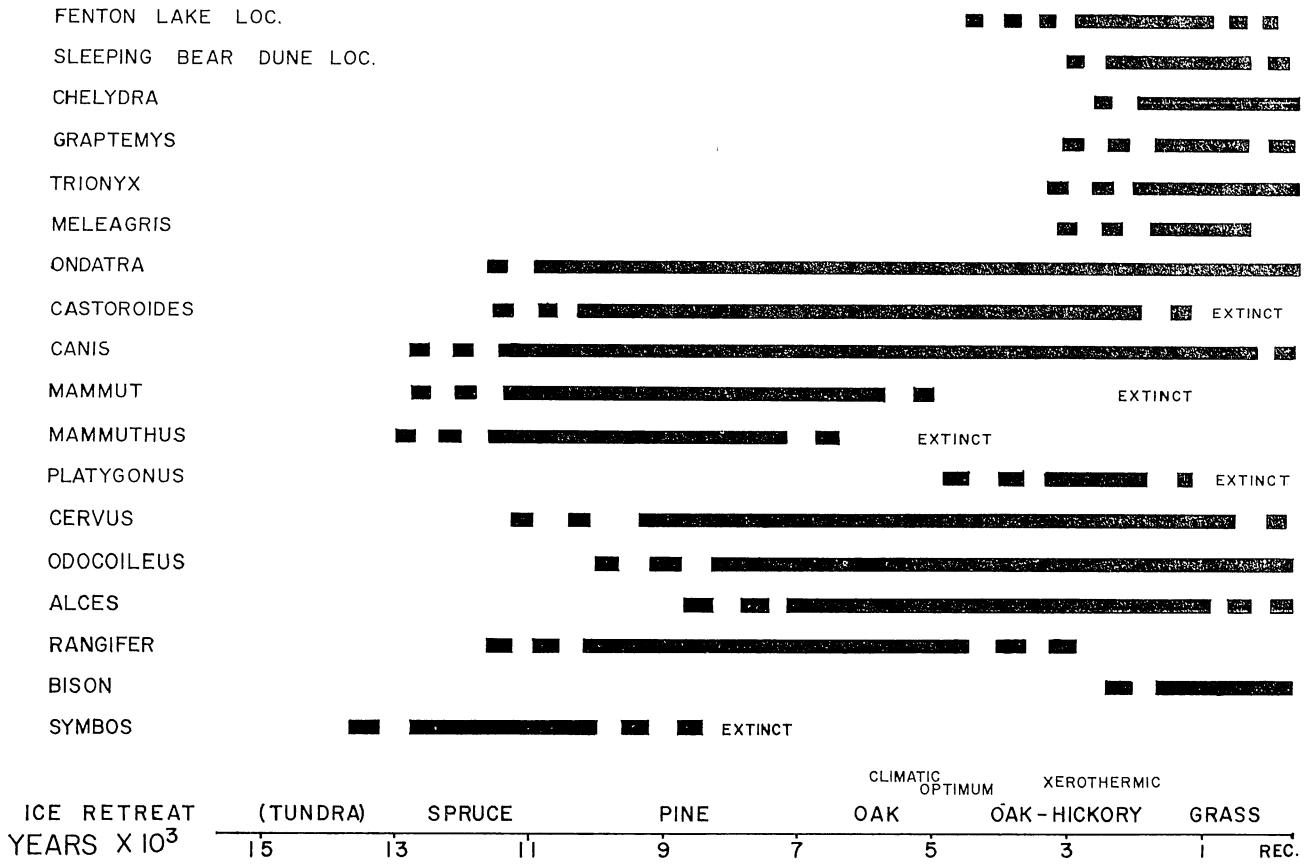

FIG. 5. Time distribution of the Michigan vertebrates and two vertebrate localities, based in part on associations, pollen, and radiocarbon dates. The morphology, as known, was a large factor in the chronological placement. This occupation is at a zone about 43° N. latitude.

most certainly the rapidly changing environment caused by climatic change.

Certain examples drawn from the Pleistocene vertebrates will illustrate the methods of correlation and thus the time of their occupation in Michigan (Fig. 5).

Three skulls of the woodland musk oxen, *Symbos cavifrons*, dated by radioactive carbon, also were studied with respect to the pollen found in the sediment inside the skulls. A specimen from the Kalamazoo Public Museum dated at 11,000 ± 400 B.P. was associated with a dominance of pine pollen (Table IV). The White Pigeon specimen was associated mainly with spruce pollen. Another musk oxen skull (UMMP 34124) was dated at 13,200 ± 600 B.P. It is suggested that *Symbos cavifrons* existed in two forest types, the spruce and later the pine (Semken and others 1964). It is also logical to suggest that the woodland musk oxen moved into Michigan with the spruce forest environment and existed into the pine forest period in spite of the rapidly changing vegetational conditions. As far as is known, extinction of *S. cavifrons* occurred during the pine period (Fig. 5).

The mammoths indicate a general type of ecological adaptation, although information on the Jefferson mammoth is inconclusive. The tooth morphology of the mammoth provides a clue to the diet of this large mammal. Skeels (1962, p. 118) states: "There is no reason to believe that the Jefferson mammoth deviated from a herbivorous, grazing mode of life." It is still not certain, however, upon which type of vegetation this mammoth grazed. The only radiocarbon date available for a Jefferson mammoth in Michigan is 8200 ± 300 B.P. years. This date was obtained from a specimen found in the extreme southwest corner of Michigan in Eau Claire, Berrien County. This date of 8200 years, and the assumed grass diet based on the teeth, indicate the possibility that *Mammuthus jeffersoni* was following the open grassland into the Michigan area.

DeVos (1964) has noted the range changes of many mammals in the Great Lakes Region. Burt (1948 and 1957) records many mammal adjustments or range retractions due to man within historic times. Vertebrates which arrived in Michigan after glaciation, such as the false map turtle and prairie vole, point to this restriction in a particular habitat. These forms provide additional information concerning climatic effects just prior to historic time.

The false map turtle, *Graptemys pseudogeographica*, provides an example of a northward range extension and then a southern

retreat (Wilson and Zug 1966). Smith (1957) utilizes the small isolated vertebrate population to show that animals found as relict groups are either increasing their ranges or were, at one time, distributed over a larger area. The false map turtle today is found in Ohio and Indiana in small isolated populations which are removed from the major distributional areas to the west and south (Conant and others 1964). The false map turtle prior to historic times, and during a warmer period of a more general climatic fluctuation, ranged northward at least to 43° 30′ latitude. Evidence provided by the relict populations, when considered with the fossil specimens, supports the conclusion that the climate today has become somewhat cooler in Michigan than it was at the time the false map turtle lived at Saginaw (Fig. 5).

The prairie vole, *Microtus ochrogaster,* found as a fossil at Sleeping Bear Dune, in Leelanau County (45° N. Lat.) further supports the idea of climatic reversal prior to historic time. This species moved northward with the grassland environment at about 2000 years ago (Fig. 5). A radiocarbon date on the prairie vole found at Sleeping Bear Dune was 730 ± 250 years B.P. (Fig. 4). Pruitt (1954) discusses the northward extension at the climatic optimum period.

Other vertebrates show distributions through time very similar to those of the false map turtle and prairie vole. Bison, for example, have not been definitely identified as fossils from Michigan due to the morphological similarity with the two forms of *Bos,* the domestic cow and the yak. Bison, however, are known to have occurred in Michigan in historic time and probably represent forms that traveled into the state at a time when the grassland was widespread.

Fig. 5 attempts to fit the vertebrates from the Michigan Pleistocene into the various vegetational or climatic zones available after glaciation.

Conclusion

All Pleistocene vertebrate fossils from Michigan are from deposits that were laid down after the last glacial retreat which began about 14,000 years ago. The larger vertebrates are found most frequently and the majority of discoveries are from deposits in the lower half of the Southern Peninsula.

The fossil vertebrate remains preserved in the lakes, streams, and bogs of Michigan are difficult to interpret stratigraphically

because of the diversity of origin of these geomorphic features. For example, a bog may be a place of burial soon after the ice retreat and yet exist at present in the same locality, still preserving the skeletal remains of vertebrates. Thus, the bog might provide a collecting place to preserve the skeletons of the various vertebrates that lived here at one time or another during the entire period beginning after the ice retreat, whereas these animals may never have existed together. The period after glaciation is a very short interval in terms of geologic time, and if it were to be studied as a deposit of an earlier geologic time the remains of life most likely would be considered as contemporaneous. As we approach historic time, the methods of dating must be modified accordingly. This change in correlation is, however, aided by the nearness to historical time. Radiocarbon dating, the associated pollen, and the ecological habits of the animals themselves provide reliable criteria to indicate the complexities of the fauna and floral changes in this time period. The ecological interpretation becomes far more reliable when living representatives of the fossil forms can be studied in conjunction with the morphology of the extinct forms. Radiocarbon can date the fossil. The ecological requirements and the associated pollen can suggest the habitat.

The apparent complexities of Wisconsin biogeography provide a broadened basis for the study of older fossil deposits. During the Pleistocene the fauna and flora might have responded much more rapidly to changes in climate than at other times in earth history; but then again, in this period close to the present these changes are more completely preserved for study.

The physical and biological events following glaciation in Michigan provide a natural experiment for the historical scientist. The retreating ice leaves a clean territory that is free of life and in a sense readied for reoccupation. The natural laboratory is set for the experiment; the successive changes of the animals and plants controlled by climatic factors are recorded in the sediments deposited after glaciation.

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LITERATURE CITED

* ALLEN, J. A. 1913. Ontogenetic and Other Variations in Muskoxen, with a Systemic Review of the Muskox Group, Recent and Extinct. Mem. Am. Mus. Nat. Hist. 1: 101-226.

* ANDERSEN, S. T. 1954. A Late-Glacial Pollen Diagram from Southern Michigan. Danmarks Geol. Unders., Ser. II, 80: 140-155.

ARNOLD, C. A. 1959. Some Paleobotanical Aspects of Tundra Development. Ecol. 40 (1): 146-148.

BANFIELD, A. W. F. 1961. A Revision of the Reindeer and Caribou, Genus *Rangifer*. Nat. Mus. Can. Bull. 177: 1-137.

BARNEY, R. L. 1926. The Distribution of the Fresh Water Sheepshead *Aplodinotus grunniens* Rafinesque, in Respect to the Glacial History of North America. Ecol. 7: 351-364.

* BENNINGHOFF, W. S., AND C. W. HIBBARD. 1961. Fossil Pollen Associated with a Late Glacial Woodland Musk Ox in Michigan. Pap. Mich. Acad. 46: 155-159.

BLAIR, W. F., A. P. BLAIR, PIERCE BRODKORB, F. R. CAGLE, AND G. A. MOORE. 1957. Vertebrates of the United States. New York: McGraw-Hill. 819 pp.

* BURT, W. H. 1942. A Caribou Antler from the Lower Peninsula of Michigan. Jour. Mamm. 23 (2): 214.

——. 1948. The Mammals of Michigan. Ann Arbor: Univ. Mich. Press. 288 pp.

——. 1957. Mammals of the Great Lakes Region. Ann Arbor: Univ. Mich. Press. 246 pp.

* CASE, E. C. 1915. On a Nearly Complete Skull of *Symbos cavifrons* Leidy from Michigan. Univ. Mich. Occ. Pap. Mus. Zool. 13: 1-3.

* ——. 1921. Something about the Paleontological Collections in the University. Mich. Alumnus 27: 292-300.

* —— AND G. M. STANLEY. 1935. The Bloomfield Hills Mastodon. Cranbrook Inst. Sci. Bull. 4: 1-8.

* —— AND OTHERS. 1935. Discovery of *Elephas primigenius americanus* in the Bed of Glacial Lake Mogodore, in Cass County, Michigan. Pap. Mich. Acad. 20: 449-454.

CONANT, RODGER. 1958. A Field Guide to Reptiles and Amphibians of the United States and Canada East of the 100th Meridian. Boston, Mass.: Houghton Mifflin. 366 pp.

——, M. B. TRAUTMAN, AND E. B. MCLEAN. 1964. The False Map Turtle, *Graptemys pseudogeographica* (Gray), in Ohio. Copeia (1964) 1: 212-213.

* CRANE, H. R. 1956. University of Michigan Radiocarbon Dates I. Science 124: 664-672.

* —— AND J. B. GRIFFIN. 1958. University of Michigan Radiocarbon Dates II. Science 127: 1098-1105.

* —— AND J. B. GRIFFIN. 1959. University of Michigan Radiocarbon Dates IV. Am. Jour. Sci., Radiocarbon Suppl. 1: 173-198.

DANSEREAU, PIERRE. 1953. The Postglacial Pine Period. Trans. Royal. Soc. Can. 47: 23-38.

DEEVEY, E. S., AND R. F. FLINT. 1957. Postglacial Hypsithermal Interval. Science 125 (3240): 182-184.

DE VOS, ANTOON. 1964. Range Changes of Mammals in the Great Lakes Region. Am. Midl. Nat. 71 (1): 210-231.

* DICE, L. R. 1920. The Mammals of Warren Woods, Berrien County, Michigan. Univ. Mich. Occ. Pap., Mus. Zool. 86: 1-20.

DILLON, L. S. 1956. Wisconsin Climate and Life Zones in North America. Science 123: 167-176.

FLINT, R. F. 1956. New Radiocarbon Dates and Late Pleistocene Stratigraphy. Am. Jour. Sci. 254: 265-287.

——. 1957. Glacial and Pleistocene Geology. New York: John Wiley and Sons, Inc. 553 pp.

—— AND F. BRANDTNER. 1961. Climatic Changes Since the Last Interglacial. Am. Jour. Sci. 259: 321-328.

* FOOTE, E. A. 1919. Report of the Pioneer Society of Michigan. 3: 402-403.

FRANKFORTER, W. D. 1966. Some Recent Discoveries of Late Pleistocene Fossils in Western Michigan. Pap. Mich. Acad. 51: 209-220.

FULLER, G. D. 1935. Postglacial Vegetation of the Lake Michigan Region. Ecol. 16: 473-487.

* GATES, D. M. 1939. A Deposit of Mammal Bones under Sleeping Bear Dune. Trans. Kan. Acad. Sci. 42: 337-338.

* GATES, F. C. 1950. The Disappearing Sleeping Bear Dune. Ecol. 31: 386-392.

* GIDLEY, J. W. 1908. Descriptions of Two New Species of Pleistocene Ruminants of the Genera *Ovibos and Bootherium*, with Notes on the Latter Genus. Proc. U. S. Nat. Mus. 34: 681-684.

* GILMORE, C. W. 1906. Notes on Some Recent Additions to the Exhibition Series of Vertebrate Fossils. Proc. U. S. Nat. Mus. 30: 610.

* HANDLEY, C. O., JR. 1953. Marine Mammals in Michigan Pleistocene Beaches. Jour. Mamm. 34 (2): 252-253.

* HATT, R. T. 1924. The Land Vertebrate Communities of Western Leelanau County, Michigan, with Annotated List of the Mammals of the County. Pap. Mich. Acad. 3: 369-402.

* ——. 1963. The Mastodon of Pontiac. News Letter, Cranbrook Inst. Sci. 32 (6) : 62-64.

* HAY, O. P. 1915. Contributions to the Knowledge of the Mammals of the Pleistocene of North America. Proc. U.S. Nat. Mus. 48: 515-575.

* ——. 1923. The Pleistocene of North America and Its Vertebrated Animals from the States East of the Mississippi River and from the Canadian Provinces East of Longitude 95°. Carnegie Inst. Wash. Pub. 322: 1-499.

* HIBBARD, C. W. 1951. Animal Life in Michigan during the Ice Age. Mich. Alumnus Quart. Rev. 57 (18) : 200-208.

* ——. 1952. Remains of the Barren Ground Caribou in Pleistocene Deposits of Michigan. Pap. Mich. Acad. 37: 235-237.

* —— AND F. J. HINDS. 1960. A Radiocarbon Date for a Woodland Musk Ox in Michigan. Pap. Mich. Acad. 45: 103-108.

* HIBBARD, E. A. 1958. Occurrence of the Extinct Moose, *Cervalces,* in the Pleistocene of Michigan. Pap. Mich. Acad. 43: 33-37.

* HINSDALE, W. B. 1925. Primitive Man in Michigan. Univ. Mich., Univ. Mus., Mich. Handbook Series 1: 1-194.

HOARE, R. D. 1964. Radiocarbon Date on Pleistocene Peccary Find in Sandusky County, Ohio. Ohio Jour. Sci. 64 (6) : 427.

HOUGH, J. L. 1958. Geology of the Great Lakes. Urbana: Univ. Ill. Press. 296 pp.

*HUBBARD, BELA. 1841. Joint Documents of the House of Representatives of Michigan: 559.

* HUBBS, C. L. 1940. The Cranium of a Fresh-Water Sheepshead from Post-glacial Marl in Cheboygan County, Michigan. Pap. Mich. Acad. 25: 293-296.

* —— AND K. F. LAGLER. 1947. Fishes of the Great Lakes Region. Cranbrook Inst. Sci. Bull. 26: 1-186.

* HUSSEY, R. C. 1930. Items. Science (n.s.) 72 (1875) : xiv.

* LANE, A. C. 1902. Report of the State Board of the Geological Survey of Michigan for the Year 1901: 252-253.

* ——. 1905. Mastodon in Bay County. Geol. Surv. Mich. 7th Ann. Rep., 1905: 553.

* LANMAN, J. H. 1839. History of Michigan. 258 pp.

* LAPHAM, I. A. 1885. On the Number of Teeth of the *Mastodon giganteus.* Proc. Bost. Soc. Nat. Hist. 5: 133.

LEVERETT, F., AND F. B. TAYLOR. 1915. The Pleistocene of Indiana and Michigan and the History of the Great Lakes. U.S.G.S. Mon. 53.

* MACALPIN, ARCHIE. 1940. A Census of Mastodon Remains in Michigan. Pap. Mich. Acad. 25: 481-490.

* MACCURDY, H. M. 1919. Mastodon Remains Found in Gratiot County, Michigan. Mich. Acad. Sci. Rep. 21: 109-110.

* MIKULA, E. J. 1964. Evidence of Pleistocene Habitation by Woodland Caribou in Southern Michigan. Jour. Mamm. 45 (3) : 494-495.

* OLTZ, D. F., JR., AND R. O. KAPP. 1963. Plant Remains Associated with Mastodon and Mammoth Remains in Central Michigan. Am. Midl. Nat. 70 (2) : 339-346.

* PILLERI, GEORG. 1961. Das Gehirn (endocranialausguss) von *Castoroides ohionensis* (Foster, 1838) (Rodentia, Castoridae) und vergleichend-anatomische Beziehungen zum Gehirn des rezenten Kanadischen Bibers. Acta. Anat. 44 (2) : 36-82.

* POTTS, R. 1959. Michigan Mammoth. Nat. Mag. 52 (9) : 471-472.

POTZGER, J. E. 1946. Phytosociology of the Primeval Forest in Central-Northern Wisconsin and Upper Michigan, and a Brief Post-Glacial History of the Lake and Forest Formation. Ecol. Mon. 16 (10) : 211-250.

* PRUITT, WM. O., JR. 1954. Additional Animal Remains from under Sleeping Bear Dune, Leelanau County, Michigan. Pap. Mich. Acad. 39: 253-256.

RUSSELL, I. C., AND FRANK LEVERETT. 1915. Description of the Ann Arbor Quadrangle. U.S.G.S. Folio 155: 1-18.

SEARS, P. B. 1942. Postglacial Migration of Five Forest Genera. Am. Jour. Bot. 29: 684-691.

——. 1948. Forest Sequence and Climatic Change in Northeastern North America since Early Wisconsin Time. Ecol. 29: 326-333.

* SEMKEN, H. A., B. B. MILLER, AND J. B. STEVENS. 1964. Late Wisconsin Woodland Musk Oxen in Association with Pollen and Invertebrates from Michigan. Jour. Paleon. 38 (5) : 823-835.

* SHERZER, W. H. 1927. A New Find of the Woolly Elephant in Michigan. Science 65 (1695) : 616.

* SKEELS, M. A. 1962. The Mastodons and Mammoths of Michigan. Pap. Mich. Acad. 47: 101-133.

SMITH, P. W. 1957. An Analysis of Post-Wisconsin Biogeography of the Prairie Peninsula Region Based on Distributional Phenomena among Terrestrial Vertebrate Populations. Ecol. 38 (2) : 205-218.

TURNBULL, W. D. 1958. Notice of a Late Wisconsin Mastodon. Jour. Geol. 66 (1) : 96-97.

* WAGNER, GEORGE. 1903. Observations of *Platygonus compressus* Le Conte. Jour. Geol. 11: 777-782.

* WARREN, J. C. 1855. Supernumerary Tooth in *Mastodon giganteus.* Am. Jour. Sci. 19 (2) : 348-353.

WILSON, I. T., AND J. E. POTZGER. 1943. Pollen Study of Sediments from Douglas Lake, Cheboygan County, and Middle Fish Lake, Montmorency County, Michigan. Ind. Acad. Sci. 52: 87-92.

*WILSON, R. L., AND G. R. ZUG. 1966. A Fossil Map Turtle (*Graptemys pseudogeographica*) from Central Michigan. Copeia, 1966 (2) : 368-369.

* WINCHELL, ALEXANDER. 1861. 1st Bien. Rep. State. Geologist: 132.

* ——. 1863. Description of Elephantine Molars in the Museum of the University. Can. Natl. and Geol. 8: 398-400.

* ——. 1864. Notice of the Remains of a Mastodon Recently Discovered in Michigan. Am. Jour. Sci. 38: 223-224.

* ——. 1888. Extinct Peccary in Michigan. Am. Geol., Personal and scientific news, 1: 67.

* WOOD, N. A. 1914. Two Undescribed Specimens of *Castoroides ohioensis* Foster from Michigan. Science (n.s.) 39: 758-759.

WRIGHT, H. E., JR. 1964a. Aspects of the Early Postglacial Forest Succession in the Great Lakes Region. Ecol. 45 (3) : 439-448.

——. 1964b. The Classification of the Wisconsin Glacial Stage. Jour. Geol. 72 (5) : 628-637.

* ZUMBERGE, J. H., AND J. E. POTZGER. 1955. Pollen Profiles, Radiocarbon Dating, and Geologic Chronology of the Lake Michigan Basin. Science 121: 309-311.

* —— AND J. E. POTZGER. 1956. Late Wisconsin Chronology of the Lake Michigan Basin Correlated with Pollen Studies. Bull. Geol. Soc. Am. 67 (5) : 271-288.