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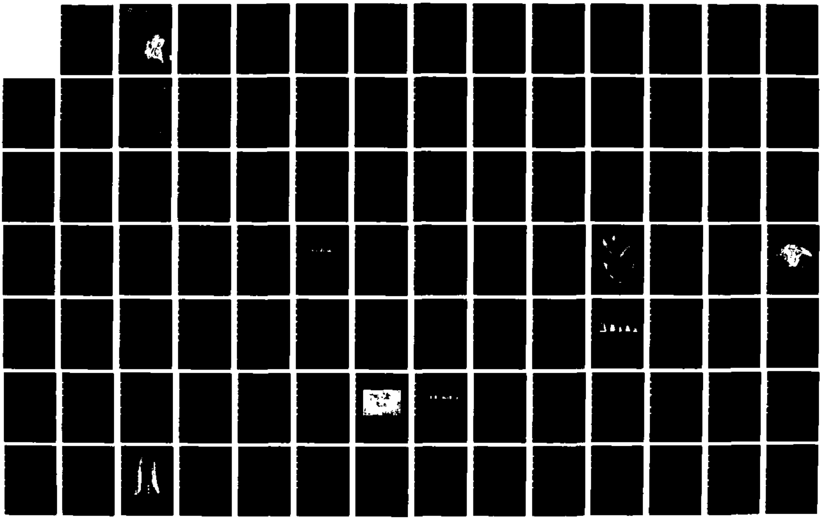

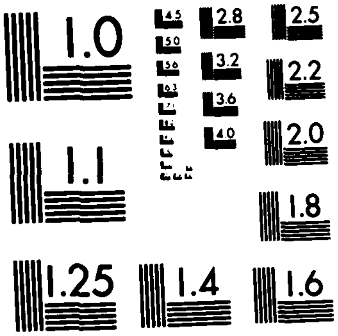

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US Army Corps
of Engineers
Kansas City District

Harry S. Truman Dam and Reservoir, Missouri

Illinois State Museum
Springfield, Illinois

Mitigation of the Adverse Effects Upon the Local Paleontological Resources

Volume I

By Jeffrey J. Saunders, Ph.D

January 1983

DACW41-77-C-0096

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SUPPLEMENTARY NOTES

Popular account of this investigation is available in the 1983 published report: Harry S. Truman Dam and Reservoir, Missouri, Ice Age Climates: Plants and Animals of WesternMissouri: A 50,000 Year Records of Change (completed under the same contract number)

KEY WORDS (Continue on reverse side if necessary and identify by block number)

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Pomme de Terre River Valley

ABSTRACT (Continue on reverse side if necessary and identify by block number)

Paleontological excavations were conducted at Jones Spring in 1977 and at rolinger Spring in 1978 and 1979. Results of excavations conducted at Trolinge pring in 1967 and 1968, at Boney Spring in 1968 and 1971, and at Jones Spring n 1973, 1975 and 1976 are reported and provide an understanding of the geology nd paleontology of late Pleistocene spring deposits occuring in the western zark Highland, Missouri.

Two fossil assemblages are described from Trolinger Spring deposits. The arlier assemblage contained 118 referred fossil vertebrate specimens representing

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) grazing fauna, co-dominated by mammoth and bison. Plant macrofossils indicated that a deciduous community dominated the landscape during this interval. The later assemblage contained 385 referred fossil vertebrate specimens represented by a browsing fauna, dominated by mastodon. Associated pollen indicate that an open pine-parkland community existed during this interval.

The Jones Spring fossil assemblage contained 812 referred fossil vertebrate specimens. Accumulation occurred during the interval 40,000 - 49,000 years ago and was episodic or punctuated. Discrete faunas could not be isolated in Jones Spring sediments. Plant macrofossils of deciduous species, dated at 48,900 years ago, were associated with the vertebrate fossils in the basal sediments. Pollen associated with the vertebrate fossils in overlying sediments indicate that the earlier deciduous community was succeeded by an open pine-parkland community before 40,000 years ago.

In the project area mastodons inhabited, dominantly, open pine-parkland as well as forests of spruce mixed with deciduous species. A previous adaptation to pine was complete by 49,000 years ago and evidenced again 34,000 years ago. A subsequent adaptation to spruce is evidenced 13,500 years ago. The mastodon sample from this period included a higher proportion of prime individuals than did two earlier samples and indicates that self-regulation was occurring just prior to their extinction. This suggests that extinction of mastodons was the consequence of the development approximately 12,000 years ago of warm conditions that favored deciduous communities for which mastodons had no adaptations.

Taxa reported from late Pleistocene deposits in Missorui for the first time are: TRIONYX sp., ALLIGATOR MISSISSIPIENSIS, EQUUS cf. SCOTTI, EQUUS CALOBATUS or E. HEMIONUS and BISON LATIFRONS.

MITIGATION OF THE ADVERSE EFFECTS UPON THE LOCAL PALEONTOLOGICAL RESOURCES OF THE HARRY S. TRUMAN DAM AND RESERVOIR OSAGE RIVER BASIN, MISSOURI

FINAL REPORT OF FINDINGS
VOLUME I: TEXT

by

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Prepared for Kansas City District
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with
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September 1982

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ACKNOWLEDGMENTS

The endeavor reported here has been a source of great enjoyment for me. Acknowledgments provide an opportunity to remember and I do this with pleasure for the field seasons represented here have presented me with an abundance of fond memories. These memories are of people, of animals, of occasions and of inanimate objects as well, if a river can be said to be inanimate.

The work reported here actually began in 1973 at Jones Spring under the direction of James E. King. His work, which became our work and, finally, my work, was supported in 1973 by a grant from the National Science Foundation. This source of support continued during 1975 and 1976, supplemented by a contract with the Kansas City District, U.S. Army Corps of Engineers. From 1977 through 1979 all work was performed under contact with the Kansas City District, U.S. Army Corps of Engineers. EARTHWATCH, Belmont, Massachusetts, provided field crew members, allayed their expenses and provided some funds for field work during 1977.

The field work reported here was conducted out of Heritage, Hickory County, Missouri and this became our summer home during 1973 and again du ing 1975 through 1979. I am especially appreciative of many services and much assistance provided by local townspeople, many of whom came to be ou very good friends and all of whom, it seemed, came to view the "bone digge as part-time residents. For providing us with lodging and for going out of their way to make us feel welcome and at home, I especially thank Jesse and Rose Kaufman, Hugo and Kathleen Liedtke and Red and Gloria Merritt. Ivan and Goldena Trolinger made us feel at home in Avery and on their former property, the site of Trolinger Spring. Jesse Kaufman provided expert backhoe service to our program, in addition to many good ideas and suggestions. Harold Musselman did equally good work for us after Jesse's retirement. Hickory County residents also came to our service as site attendents during our absences in the evenings and on our days off. Often these periods witnessed, or were occasioned by, severe thunderstorms, during which our site attendents worked above and beyond their normal duties of "site-sitting". It is with appreciation and gratitude that I thank our "night watch," which over the years included Dennis and Walter Hutton, Chip Hyzer, Joe Kennedy and Hugo Liedtke, as well as the volunteered services of Bob Kennedy.

The "bone diggings" received the interest of many people residing in west-central Missouri and many came to visit our excavations and excavators from time to time. Among our visitors were several who, after repeated visits early in our program, came to be a part of our endeavor by contributing their assistance in many areas. Here I wish to thank Kenny Lasswell, Ike Parker and Dan White of Clinton, Missouri, and to remember our deceased friend Herb Brown.

Numerous colleagues contributed their time, ideas and expertise during the course of this research program. In all instances assistance was far in excess of any financial compensation. Among these I especially thank William H. Allen, G. Robert Brakenridge, Beth Dawson-Saunders, Oscar Hawksley, C. Vance Haynes, David Hoffman, Donald L. Johnson, Marvin Kay, Frances B. King, James E. King, Curtis McKinney, R. Bruce McMillan, Gifford Miller, James R. Purdue, Viola Rawn, Barney J. Szabo, Tom Thompson, Ronald Ward and W. Raymond Wood.

Without field crews, this work would not have been accomplished. I have been extremely fortunate to work with field crews composed of amiable and well qualified individuals. Many of these returned year after year, and came to enthusiastically view this research program as their own. Under the category of "bone digger" I gratefully acknowledge Deborah Adams, Chip Allen, Jon Baskin, LaRamie Bina, Francine Bonello, Ken Cole, Peggy Corman, Mickey Dummitt, Barb Dutrow, Elisabeth Evans, Lorrie Farrington, Jessica Harrison, Lisa Haynes, Clark Hood, Lou Jacobs, David Johnson, Mary Ann Jones, Susan Kerndt, Sally LaMarche, Peter Lautze, David Lindsay, Leo Lindsay, Jeanne Lundquist, Claire Martin, Alex McCord, Nancy Natchway, Karin Olsson, Linda Peden, Ann Reed, Linda Rice, Kent Robinson, Jack Rodgers, Tom Shirley, Bryan Stepanek, Karen Svoboda, Jane Tiers and Ed Ward. In addition many old friends and new acquaintances volunteered their vacations, weekends, or simply days off to participate as excavators. Among these I thank Duncan Carlsmith, Curt Dawson, Bill Easton, Bonnie Fine, Larry Flynn, Debra Greear, Dick Haskin, Kelly Hood, Patricia Hood, Don Hotalling, Scott King, Mark Lurton, Stanley Lurton, Virginia McMillan, Mike Pasenko, Nancy Sallee, Lou Taylor, Mary Taylor and George Trussel.

To all of the aforementioned: "Thanks, you guys."

Gale Marr drew the excavation maps appearing in VOLUME II: PLAN MAPS OF EXCAVATIONS. Original text figures were drawn by William C. Stone. Photographs appearing in the text were produced by Marlin W. Roos. The cover illustration is a soft-ground etching of a mammoth done by Gregory E. Dawson.

ABSTRACT

Paleontological excavations were conducted at Jones Spring in 1977 and at Trolinger Spring in 1978 and 1979. Results of earlier excavations conducted at Trolinger Spring in 1967 and 1968, at Boney Spring in 1968 and 1971, and at Jones Spring in 1973, 1975 and 1976 are reported and together add to an understanding of the geology and paleontology of late Pleistocene spring deposits occurring in the western Ozark Highland, Missouri.

Two fossil assemblages are described from Trolinger Spring deposits. The earlier assemblage contained 118 referred fossil vertebrate specimens. Accumulation occurred prior to 35,000 years ago. The assemblage represented a grazing fauna, co-dominated by mammoth and bison. Associated plant macrofossils indicate that a deciduous community dominated the landscape during this interval. The later assemblage contained 385 referred fossil vertebrate specimens. Accumulation occurred sometime during the interval 29,000-34,000 years ago. This assemblage represented a browsing fauna, dominated by mastodon. Associated pollen indicate that an open pine-parkland community existed in western Missouri during this interval.

The Jones Spring fossil assemblage contained 812 referred fossil vertebrate specimens. Accumulation occurred during the interval >40,000-49,000 years ago and was episodic or punctuated. Discrete faunas could not be isolated in Jones Spring sediments and the fauna is treated as a single, diverse assemblage lacking temporal and environmental unity. The fauna was dominated by mastodons. Plant macrofossils of deciduous species, dated at 48,900 years ago, were associated with the vertebrate fossils in the basal sediments. Pollen associated with the vertebrate fossils in overlying sediments indicate that the earlier deciduous community was succeeded by an open pine-parkland community before 40,000 years ago.

Geological characteristics of spring site fossil assemblages include (1) coarse and fine-grained sediments, (2) variable proportion of the sedimentary particles are fossil remains, (3) specimen long axes lack preferred orientation(s), and (4) specimen long axes have a preferred attitude in bone bed concentrations and lack this in dispersed, nonconcentrated, accumulations. Biological characteristics include (1) the remains of animals that inhabited the site or frequented the immediate area but not the remains of animals that were transported to the site from outside the immediate area, (2) mostly dissociated, variably dispersed animal remains, and (3) sample age structures of the dominant taxon, *Mammut americanum*, that point to the catastrophic or mixed but not solely attritional nature of mortality.

In the project area mastodons inhabited, dominantly, open pine-parkland as well as forests of spruce mixed with deciduous species but had different morphological adaptations to each. A previous adaptation to pine was complete by 49,000 years ago and is evidenced again 34,000 years ago. This included general small size and rugged cheek teeth. A subsequent adaptation to spruce is evidenced 13,500 years ago. This included increased size and smooth cheek teeth. The mastodon sample from 13,500 years ago included a higher proportion of prime individuals than did two earlier samples and indicates that self-regulation was occurring in mastodons just prior to their extinction. This suggests that extinction of mastodons was the consequence of the development approximately 12,000 years ago of warm conditions that favored deciduous communities for which mastodons had no adaptations.

Taxa reported from late Pleistocene deposits in Missouri for the first time are: *Trionyx* sp., *Alligator mississipiensis*, *Equus* cf. *scotti*, *Equus calobatus* or *E. hemionus* and *Bison latifrons*.

INTRODUCTION

Physical Setting

The spring sites reported here occur along the lower Pomme de Terre River valley in northern Hickory County, Missouri (Fig. 1). Geographically, this area is in southwestern Missouri near the boundary of the Ozark Plateaus and Cherokee Lowland physiographic provinces (Fenneman 1938). The Ozark Plateaus represent ancient, deeply eroded surfaces generally expressed as hills and rugged intervening stream-cut valleys.

The Pomme de Terre River is typical of the generally less vigorous western Ozark streams. It meanders northward along a 162 km (100 mile) course from its headwaters in western Webster County, 24 km northwest of Springfield, Missouri, to its confluence with the Osage River 7 km south of Warsaw in Benton County. Along this course in antiquity meanders were occasionally cut off, leaving abandoned, U-shaped valleys enclosing a "lost hill" (Bretz 1965: 113). Such an abandoned meander, enclosing a "lost hill", locally called the Breshears Bottom after earliest settlers, contains the spring sites reported here (Fig. 1).

In the reported area, the bluff tops lie 60 to 90 m above the valley floor; the latter averages approximately 206 m above mean sea level. The bluffs along the lower Pomme de Terre River valley are formed by the Jefferson City dolomite of Lower Ordovician age. Chert is abundant in this formation and resistant to both mechanical erosion and chemical solution. For this reason a chert residuum overlies the bedrock surfaces and is abundant, as gravel, along the bed of the river and in the surficial alluvium, including spring deposits.

Trolinger and Jones springs occur within alluvial terraces bordering the Pomme de Terre River. These terraces represent late Pleistocene high-river levels (Haynes 1976). During the formation of these terraces, artesian discharge formed numerous springs that are now expressed as low marshy areas, sometimes developed as ponds, along the river bottomlands.

Trolinger and Jones spring sediments cut floodplain alluvium deposited by the Pomme de Terre River while it still occupied the Breshears meander prior to 30,000 years ago. The stratigraphy within Trolinger Spring reflects a general history of diminishing discharge. That in Jones Spring reflects a history of diminishing discharge interrupted by several, possibly vigorous or eruptive, periods of rejuvenation.

Review of Background Research

The Pomme de Terre River valley has a long history of paleontological investigations. The Koch Site (Fig. 1) is the location of excavations conducted by Albert C. Koch, proprietor of the St. Louis Museum, during the last century. From well preserved remains of mastodons recovered there in 1840, Koch assembled a composite skeleton of the "Missourium", an imaginative creature with

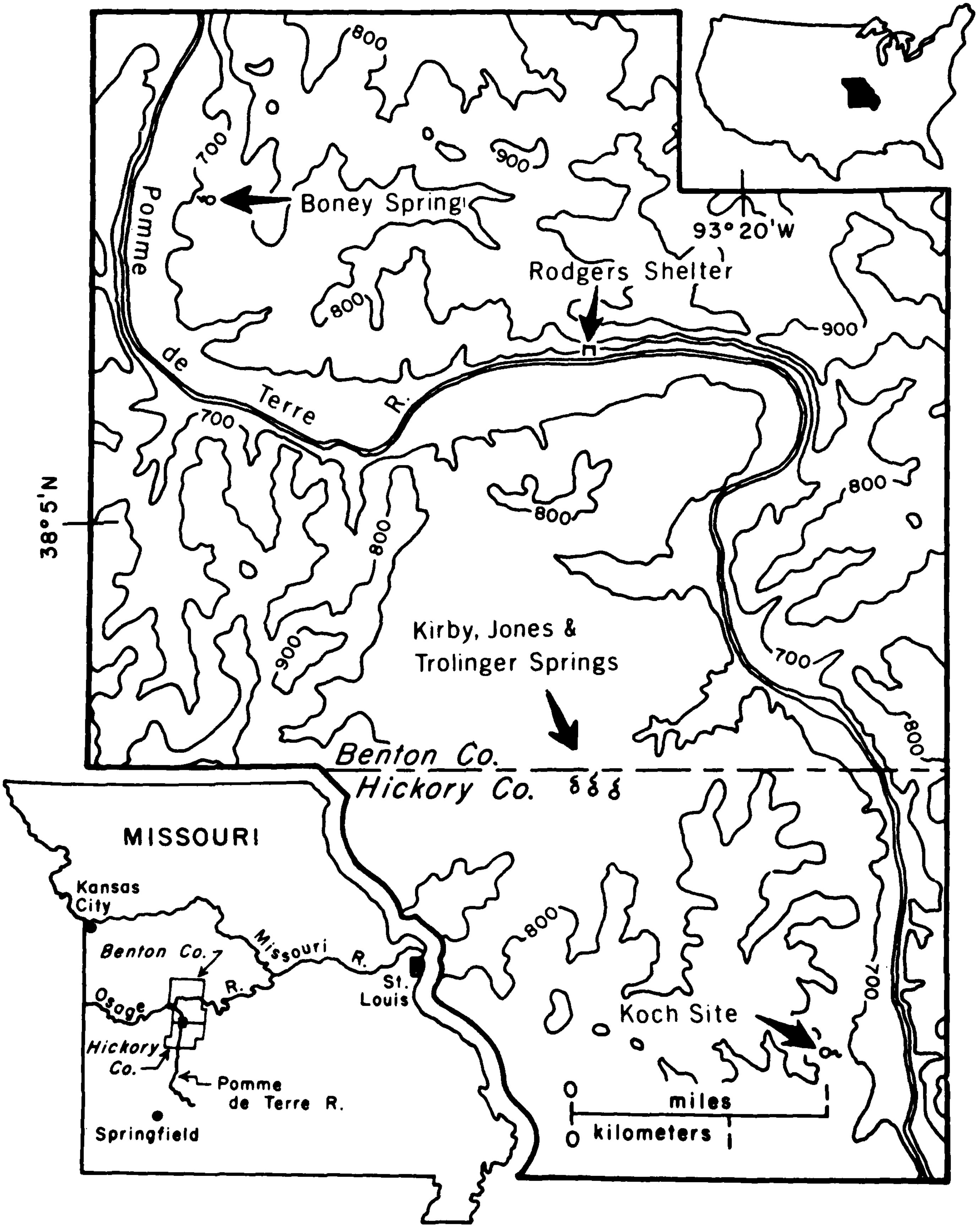

Figure 1. Map showing the location of sites mentioned in this report.

moustach-like tusks and webbed feet. In 1843 this skeleton, and other portions of Koch's extensive collection of mastodon and other fossils, were sold to the British Museum (Natural History). Sir Richard Owen recognized that Koch's "Missourium" was in fact a misconstructed mastodon and took corrective measures to restore it as *Mastodon americanus* (=*Mammut americanum*). The restored mount is currently exhibited in the galleries of the British Museum (Natural History) in London, with a label identifying it as having been recovered from the Pleistocene of Missouri, U.S.A.

A current phase of Pomme de Terre River valley investigations, of which this report is a contribution, began in 1963 as an archaeological salvage program at Rodgers Shelter, Benton County (Fig. 1). The absence of pollen in the Rodgers Shelter sediments focused attention on nearby springs, including Boney Spring in Benton County. Boney Spring was sampled with a corer in 1966. During this process, tusk and bone fragments were recovered. With this discovery, interest in the proposed impoundment area expanded to include vertebrate paleontology. The following summer (1967) the bone bed and peat deposits in Trolinger Spring were discovered.

Initial excavation of Trolinger Spring was conducted during the summers of 1967 and 1968. E. H. Lindsay, University of Arizona, Tucson, was in charge of the paleontological recovery. The method involved trenching the spring periphery to isolate the fossiliferous deposits and to expose stratigraphy of the spring margins. Excavation proceeded systematically by levels and resulted in the excavation of about one-half of the total deposit exposed by trenching. During this period of excavation, conducted by funds provided by the National Science Foundation in a grant to R. W. Wood and R. B. McMillan, 135 fossil vertebrate specimens representing seven mammalian taxa were recovered (Mehringer, King and Lindsay 1970; Saunders 1977a).

I joined the western Ozarks research program during 1971 when excavation, begun in 1968, was renewed and completed at Boney Spring; the Koch Site was reexcavated; and Jones and Kirby springs were sampled. Tests at the Koch Site and Kirby Spring determined that these spring sites had been excavated in a search for fossil bones during the last century and that no significant faunal concentrations remained *in situ* in their sediments.

Jones Spring was discovered to be fossiliferous by James E. King in 1971 during the initial phases of a search for additional, potentially fossiliferous spring sites in the lower Pomme de Terre River valley in southern Benton and northern Hickory counties, or from Fairfield (since abandoned) south to Williams Bend (see King 1975). Test trenching during that summer revealed proboscidean tusk fragments and turtle bones occurring in a rich peat developed beneath the modern spring surface. In 1973 a single 6" well casing was driven into the spring, near its present-day center and water was pumped and diverted from the spring, enabling formal excavations to begin during the month of July. More than 175 fossils were recovered in this phase of the program, conducted principally with funds from a National Science Foundation grant to James E. King. The faunal concentration in Jones Spring proved to be more extensive than originally anticipated, and during the summers of 1975, 1976 and 1977 excavations there continued, resulting in the recovery of 903 additional fossil specimens. At the end of the 1977 season, no further excavations were planned for Jones Spring.

Up to 1976 these investigations had been principally funded by grant awards, dominately from the National Science Foundation. Subsequent vertebrate paleontological activities, including one season of field work to complete excavation of Jones Spring (1977) and two seasons of field work to renew and complete excavation of Trolinger Spring (1978, 1979), have been supported by the

U.S. Army Corps of Engineers, Kansas City District, by contract with the Illinois State Museum Society. The results of this later phase of current investigations are reported below.

Study Approach

Problem orientation and research design

This study encompasses the report of systematic excavation of two Pleistocene spring sites occurring within the Pomme de Terre arm of the Harry S. Truman Dam and Reservoir project in west-central Missouri. These sites are Trolinger Spring and Jones Spring. Selection of these sites was made following an analysis of the material previously recovered from these localities. This report also includes the presentation and analysis of the recovered data.

The Pomme de Terre River valley in southern Benton and northern Hickory counties, Missouri, remains the most paleontologically significant region in the project area. There had been conducted, as contracted by the Kansas City District, U.S. Army Corps of Engineers, two paleontological resources surveys for additional, potentially important late Pleistocene spring sites in the Harry S. Truman Project area. The first, conducted by James E. King, Illinois State Museum, explored the lower Pomme de Terre River valley in Benton and Hickory counties (King 1975). The second, conducted by this writer, explored the valleys of the Tebo, South Grand and Osage arms of the project area in Bates, Benton, Cedar, Henry, St. Clair and Vernon counties (Saunders 1977b). Both of these surveys, while useful and necessary, discovered no additional springs with potential for full-scale excavation of fossil remains. There were several interesting discoveries made during these surveys, however, including notably, the result of tests by King (1975) in Phillips Spring, Hickory County, as well as the recovery of a mastodon tooth fragment and proboscidean bone fragments by this writer during test trenching of White Sulphur Springs, Benton County (Saunders 1977b:26, 28). It was concluded nevertheless to forego preparing for excavations at the latter locality in favor of completing excavation of known localities which had previously been sampled. Boney Spring, Benton County, had demonstrated the quantum difference between extensive sampling and complete excavation of a bone bed from point of view of research conclusions. Sampling requires that conclusions be weighed relative to subjective confidence in techniques and other biases. Full and total excavation, on the other hand, enables more confidently derived conclusions from the data set. The merit of this decision is apparent, I believe, when the earlier Trolinger Spring sample (Saunders 1977a) is compared with the results and conclusions of total excavation reported here.

Hypotheses and conclusions previously generated have, as an initial approximation, geologically and biologically characterized these as low energy, intermittent spring environments (King 1973; Haynes 1976; Saunders 1977a). Springs as sedimentary environments have not received prior attention and those along the lower Pomme de Terre River are providing the basis for initial understanding. In addition, these excavations are providing Pleistocene faunas tied to initial chronological and paleoecological frameworks. Further refinement of initial approximation in both these categories (sedimentary environment and faunal reconstruction) requires complete recovery and analysis of the late Pleistocene records from already well sampled spring sites. The following brief statements summarize the scope of work conducted at each of these spring sites.

Boney Spring. Materials recovered from this site in 1968 and 1971 were studied for comparison of a full-glacial Wisconsinan fauna and flora with the earlier faunas and floras from Trolinger and Jones springs. These materials also enabled resolution of the question of man and mastodon association in the project area. In addition further sampling at this locality was directed toward resolution and refinement of the stratigraphic framework in this portion of the project area.

Trolinger Spring. Work was directed toward a complete recovery of the late Pleistocene record and provided for comparison with spatially adjacent but temporally removed Boney and Jones springs.

Jones Spring. Work was directed toward a better understanding of the ecological flexibility of each fossil taxon, particularly the mammoth and mastodon, as well as to a comparison with spatially adjacent but temporally removed Boney and Trolinger springs. In addition, this work provided the populational variation required for taxonomic determination of *Mammuthus* in Missouri.

The results reported below are integral to a now evolved research program in vertebrate paleontology in western Missouri aimed at elucidating and understanding 1) taxa; 2) intrasite patterning; 3) intersite faunal similarities and differences tied to chronologically controlled varying climatic phases, paleoenvironments and/or depositional history; 4) processes and modes of faunal accumulation; 5) paleoecology; 6) microevolution among populations; and 7) general synthesis. These aspects of vertebrate paleontology are or will be contributions to an interdisciplinary research program directed toward the understanding of the late Quaternary geological and biological history of the western Ozark Highland, Missouri.

Methodology

The methodology guiding field excavations and subsequent laboratory analyses of materials recovered from each spring site was similar. This methodology was first and foremost the systematic recovery of each fossil specimen from an excavation maintained to facilitate precise documentation of all removed objects, as explained more fully below. Laboratory procedures and formal analyses were conducted in the laboratories of the Illinois State Museum, Springfield, where all reported materials, notebooks, maps and data forms are stored.

Field methodology. Because both springs are part of a single research design developed during the past fourteen years, field procedures were the same for each site. In both cases, excavations were based on procedures and techniques maximizing data recovery within a stratigraphically controlled framework.

During the summer of 1978, and continuing and concluding during the summer of 1979 excavation of Trolinger Spring was renewed. This phase of the Trolinger Spring program was conducted under contract with the U.S. Army Corps of Engineers, Kansas City District (Contract No. DACW41-77-C-0096). The previous excavation walls, covered with polyethylene sheeting at the close of the 1968 season then back-filled, were first re-exposed and compared with maps and photographs of the earlier excavations. A steel pin, driven vertically into unexcavated spring deposits during 1968 by James E. King and Peter J. Mehringer, Jr. and marking one of their pollen profiles, was discovered during reopening procedures in 1978. This circumstance enabled precise re-establishment of the previous years' horizontal grid system of 10-foot squares. Since earlier excavations had been conducted in the English system of feet and inches, and because it was felt that less than one-half the site area remained to be excavated, it was decided to continue in that system of measurement. Consequently renewed excavation in the newly exposed deposits were conducted in five-foot squares corresponding to the earlier horizontal grid and planimetric maps. Unfortunately, vertical control could not be coordinated with the earlier phase of excavation. Vertical control for renewed excavation was established by a screw set into the collar of the 8" well casing earlier implaced to control spring discharge. This point remained constant throughout the interval of renewed excavations.

In Trolinger Spring fossiliferous deposits, several squares were excavated simultaneously, beginning at the top and west-facing side of the 1968 exposure and proceeding into the late Pleistocene deposits. Paleontological materials, radiocarbon samples, and bulk sediment samples were located by grid square number (assigned at the southwestern corner), their provenience in the square and their depth below excavation datum. All recovered materials were drawn on the planimetric maps of the excavation (in separate map volume). As excavation proceeded, stratigraphic cross-sections of excavation walls were constructed and maintained. In addition, major features were photographed.

Faunal elements in Trolinger Spring were initially encountered in only three stratigraphic units: 1) gray sand of the spring feeder (unit b), 2) overlying variegated organic sand (unit c), and 3) adjacent dark brown, sandy, clayey peat and dark brown clay (Saunders 1977a). The later phase of excavations demonstrated, in 1979, that in addition to these fossiliferous deposits, dominantly sand and peat and containing a unit fauna with almost exclusively browsing affinities, there was a stratigraphically lower, presumably appreciably earlier, unit fauna with almost exclusively grazing affinities, contained in gray mixed sand and gravel and peripheral brown mixed sand and gravel of the conduit system as well as in peripheral gray clay of the host alluvium.

As each faunal element was excavated, a preservative of polyvinyl acetate and methanol was applied to exposed surfaces. Simultaneous with excavation, each specimen was assigned a field number in the notebook (e.g., 19-TS78). Beside each field number entered in the latter, notes on anatomical identity, taxonomic identity, posture, enclosing matrix, and measurements of orientation were recorded. For the latter, a Brunton compass was used to obtain long axis direction and dip. Each specimen was drawn on the planimetric site maps before final removal, when necessary in plaster jackets. These techniques and procedures are now standard in the research design that includes Trolinger Spring as well as Jones Spring, and were carried out during excavation of the latter locality as well.

Excavation of Jones Spring proceeded incrementally, with each increment (i.e., each season's activities) defined by the success to control spring discharge with increasing depth. During each season's activity, horizontal control within the ever enlarging excavation area was maintained by a 2 m grid system laid off onto the excavation floor. Vertical control was established with a pin surveyed into the excavation's east wall. This pin was positioned 2 m beneath the permanent site datum established in an adjacent juniper tree.

Precise provenience of plant macrofossils, invertebrate and vertebrate faunal elements, radiocarbon samples, pollen profiles and bulk matrix samples was recorded and drawn on planimetric site maps (in separate map volume). As the deposits were excavated, stratigraphic cross-sections were constructed and maintained by C. V. Haynes.

Laboratory methodology. Taxonomic sorting and identification was facilitated by a familiarity with the studies of previous workers in Missouri as well as by colleagues in other institutions or by direct museum comparisons. Barry Miller, Department of Geology, Kent State University, identified the molluscs from Jones Spring. Turtles from Trolinger Spring were identified with the assistance of Leo Carson Davis, Department of Geology, Doane College and those from Jones Spring were identified with the assistance of Thomas R. Van Devender, formerly of the Department of Geosciences, University of Arizona. Alligators from Jones Spring were compared directly with Recent specimens in the Laboratory of Paleontology, University of Arizona. Paul W. Parmalee, Department of Anthropology, University of Tennessee, identified the birds from Jones Spring. Gordon Edmund, Royal Ontario Museum, assisted in the identification of the ground sloth from this locality. The sabertooth cat in this fauna was identified by direct comparison with specimens in the George C. Page Museum, Los Angeles. Oscar Hawksley, Department of Biology, Central Missouri State University, identified the bear from Trolinger Spring. The identification of Jones Spring camels was verified by Jessica A. Harrison, National Museum of Natural History. She and Jerry N. McDonald, formerly of the Department of Geography, University of California, Los Angeles, assisted as well with the identification of bison from Jones Spring. In all instances of identification and comparison, the Illinois State Museum osteology collections were consulted.

Principal sources for distributional data were Conant (1958) for living reptiles and Burt and Grossenheider (1964), Hall and Kelson (1959) and Walker (1964) for living mammals. The classification and nomenclature used for Recent mammalian species is based on that of Schwartz and Schwartz (1959). Simpson (1945a) was followed in cases of generic synonymy.

Anatomical elements were tabulated for each taxon and minimum numbers of individuals determined either by duplicate counts or, frequently, by the stage of development, eruption, wear or loss of dental specimens. To standardize comparisons, measurements recorded conform to those already well explained in the literature. Special forms were prepared to facilitate tabulation of mastodon and mammoth elements.

In this report the following references are used:

EHL - field number assigned to a specimen or bulk sediment sample recovered from Trolinger Spring during 1968 by Everett H. Lindsay (e.g., EHL200).

UM - specimen collected from Trolinger Spring in 1967 during excavations by the University of Missouri, Columbia (e.g., UM23HI-210, where 23HI is standard archaeological reference for Missouri [23], Hickory County [HI]).

TS - specimen recovered from Trolinger Spring (e.g., 74TS79 is the 74th specimen recorded during the 1979 field season; when the prefix number is missing, e.g., TS79, the specimen was recovered without provenience information during 1979 and was not recorded as a discrete notebook entry).

TSWd - wood specimen recovered from Trolinger Spring (e.g., 13TSWd79 is the 13th wood specimen collected during the 1979 field season).

JS - specimen recovered from Jones Spring (e.g., 115JS77 is the 115th specimen recovered during the 1977 field season; when the prefix number is missing, e.g., JS77, the specimen was recovered without provenience information during 1977 and was not recorded as a discrete notebook entry).

JEK - wood specimen recovered from Jones Spring for James E. King, e.g., 1JEK77 is the 1st wood specimen collected during the 1977 field season.

ISM - specimen catalogued in the vertebrate paleontology collections of the Illinois State Museum (e.g., ISM490,014).

The following notation is used in this report in reference to teeth:

I - incisor, where e.g., $I^1/$ is the first upper incisor and $I/_1$ is the first lower incisor, etc.

C - canine, where $C^1/$ is the upper canine and $C/_1$ is the lower canine.

P - premolar, where e.g., $P^1/$ is the first upper premolar and $P/_1$ is the first lower premolar, etc.

d - a prefix indicating a deciduous tooth (dI, dC or dP).

M - molar, where e.g., $M^1/$ is the first upper molar and $M/_1$ is the first lower molar, etc.

Ancillary studies

Several consultants participated actively in the research program at Trolinger and Jones springs. Their studies can be grouped into geological and biological areas and include the following: 1) alluvial stratigraphy and geochronology studies conducted by C. Vance Haynes, Departments of Geology and Anthropology, University of Arizona; 2) hydrology and bedrock geology studies conducted by Ronald Ward, Division of Geological Survey, Missouri Department of Natural Resources; 3) paleobotany studies conducted by Frances King, Illinois State Museum; and 4) palynology and paleoecology studies conducted by James E. King, Illinois State Museum. The contribution of each discipline and consultant to the research program as a whole is described briefly below.

Alluvial stratigraphy and geochronology. This area of study, analysis and interpretation was conducted by C. Vance Haynes. Haynes has carried out research in the area now occupied by the Harry S. Truman Dam and Reservoir since 1966, including first-hand participation in excavations and analyses at Rodgers Shelter, Trolinger Spring, Boney Spring, Koch Spring, Jones Spring, Kirby Spring and Phillips Spring. During this interval of activities he has developed and refined a chronological framework for late Quaternary geological events in the lower Pomme de Terre River valley, Benton and Hickory counties, Missouri (Haynes 1976; 1980). The geochronological framework of spring intrusion and development as well as the stratigraphy and relationships of spring deposits reported here are the published, occasionally unpublished, results of Haynes' studies.

Hydrology and bedrock geology. The area of study, analysis and interpretation relating spring discharge dynamics and behavior to bedrock geology and deep aquifers was pursued by Ronald Ward and colleagues from the Missouri Geological Survey. Ward has participated actively in the research program since 1975 at Trolinger and Jones springs. He has been responsible for well drilling, casing and pump emplacement and discharge control at the spring sites discussed here. In the course of these field activities he has formulated and tested hypotheses that have significantly increased our ability to predict spring behavior and thus to more conveniently and successfully conduct excavations below the local water table in spring sites.

Paleobotany. Frances B. King has participated actively in the research program reported here since 1973 at Jones Spring. More recently, she has been a consultant to this research program and has identified plant macrofossils, dominately wood and root stock fragments and seeds, from Trolinger and Jones springs. Her identifications of wood and root stock fossils from the Trolinger Spring conduit gravels and from the basal spring deposits in Jones

Spring, which are both void in pollen but contain fossil vertebrate specimens, have enabled an independent paleoenvironmental interpretation for these basal sediments and associated fauna.

Palynology and paleoecology. The collection, analysis and interpretation of fossil pollen samples and their chief use in paleoenvironmental reconstruction have, since 1968 at Trolinger and Boney springs, continued to be conducted by James E. King. His field activities have been carried out in coordination with those of Haynes as well as those conducted in the spring site excavations reported here. During the more than 12 year interval of his participation in tests and excavations at Rodgers Shelter, Trolinger Spring, Boney Spring, Koch Spring, Jones Spring, Kirby Spring and Phillips Spring, King has developed and refined a pollen-floristic framework for the last 50,000 years in western Missouri (Mehringer, King and Lindsay 1970; King 1973; Van Devender and King 1975; King and Lindsay 1976).

TROLINGER SPRING

Trolinger Spring is located 19.5 km SSE of Warsaw, Missouri, in a small field adjacent to the Pomme de Terre River (Fig. 1). The spring occurs 16 m above and 1800 m directly west of the Pomme de Terre River at an elevation of 223 m above sea level.

Stratigraphy

Two distinct fossil faunas occur in Trolinger Spring sediments. These are here designated Trolinger Spring I and Trolinger Spring II. The former is earlier than the latter and each reflects a distinctly different paleoenvironment. The fossils comprising Trolinger Spring I were concentrated in three units: 1) gray mixed sand and gravel, 2) brown mixed sand and gravel, and 3) gray clay. The gray mixed sand and gravel and brown mixed sand and gravel represent, respectively, the penultimate and ultimate distal concentric permeable bodies comprising the conduit complex in Trolinger Spring. The gray clay occurs peripheral to brown mixed sand and gravel and forms the host alluvium for spring development. These sediments contained fossils representing a grazing or steppe fauna including bear, mammoth, horses, deer and bison. Fossil wood specimens recovered in firm association with fossil vertebrate specimens from these sediments indicate that the spring was during this earlier period surrounded by a deciduous forest, woodland, savanna, or savanna-steppe. The known or inferred affinities of the associated fauna indicate that savanna-steppe most probably dominated the landscape during this time prior to 34,000 years ago. The fossils comprising the Trolinger Spring II fauna were also concentrated in three strata: 1) gray sand filling the center, or feeder, of the spring 2) variegated organic sand transitional to adjacent peat, and 3) dark brown, sandy, clayey peat. In general, these sediments and fossils occurred from 2 to 2.5 m below the present day surface. Those fossils recovered from variegated organic sand or dark brown, sandy, clayey peat occurred above sediments containing Trolinger Spring I fauna. These fossils occurring in gray sand filling the spring feeder were recovered over a considerable depth, however, including depths adjacent to sediments containing Trolinger Spring I fauna. These dominantly organic sediments contained fossils representing a browsing fauna including mastodon, stilt-legged deer and woodland muskox. Pollen associated with these fossils (King 1973) indicate that the Trolinger Spring II fauna occupied an open pine-parkland.

Stratigraphic cross-sections of Trolinger Spring deposits, produced by C. Vance Haynes during 1978 and 1979, are presented in Figures 2 and 3. Figures 4 through 10 (in separate map volume) are plan maps of the Trolinger Spring excavations. These maps show, in order of increasing depth, the seven arbitrary levels (Maps 1 through 7) required to fully illustrate the relationship of each major specimen in the bone bed. Figure 11 (in separate map volume) is a composite map of the Trolinger Spring excavation, incorporating the

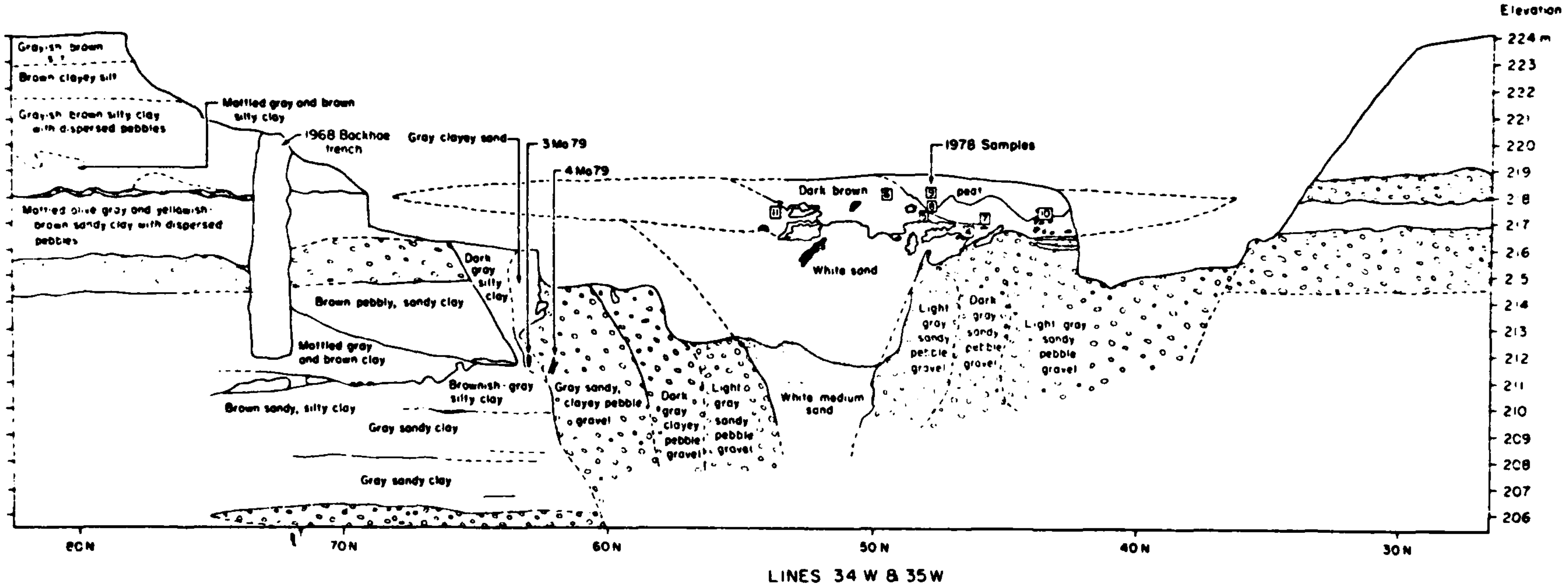

Figure 2. Stratigraphic cross section of Trolinger Spring along lines 34W and 35W showing the relationship of the fossil assemblages to the spring-laid sequence. The Trolinger Spring I fossil assemblage was contained in the gravels on either side of the White sand-filled feeder and in Gray clayey sand and Dark gray silty clay. The Trolinger Spring II fossil assemblage occurred in Dark brown peat, mixed peat and White sand, White sand and, adjacent to the gravels, in White sand and fine chert gravel. (From C. V. Haynes 1980.)

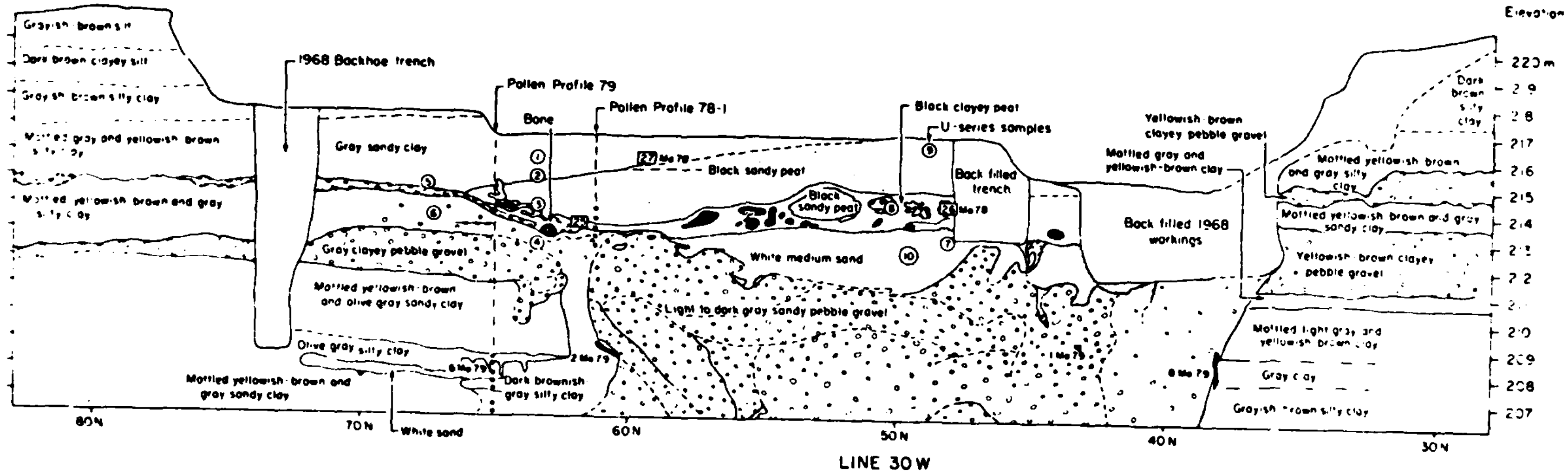

Figure 3. Stratigraphic cross section of Trolinger Spring along line 30W showing the relationship of the fossil assemblages to the spring-laid sequence. Fossil assemblages relate to individual strata as in previous figure. (From C. V. Haynes 1980.)

two maps produced during the 1967 and 1968 field seasons.

Age and Correlation

The spring associated deposits containing the Trolinger Spring I fauna are as yet undated. It is inferred from site stratigraphy and from definitive radiocarbon age determinations relating to the Trolinger Spring II fauna that the earlier savanna-steppe fauna dates from prior to 35,000 years ago. The sediments containing the later, Trolinger Spring II fauna are dated 20,000 to 35,000 years ago (Saunders 1977a:21). The actual accumulation of fossils may have been restricted within this interval to between 29,000 and 34,000 years ago (Saunders 1977a:21). In any event, this accumulation ceased by 20,000 years ago.

The duration of all faunal accumulation in Trolinger Spring places both faunas within the Rancholabrean Land Mammal Age characterized by the presence of the genus *Bison* in North America. Haynes (1976) tentatively correlated the terrace containing Trolinger Spring with the Altonian substage of the Wisconsinan Glacial Interval, or to between 28,000 and 75,000 years ago.

Systematic Discussion of Trolinger Spring I Fauna

Class REPTILIA
Order CHELONIA
Family TESTUDINIDAE
Chrysemys (Trachemys) scripta
Pond slider

ABUNDANCE. One individual. A single specimen, left hypoplastron, 74TS79.
HABITAT. The Pond slider is an aquatic turtle whose presence in the Trolinger Spring fauna indicates permanent water near the site of deposition. *Chrysemys scripta* has two living subspecies. *Chrysemys scripta scripta*, occuring in the southeastern United States, utilizes a wide variety of habitats including rivers, ditches, sloughs, lakes and ponds. *Chrysemys scripta elegans*, occuring from Ohio and Iowa to New Mexico, prefers quiet water with muddy bottoms and much vegetation. Today *Chrysemys scripta elegans* occurs widely over Missouri, exclusive of the northwestern portion.
DISCUSSION. The fossil is a nearly complete left hypoplastron of a *Chrysemys* of moderate to large size. Size and shape of the specimen, as well as details of the shape and posterior sculpturing of the carapace/plastron bridge are identical to Recent *Chrysemys scripta* examined by me in the Illinois State Museum osteology collections.

The fossil was recovered from gray, plastic clay. This unit, containing wood (13TSWd79, *Maclura pomifera* or *Robinia pseudoacacia*, Osage orange or Black locust), occurs peripheral to the brown mixed sand and gravel that contained fossils of *Ursus americanus amplidens*, extinct Black bear Additional wood (11TSWd79, *Juniperus*, Cedar) was recovered at the gray clay/brown mixed sand and gravel contact. On the basis of stratigraphic position and plant macrofossils, *Chrysemys scripta* is associated here with the grazing fauna contained in Trolinger Spring sediments.

Chrysemys scripta is a common late Pleistocene fossil. Wisconsinan-aged specimens have been reported from Texas (Johnson 1974) to Illinois (Holman 1966). In Missouri *Chrysemys scripta* has been previously reported in the Jones Spring fauna (Moodie and Van Devender 1977).

Class MAMMALIA
Order CARNIVORA
Family URSIDAE
Ursus americanus amplidens (Leidy, 1853)
Black bear

ABUNDANCE. One individual. Three specimens, left C1/, 236TS78; right M2/, 59TS79; left M/3, 53TS79.

HABITAT. Today Black bears are widely distributed over North America. In the north they range from northwestern Alaska across Canada to Newfoundland and the Maritime Provinces, thence southward along the Appalachian system to northern Georgia in the east, westward from New York through Ontario, northern Michigan, Wisconsin and northeastern Minnesota, southern Manitoba and Saskatchewan to central Montana, thence southward again along the Rocky Mountains to northcentral Mexico and the Cascade and Sierra Nevada ranges to southern California. Disjunct populations occur today along the northern Gulf Coast and in the Ozark Plateaus, including southeastern Missouri. In the eastern portion of its range *Ursus americanus* inhabits dense forests and swamp borders; in the west it inhabits chiefly mountainous areas. Throughout its range *Ursus americanus* is an omnivore, subsisting on a wide variety of plant and animal foods.

Not surprisingly, Black bears of the large, extinct subspecies *Ursus americanus amplidens* were also widely ranging in North America during the middle and late Pleistocene. Fossil Black bear remains have been reported from California, Arizona, Texas, Florida, Maryland, Pennsylvania as well as the Ozark portions of Arkansas and Missouri. The paleoenvironmental evidence from Trolinger Spring suggests that the extinct Black bear was an omnivore in a deciduous savanna-like environment.

DISCUSSION. The teeth are from a single individual. The roots are not formed, or were not preserved, and the crowns are little worn.

The lower molar (53TS79) was recovered from gray mixed sands and gravels; the upper molar (59TS79) was recovered from the adjacent but peripheral brownish-gray mixed sands and gravels. The canine (236TS78) was recovered in coarse sand and gravel of the spring conduit. The fossil specimens occurred in contexts that yielded the fossils of mammoth, horse and bison that are here attributed to the grazing fauna, and are associated with them. Wood specimens recovered from the sediments containing the grazing fauna indicate that the spring was at this time surrounded by a deciduous savanna or forest containing elm (*Ulmus* spp.), oak (*Quercus* spp.), ash (*Fraxinus* sp.) and hickory (*Carya* sp.), in addition to plum (*Prunus* sp.) and others (F. B. King, pers. comm., 1980).

The molars are markedly larger than comparable teeth in Recent *Ursus americanus* available to me for examination and compare in this feature with the diagnostic attribute of *Ursus americanus amplidens* as discussed by Kurtén (1963:3-9). Measurements for the Trolinger Spring molars are: M2/ (59TS79) length = 31.2 mm, breadth = 17.4 mm; M/3 (53TS79) length = 18.0 mm, breadth = 14.1 mm. Based on tooth measurements, the Trolinger Spring individual compares very closely with *Ursus americanus amplidens* from Friesenhahn Cave, Bexar County, Texas, discussed by Kurtén (1963:3-9). Unlike the molars, the size and morphology of the canine compare well with upper canines in Recent *Ursus americanus* examined by me. Measurements of the canine (236TS78) from Trolinger Spring are: crown height = 29.5 mm, anteroposterior diameter at base = 15.8 mm, transverse diameter at base = 12.9 mm.

Missouri fossil bears, including *Ursus americanus amplidens*, are currently being studied by other researchers with their results yet to be published. For this reason it is not possible here to compare or contrast the Trolinger Spring individual with others known from the Missouri Ozark region.

Family ELEPHANTIDAE
Mammuthus jeffersonii (Osborn 1922)
Mammoth

ABUNDANCE. Five individuals, inferred from assembled dentitions. Fifteen specimens, including associated right and left M1/, 252TS78 and 92TS79, right and left M2/, 73TS79 and 22TS79, and right M/1, 124TS79; associated right and left M/3, 134TS79 and 98/125TS79; right M3/, 89TS79; associated (provisionally) right M3/, 5TS79, and right M/3, 38TS79; left M/3, 75TS79; and two enamel plate fragments, 83TS79 and 95TS79. In addition there is an indeterminable fragmentary cheek tooth recovered in 1968, UM23HI-210 (Saunders 1977a:36).
HABITAT. *Mammuthus* is a common fossil in middle and late Pleistocene deposits throughout North America. The wide distribution of several species suggests diverse habitat preferences. In the southwestern United States *Mammuthus* was frequently associated with other grazers, notably *Equus* and *Bison* (Saunders 1970). Fossils from Jones Spring, Missouri (this report) indicate that in parts of the central United States *Mammuthus* was associated with browsers, notably *Mammut*.

Mammuthus jeffersonii is widespread across the United States, generally above 40° N latitude, in the late Pleistocene. The species has been reported from Alaska and the Pacific Northwest to Montana and the western and central Great Lakes region to New York. Elsewhere in Missouri, Simpson (1945b:71) has provisionally reported *Mammuthus jeffersonii* as occurring in the Pleistocene fauna recovered from Enon Sink, Moniteau County.

Plant macrofossils from Trolinger Spring indicate that *Mammuthus jeffersonii* here occupied an open deciduous savanna or woodland, where it was predominantly a grazer on associated grasses.
DISCUSSION. *Mammuthus* is not a common fossil in Missouri. Mehl's 1962 survey of Missouri's Pleistocene fauna mentions only 15 localities where mammoth remains had been found. The sample reported here from Trolinger Spring and that from Jones Spring are the most important collections of mammoth remains currently known to exist from Missouri.

The majority of the mammoth fossils (11 specimens, including 252TS78, 5TS79, 38TS79, 83TS79, 89TS79, 92TS79, 95TS79, 98TS79, 124TS79, 125TS79, and 134TS79) were recovered from the gray, dominantly mixed sands and gravels of the conduit complex. This unit occurred peripheral to the fine light gray sand and blue chert gravel that surrounded the fine light gray sand filling the feeder of the spring. One of these specimens, 89TS79, the right M3/ of an extremely large mammoth, though enclosed by gray mixed sand and gravels, occurred very near the contact of this unit with the fine light gray sand and blue chert gravel. Two of the mammoth teeth (an associated pair of M2/'s, 22TS79 and 73TS79) occurred in gray mixed sandy, gravelly clay which is a facies of the gray mixed sands and gravels that contained the remainder of this association. One specimen (75TS79) occurred in brown, mixed sands and gravels peripheral to the gray mixed sands and gravels. Finally, the mammoth tooth recovered in 1968 (UM23HI-210) was collected at the contact of light brown clayey sandy gravel with overlying dark brown clay, approximately 10 m south of the center of the spring. These matrices are the same that contained the other fossil remains (of bear, horse and bison) here attributed to the grazing fauna from Trolinger Spring.

Numerous variable features of *Mammuthus* cheek teeth have been considered to have taxonomic significance. Osborn (1942:998, 1071, 1083-1088) lists, among others, the following as being specific characters of *Mammuthus* cheek teeth: enamel plate number, width, thickness, shape and compression; degree of enamel folding on the occlusal surface and enamel thickness; configuration of the third molars; and thickness of external cement. More recent studies (Savage 1951; Lance 1953, 1959; Saunders 1970; Maglio 1973) have indicated a large amount of individual and populational variation for these features in *Mammuthus* samples. For this reason there is no current agreement among researchers regarding reliable specific characters of mammoth cheek teeth. The most widely used, presumably most reliable, single variable continues to be formulae of the third molars (Osborn 1942; Savage 1951; Lance 1953, 1959; Saunders 1970; Maglio 1973), with other variates considered secondarily.

Following this convention there are currently four species of *Mammuthus* commonly recognized as occurring in the middle and late Pleistocene of North America. *Mammuthus primigenius* is characterized by small to medium size, narrow, closely spaced enamel plates, extremely thin enamel and an enamel plate formula of M3:24-27/24-27 (Maglio 1973:60; Osborn 1942:1156). *Mammuthus columbi* has been distinquished chiefly on the basis of moderate enamel compression and an enamel plate formula of M3:18-20/15-18 (Saunders 1970: 32). *Mammuthus imperator* is contrasted by having broader, more widely spaced enamel plates with a thick outer coating of cement and an enamel plate formula of M3:17-17/18-20 (Osborn 1942:1586). *Mammuthus jeffersonii* is distinquished by a high enamel plate compression, approaching that of *M. primigenius*, but with more widespread enamel plates and a formula of M3:25/24 (Osborn 1942: 1087-1088).

Table 1 summarizes measurements of *Mammuthus* cheek teeth from Trolinger Spring. Listed for each tooth is information on the number of enamel plates comprising the specimen (Pl.), the number of enamel plates showing wear (A.), the length (Lg.), height (Ht.) and width (W.) of the specimen, as well as enamel thickness (En.), the number of enamel plates in 100 mm (Lf.) measured at the occlusal surface (occ.), mid crown (m. c.) and near the base of the specimen (base), and thickness of external cement (c.).

For the Trolinger Spring sample, the number of enamel plates comprising the M3's (+19+/21+, excluding the extremely worn 75TS79) is greater than the number in *Mammuthus columbi* (18-20/15-18) (Osborn 1942:1076; Saunders 1970:Table 7, pp. 43-44). It is however close to that in *Mammuthus jeffersonii* (25/24) reported by Osborn (1942:1083). Furthermore, the number of enamel plates (19) comprising the M2/'s from Trolinger Spring is greater than the number in *Mammuthus columbi* (maximum = 17) studied by me (Saunders 1970:Table 7, pp. 43-44) or reported by Osborn (1942:1076). It is however exactly that in *Mammuthus jeffersonii* (18-19e) given by Osborn (1942:1083). On the primary basis of enamel plate count in M3's and secondarily on the basis of the same in M2/'s, as well as the generally high enamel plate compression in the latter, the Trolinger Spring sample is referred to *Mammuthus jeffersonii*.

Maglio (1973:61-63) briefly discussed North American mammoths in his recent monograph on the origin and evolution of the Elephantidae. It was his conclusion that the mammoth here called *Mammuthus jeffersonii* is synonymous with *Mammuthus columbi* when mammoth distribution is viewed within the whole North American spatial-temporal framework. The *Mammuthus* record is now being reviewed and revised from this perspective. Until that study is completed and its results reported and assessed, I continue to accept *Mammuthus jeffersonii* as a distinct species of late Pleistocene North American mammoth.

TABLE 1

Measurements (in millimeters) of *Mammuthus jeffersonii* from Trolinger Spring, Hickory County, Missouri. (Exclusive of UM23HI-210, from which no useful measurements can be obtained.)

Specimen	Pos.	Pl.	A.	Lg.	Ht.	W.	En.	Lf. occ.*			Lf. m.c.**		Lf. base**		c.
92TS79	lM1/	+5	+5	68.4	-	62.6	2.6	-	-	-	-	-	-	-	-
252TS78	rM1/	+4	+4	67.7	-	63.7	2.5	-	-	-	-	-	-	-	1
124TS79	rM/1	+7	+7	146.7	-	61.0	2.7-3.6	-	6	-	-	-	-	-	-
22TS79	lM2/	19	8	231.0	177.3	73.5	2.4	9	9	9	7½	7½	7½	7½	-
73TS79	rM2/	19	9	227.0	178.9	73.8	2.4	8½	9	8½	7½	7½	7½	-	0.5-1.3
89TS79	rM3/	+19+	+11	392.0e	250.9	100.0	3.6	5	5	5	5½	5	4½	4½	-
98/125TS79	lM/3	12+	12+	-	-	91.6	2.1-2.6	6	6½	6½	6	6½	5	5½	1.6
134TS79	rM/3	21+	14	291.0e	146.9e	93.2	2.1-2.7	6	6½	6½	5½	6½	5	5½	1.6
5TS79	rM3/	+12	+9	185.0+	-	97.3	3.4	3½	3½	3½	-	5½	-	5	1.4
38TS79	rM/3	+10	+10	-	-	110.6	3.2	-	5	-	-	-	-	-	2.7
75TS79	lM/3	+10	+10	266.0	34.2	90.8	3.0-3.3	4	5	4½	-	-	-	-	-

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*values recorded are lingual, medial and labial, respectively.
**values recorded are lingual and labial, respectively.

Order PERISSODACTYLA

Family EQUIDAE

Equus complicatus Leidy, 1858

Horse

ABUNDANCE. Four individuals based on assembled dentitions. Sixty-five specimens, left I1/, 21TS79; left I1/, 47TS79; left I1/, 139TS79; right I1/, 257TS78; right I1/, 135TS79; left I2/, 27TS79; left I2/, 111TS79; right I2/, 41TS79; right I3/, 245TS78; right dP2/, 117TS79; right dP3/, 128TS79; left dP4/, TS79; right dP4/, 82TS79; deciduous upper premolar, 30TS79; left P2/, 63TS79; right P2/, 237TS78; right P2/, 29TS79; left P3/, 49TS79; right P3/, 48TS79; right P3/, 85TS79; right P3/, 131TS79; left P4/, 222TS78; left P4/, 101TS79; right P4/, 37TS79; left M1/, 115TS79; right M1/, 26TS79; right M1/, 116TS79; left M2/, 52TS79; left M2/, 65TS79; left M2/, 127TS79; left M2/, 137TS79; right M2/, 19TS79; right M2/, 33TS79; right M3/, 104TS79; right M3/, 138TS79; left upper cheek tooth, 121TS79; left I/1, 133TS79; right I/1, TS79; left I/2, 58TS79; left I/2, 129TS79; right I/2, 16TS79; left I/3, 42TS79; left I/3, 241TS79; right I/3, EHL 200; right I/3, 62TS79; deciduous lower premolar, TS78; left P/2, 102TS79; right P/2, 23TS79; right P/2, 35TS79; left P/4, 72-TS79; left M/2, 36TS79; left M/2, 103TS79; right M/2, 40TS79; right M/3, 60-TS79; right M/3, 112TS79; lower cheek tooth, 251TS78; seven cheek tooth fragments, TS78, TS78, TS78, 96TS79, TS79, TS79, TS79, right scapula, EHL 153; left astragalus, 2TS79.

HABITAT. Pleistocene *Equus* was a grazer occurring abundantly in steppe habitats throughout North America and elsewhere. *Equus complicatus* was the common moderate to large-sized horse of the eastern United States during the middle and late Pleistocene. Its distribution extends from the Gulf Coast of Texas eastward to Florida and northward to South Carolina, Kentucky and Missouri (Kurtén and Anderson 1980). Elsewhere in Missouri, *Equus complicatus* also occurs in the fauna from Jones Spring (this report). Hay (1924:139) reports that *Equus complicatus* occurs in the late Pleistocene fauna from Kimmswick, Jefferson County. In addition, *Equus* cf. *complicatus* has been reported by Simpson (1945b:71) in the Pleistocene fauna from Enon Sink, Moniteau County.

As previously mentioned fossil wood fragments and seeds recovered from Trolinger Spring sediments that also contained fossils of *Equus complicatus* indicate that the spring was at this time surrounded by a deciduous savanna or woodland. Horses presumably occupied the grassy openings in this savanna or woodland.

DISCUSSION. The majority of the fossils referred to *Equus complicatus* from Trolinger Spring (40 specimens) were recovered from gray mixed sand and gravel or gray mixed sandy, gravelly clay. Six specimens were recovered from brown mixed sand and gravel or brown mixed clayey, sandy gravel occurring peripheral to gray mixed sand and gravel or gray mixed sandy, gravelly clay. One specimen was recovered on the contact of these two units. As previously discussed these two predominantly gravel matrices represent, respectively, the penultimate and ultimate distal concentric permeable bodies comprising the conduit complex in Trolinger Spring (Fig. 1). Two specimens (EHL 200, right I/3; EHL 153, right scapula) were recovered in 1968 by E. H. Lindsay from the lower portion of dark brown peat (lower unit d_3) during earlier excavations in Trolinger Spring. Two specimens were recovered either from gray sand (245TS79, right I3/) or from light gray coarse sand and mixed blue chert gravel (2TS79, left astragalus) of the feeder system (unit b) underlying dark brown peat (unit d_3). Fourteen specimens were recovered from unknown or imprecisely recorded provenience.

The two specimens recovered from lower unit d_3, dark brown peat, and two from underlying unit b, light gray sand or light gray sand and mixed blue chert gravel, are the only fossils of *Equus complicatus* recovered from either peat or feeder sand and gravels in Trolinger Spring. With these exceptions, and excluding the 14 specimens recovered without precise provenience information, the fossils of *E. complicatus* were recovered from the conduit gravels that yielded the fossils of bear, mammoth, deer and bison that were or will be attributed to an earlier, predominantly grazing, fauna from Trolinger Spring. On this basis of predominance *Equus complicatus* is also to be associated with this earlier fauna. The four specimens of *E. complicatus* not recovered from the conduit occurred either in the lower part of dark brown peat (unit d_3) or from underlying feeder sand and generally fine gravel (unit b) which, together with variegated organic sand (unit c), yielded abundant fossils or mastodon, stilt-legged deer and musk-oxen attributed to a later, predominantly browsing, fauna from Trolinger Spring. These fossils of *Equus complicatus* represent, with few other exceptions, the only grazing element in this otherwise browsing fauna. They are most probably explained as having been extruded into younger units from a primary context in conduit mixed sand and gravel during a later period of spring rejuvenation.

There are 18 upper and lower incisor teeth referred to *Equus complicatus* from Trolinger Spring. They all bear a central, enamel-bordered and cement-filled, depression or infundibulum, commonly termed the "cup" or "mark", regardless of wear stage. The incisors can be arranged into arcades representing at most four individuals and presumably are associated with the four cheek tooth dentitions discussed below.

The cheek teeth referred here to *Equus complicatus* compare well with teeth assigned to this taxon from elsewhere, for example from Ingleside, Texas (Lundelius 1972:63-68). The upper teeth, though variable, are generally large and, with the exception of P2/, are nearly square in cross-section. The protocones are elongated anteroposteriorly and have a pronounced groove on their inner surfaces. The hypocone is separated from the rest of the tooth by a well developed hypoconal groove; in the third molar this groove is closed off and forms a separate lake in the posterior-internal portion of the tooth. The parastyle and mesostyle are large and open and, in the premolars, tend to be bifurcated. The enamel surrounding the fossettes or lakes is complexly folded on both anterior and posterior faces, with the posterior side of the anterior lake and the anterior side of the posterior lake possessing the greater number of secondary folds. The lower teeth are more complicated than those of the Recent horse but are approximately the same size. The metaconid is rounded and expanded and the adjoining metastylid is oval in shape, with the posterior-internal end drawn out to form a characteristic point. The metaconid and metastylid connect with the protoconid via a non-paralled sided isthmus. The protoconid and the hypoconid are flattened or somewhat concave on their outer surfaces. The paralophid does not extend as far toward the inner margin of the tooth as the metaconid and its posterior surface bulges into the fold between the metaconid and protoconid.

The cheek teeth of *Equus complicatus* from Trolinger Spring can be arranged into four dentitions (D-1 through D-4 in the tables below) of variable completeness, indicating the presence of four individuals in the fauna. One dentition contains deciduous premolars in wear and indicates a colt less than two and one-half years in age (Getty 1975:467). The other three individuals have dentitions containing only permanent premolars and molars and are older. There are two sizes of horses, based on size of teeth, represented among the latter. All measured teeth show broad overlap with values reported by Lundelius (1972:64, 68) for *Equus complicatus* from Ingleside, Texas, however, and no taxonomic importance is given this size difference here (small *Equus complicatus*-like teeth are often referred to a separate species, *Equus fraternus*). Tables 2 and 3 give measurements of cheek teeth, arranged as dentitions, of *Equus complicatus* from Trolinger Spring. One tooth not listed in the tables or assigned to a dentition is a well worn left upper premolar (TS79) that had probably been eliminated naturally from a dentition during visitation at the spring. Measurements on this tooth are: length along ectoloph = 29.2 mm, width normal to parastyle-mesostyle = 25.6 mm, anteroposterior length of protocone = 11.2 mm, height of crown = 17.2 mm.

The right scapula from Trolinger Spring (EHL 153) referred here to *Equus complicatus* is from a horse of moderate size, as large or larger than Recent horse in the Illinois State Museum osteology collections. It is assigned to *Equus complicatus* on the basis of smaller size compared to published measurements of *Equus scotti*. Measurements and comparison of this specimen are provided in Table 4.

Equus cf. *scotti* Gidley, 1900
Horse

ABUNDANCE. Two individuals based on right P2/'s. Five specimens, right P2/, 258TS78; right P2/, 1TS79; left P/3, 120TS79; right P/4, 206TS78; right P/4, 31TS79.

HABITAT. *Equus* cf. *scotti* was a large horse with relatively large and high-crowned cheek teeth well suited to a diet of grass. Unlike *E. complicatus*, *Equus scotti* possessed short, heavy legs. This, coupled with a relatively large skull, deep jaw and short neck, indicates a horse that was less fleet of foot than *E. complicatus* and, with differences observed in cheek teeth of the two forms, suggests that the two probably had quite different adaptive strategies. This in turn suggests that *E. scotti* and *E. complicatus* were for the most part noncompetitive contemporaries on open landscapes during the middle and late Pleistocene. *Equus scotti* is best known from localities on the High Plains of Texas, New Mexico and Oklahoma, northward to southeastern Alberta, but occurs as well in central Florida (Kurtén and Anderson 1980). The fossils of *E.* cf. *scotti* from Trolinger Spring represent the first known record of this primarily western species from Missouri.

Plant macrofossils associated with the fossils of *Equus* cf. *scotti* from Trolinger Spring indicate that this horse probably inhabited openings in deciduous savanna or woodland, where it was primarily a grazer.

DISCUSSION. Four of the specimens referred to *Equus* cf. *scotti* were recovered from the conduit in Trolinger Spring, either from gray sandy clay (1TS79; 31TS79), grayish brown clayey, sandy gravel (120TS79) or coarse sand and mixed gravel (258TS78). One specimen (206TS78) occurred in light gray sand of the feeder. As previously mentioned under the discussion of *E. complicatus* from Trolinger Spring, fossils of animals with grazing affinities recovered from peat, variegated organic sand or the gray sand or gray sand and blue chert gravel of the feeder in Trolinger Spring (such as 206TS78, right P/4) are interpreted here to have been transported from a primary context in the conduit. On the basis of predominant stratigraphic context, *Equus* cf. *scotti* is included here in the earlier grazing fauna recovered from, and contained almost exclusively in, the conduit in Trolinger Spring.

The teeth assigned here to *Equus* cf. *scotti* are generally larger than those previously referred to *Equus complicatus*, and have simpler enamel patterns. In addition, the upper teeth share the following characters

TABLE 2

Measurements (in millimeters) of upper dentitions of *Equus complicatus* from Trolinger Spring.

Variate	D-1	D-2	D-3	D-4
Length				
dP2/	37.1(117TS79)			
dP3/	31.6(128TS79)			
dP4/	30.2(82TS79)			
P2/			40.7(237TS78)	38.6(63TS79/38.4(29TS79)
P3/	31.1(49TS79)/30.3(48TS79)		33.9(131TS79)	31.8(85TS79)
P4/	31.2(101TS79)		34.3(222TS78)	29.4(37TS79)
M1/			28.2(115TS79)/28.6(116TS79)	27.0(26TS79)
M2/	31.2(65TS79)/31.3(19TS79)	29.2(137TS79)	28.8(127TS79)	27.6(52TS79)/27.9(33TS79)
M3/		- (138TS79)	31.1(104TS79)	
Width				
dP2/	22.8(117TS79)			
dP3/	22.2(128TS79)			
dP4/	23.3(82TS79)			
P2/			28.2(237TS78)	24.3(63TS79)/24.8(29TS79)
P3/	24.3(49TS79)/ - (48TS79)		31.2(131TS79)	28.4(85TS79)
P4/	- (101TS79)		32.2(222TS78)	29.0(37TS79)
M1/			29.4(115TS79)/29.4(116TS79)	26.4(26TS79)
M2/	25.3(65TS79)/25.9(19TS79)	26.8(137TS79)	28.4(127TS79)	26.7(52TS79)/26.3(33TS79)
M3/		- (138TS79)	25.0(104TS79)	
Protocone				
dP2/	9.4(117TS79)			
dP3/	10.1(128TS79)			
dP4/	11.2(82TS79)			
P2/			14.9(237TS78)	15.0(63TS79)/14.9(29TS79)
P3/	14.9(49TS79)/ - (48TS79)		16.9(131TS79)	13.4(85TS79)
P4/	- (101TS79)		16.9(222TS78)	14.5(37TS79)
M1/			16.5(115TS79)/16.2(116TS79)	11.4(26TS79)
M2/	15.0(65TS79)/15.1(19TS79)	13.1(137TS79)	17.0(127TS79)	13.0(52TS79)/13.2(33TS79)
M3/		- (138TS79)	16.3(104TS79)	
Height				
dP2/	30.6(117TS79)			
dP3/	33.2(128TS79)			
dP4/	33.1(82TS79)			
P2/			59.2(237TS78)	51.6(63TS79)/52.7(29TS79)
P3/	80.9(49TS79)/ - (48TS79)		67.6(131TS79)	61.6(85TS79)
P4/	- (101TS79)		75.4(222TS78)	72.9(37TS79)
M1/			66.9(115TS79)/66.5(116TS79)	63.2(29TS79)
M2/	- (65TS79)/84.6(19TS79)	88.7(137TS79)	79.3(127TS79)	70.5(52TS79)/69.4(33TS79)
M3/		- (138TS79)	78.5(104TS79)	

TABLE 3

Measurements (in millimeters) of lower dentitions of *Equus complicatus* from Trolinger Spring.

Variate	D-1	D-2	D-3	D-4
Length				
P/2			38.8(102TS79)/38.2(35TS79)	34.6(23TS79)
P/3				
P/4				27.1(72TS79)
M/1				
M/2			29.8(103TS79)	26.9(36TS79)/27.1(40TS79)
M/3	32.0(112TS79)			32.2(60TS79)
Width				
P/2			17.1(102TS79)/16.4(35TS79)	14.6(23TS79)
P/3				
P/4				14.4(72TS79)
M/1				
M/2			15.9(103TS79)	12.7(36TS79)/13.2(40TS79)
M/3	12.8(112TS79)			12.4(60TS79)
Metaconid/ Metastylid				
P/2			17.9(102TS79)/18.3(35TS79)	17.3(23TS79)
P/3				
P/4				14.3(72TS79)
M/1				
M/2			16.2(103TS79)	13.3(36TS79)/13.1(40TS79)
M/3	14.1(112TS79)			12.6(60TS79)
Height				
P/2			57.7(102TS79)/58.2(35TS79)	46.4(23TS79)
P/3				
P/4				59.6(72TS79)
M/1				
M/2			75.1(35TS79)	- (36TS79)/66.0(40TS79)
M/3	58.6(112TS79)			70.3(60TS79)

TABLE 4

Measurements (in millimeters) of the right scapula of *Equus complicatus* from Trolinger Spring compared with scapula measurements of *Equus scotti* from New Mexico, and with Recent *Equus caballus* from Illinois.

Variate	*E. complicatus* (EHL 153)	*E. scotti*[1] (31-51)	*E. caballus* (684051)
Least anteroposterior diameter of neck:	71.6	-	66.7
Length of supraglenoid tubercle, measured from anterior border of glenoid fossa to anterior border of coracoid process, along a straight line:	54.4	51.7	58.6
Greatest anteroposterior diameter of glenoid fossa:	63.8	71.9	60.2
Least anteroposterior diameter of glenoid fossa:	53.6	59.9	50.0
Greatest transverse diameter of glenoid fossa:	53.0	57.5	52.9
Least transverse diameter of supraglenoid tubercle:	23.2	25.8	21.1

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[1] as reported by Harris and Porter (1980: Fig. 1, p. 47 and Table 1, p. 52).

usually mentioned in discussion of upper teeth of *Equus scotti*: 1) a very long pli caballin, the length of which equals two to two and one-half times its width; 2) a post protoconal groove that is wide relative to its length and that is expanded anteriorly; 3) relatively narrow fossettes; 4) a hypocone that is constricted posteriorly by the hypoconal groove and a shallow groove entering from the internal border of the post protoconal groove; 5) a bifurcated mesostyle. Regarding the lower molars, the metaconid-metastylid is joined to the protoconid-hypoconid by a markedly parallel-sided isthmust (especially 120TS79, left P/3 and 31TS79, right P/4). This feature has been considered to be characteristic of the lower teeth of *Equus scotti* (Lundelius 1972:66). Table 5 gives measurements of the cheek teeth of *Equus* cf. *scotti* from Trolinger Spring.

TABLE 5

Measurements (in millimeters) of *Equus* cf. *scotti* teeth from Trolinger Spring.

Variate	258TS78 (rP2/)	1TS79 (rP2/)	120TS79 (lP/3)	206TS78 (rP/4)	31TS79 (rP/4)
Length	- -	37.1	33.3	33.0	33.5
Width	28.6	23.9	18.2	19.7	18.7
Protocone Length or Length of Metaconid-Metastylid	12.1	12.1	18.7	20.1	18.1
Height	73.5	59.0	74.0	98.7	86.1

Order ARTIODACTYLA
Family CERVIDAE
Odocoileus sp. Rafinesque, 1832
Deer

ABUNDANCE. Three individuals based on size and wear differences of upper and lower cheek teeth. Three specimens, right M1/, 253TS78; left M3/, 70TS79; right mandibular ramus with P/3-M/3, 10TS79.

HABITAT. Deer are browsers in a wide variety of habitats. *Odocoileus virginianus*, the White-tailed deer, is distributed across Canada, generally south of 52° N latitude, the United States, exclusive of some southwestern desert regions, and Mexico through Central America to northern South America. The White-tailed deer inhabits woodlands, forest borders and thickets along streams and around swamps. *Odocoileus hemionus*, the Mule deer, occurs in western Canada, generally south of 60° N latitude, the western United States and northern Mexico. The Mule deer inhabits coniferous forest, grassland and desert regions. Currently, *Odocoileus virginianus* occurs throughout Missouri.

DISCUSSION. The left M3/, 70TS79, was recovered from gray, plastic clay that occurred peripheral to brown mixed sands and gravels. The right mandibular ramus, 10TS79, was recovered from gray mixed sand and gravel that occurred proximal to the brown mixed sand and gravels. The right M1/, 253-TS78, was recovered from a mixed gray clay and dark brown peat that most probably represents backhoe trench fill. Because of the high probability of redeposition of this specimen it is not possible to assign this M1/ to one or the other of the two stratigraphically distinct faunas in Trolinger Spring. It is included here because *Odocoileus* sp. does not otherwise occur in the later, browsing fauna.

Measurements of the M3/ are: length = 15.0 mm, anterior width = 16.2 mm, posterior width = 12.9 mm. Measurements of the ramus are given in Table 6. This upper tooth and lower dentition are well worn, indicating that these two individuals were fully mature (greater than 3½ years of age based on M/1 wear stage). The size of the teeth as well as the proportions of the mandible indicate that these individuals were quite small. The redeposited M1/, 253TS78, is a relatively large tooth exhibiting moderate wear. It indicates that the third individual was larger. Measurements of this tooth are: length = 17.1 mm, posterior width = 16.6 mm. These values are slightly above the range for these variates in teeth of *Odocoileus virginianus* (M1/ length range: 14.6-16.5 mm, mean = 15.6 mm, n = 8; M1/ width range: 14.0-15.7 mm, mean = 14.5 mm, n = 7) and *Odocoileus hemionus* (M1/ length range: 14.6-16.6 mm, mean = 15.9 mm, n= 9; M1/ width range; 13.9-15.4 mm, mean = 14.8 mm, n = 9) measured by me on materials in the Illinois State Museum collections but are probably within the range, though near the upper limit, of these variates in larger deer samples. Because there is extreme size variation among living deer, size, as inferred from dentitions alone does not distinquish *O. virginianus* from *O. hemionus*. Without a more adequate sample including antler material it is not possible to assign the Trolinger Spring *Odocoileus* to either species with confidence.

TABLE 6

Measurements (in millimeters) of *Odocoileus* sp.
lower dentition from Trolinger Spring.

Variate	Ramus	P/3	P/4	M/1	M/2	M/3
Greatest thickness:	13.7					
Depth[1]:	22.3					
Length		11.7	12.0	14.0	15.3	22.1
Anterior width:		- -	7.6	9.0	10.4	11.0
Middle width:		- -	- -	- -	- -	10.4
Posterior width:		7.5	8.2	9.4	10.3	7.0

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[1] measured labially at anterior face of M/3.

Elsewhere in Missouri, *Odocoileus virginianus* has been reported in the Pleistocene faunas from Herculaneum Fissure (Olson 1940), Crankshaft Cave (Parmalee, Oesch and Guilday 1969), Brynjulfson Caves (Parmalee and Oesch 1972) and Jones Spring (this report). In addition, *Odocoileus* sp. has been reported in the Pleistocene fauna from Boney Spring (Saunders 1977a). Elsewhere in the Ozark Plateaus, both *O. virginianus* and *O. hemionus* have been reported in the fauna from Conard Fissure, Arkansas (Brown 1908).

Family BOVIDAE
Bison sp. H. Smith, 1827
Bison

ABUNDANCE. One juvenile and four adult individuals, based on one left dP/4 and wear differences among four M/3's. Twenty-six specimens, left M1/, 25TS79; left M2/, 44TS79; right M2/, 130TS79; right M3/, 86TS79; six incisors, 39TS79, 88TS79, 100TS79, 113TS79, 136TS79, TS79; left dP/4, TS79, left P/3, 110TS79; right P/4, 126TS79; left M/1, 132TS79; left M/1, 140TS79; left M/2, 57TS79; left M/2, 91TS79; right M/2, 122TS79; left M/3, 76TS79; left M/3, 78TS79; left M/3, 107TS79; right M/3, 105TS79; right M/3, 106TS79; fragments of two additional lower cheek teeth, TS79 and TS79; right calcaneum, 77TS79.

HABITAT. Whereas living *Bison* are almost exclusively grazers adapted to life on the open plains, earlier forms had other adaptations, for example as both browser and grazer in forests or woodlands (*B. latifrons*) as well as predominantly a grazer in savannas or steppes (*B. antiquus*). Plant macrofossils from Trolinger Spring conduit gravels indicate that *Bison* sp. here occupied a deciduous savanna-like environment containing elm (*Ulmus* spp.), oak (*Quercus* spp.), ash (*Fraxinus* sp.) and hickory (*Carya* sp.) in addition to plum (*Prunus* sp.) and others (F. B. King, pers. comm., 1980).

DISCUSSION. Eighteen specimens were recovered from gray mixed sand and gravel or from gray mixed sandy, clayey gravel of the conduit. Three specimens were recovered from adjacent but peripheral brown mixed sand and gravel, also of the conduit, and near the contact with gray mixed sand and gravel. One specimen, encased in gray, sandy organic clay, was recovered in light gray sand and fine blue chert gravel of the feeder (unit b). This specimen was most probably redeposited in the feeder (unit b) from a primary context in the conduit. Four specimens are of unknown stratigraphic provenience. All of the *Bison* fossils occurred in sediments that yielded the other fossils of bear, mammoth, horse and deer that are here attributed to an earlier grazing or savanna-steppe fauna in Trolinger Spring.

The specimens referred here to *Bison* sp. consist, with one exception, only of isolated incisors and cheek teeth. Upper teeth are under represented in the collection (4 vs. 21 specimens). There are no postcranial materials assigned to *Bison* sp. in the Trolinger Spring assemblage, and in the absence of complete or even partial skulls with horn cores, it is not possible to assign the Trolinger Spring *Bison* remains to species.

Table 7 gives measurements of *Bison* cheek teeth from Trolinger Spring. Those specimens in stage of wear A in the table represent a single early adolescent individual. In addition, there are two individuals that were in late adolescence (S-1; represented by 86TS79, right M3/ and 106TS79, right M/3 and by 132TS79, left M/1, 122TS79, right M/2, 76TS79, left M/3 and 105TS79, right M/3, respectively) and two individuals were in full maturity (S-3; represented by 91TS79, left M/2 and 107TS79, left M/3 and by 78TS79, left M/3, respectively).

Comparing cheek teeth length and width of four adult individuals of *Bison* sp. from Trolinger Spring with measurements obtained from cheek teeth of adult *Bison latifrons* and/or *Bison antiquus* from Jones Spring (this report) the following conclusions can be noted: 1) the Trolinger Spring M3/ (86TS79) is longer and wider, facts probably attributed to slight pathology in this specimen; 2) the Trolinger Spring P/4 (126TS79) is at the upper limit for length but at the lower limit for width; 3) the Trolinger Spring M/1 (132TS79) is virtually identical; 4) the Trolinger Spring M/2's (91TS79 and 122TS79), one of which is within, and the other outside, the range for width are both outside the range for length and may in fact be significantly shorter; 5) the Trolinger Spring M/3's (76TS79, 107TS79, 78TS79, 106TS79 and 105TS79) are, on average, appreciably wider and, with one exception, are also outside the range for length and may in fact be significantly shorter. In summary, there is some indication that the Trolinger Spring *Bison* was,

TABLE 7

Measurements (in millimeters) of *Bison* sp. cheek teeth from Trolinger Spring.

Variate	25TS79 (1M1/)	44TS79 (1M2/)	130TS79 (rM2/)	86TS79 (rM3/)	110TS79 (1P/3)	126TS79 (rP/4)	140TS79 (1M/1)	132TS79 (1M/1)
Stage of Wear*	A	A	A	S-1	-	-	A	S-1
Length-								
M1/	32.6							
M2/		37.1	37.1					
M3/				39.6				
P/3					24.3			
P/4						26.7		
M/1							32.6	30.3
M/2								
M/3								
Width-								
M1/	28.8							
M2/		27.6	29.2					
M3/				34.6				
P/3					12.9			
P/4						14.2		
M/1							19.7	19.6
M/2								
M/3								

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* as defined by Skinner and Kaisen (1947) for upper molars; inferred for lower molars:

I	(Immaturity)	M1/ in wear.
A	(Early Adolescence)	M2/ erupting, M2/ in wear, M3/ erupting.
S-1	(Late Adolescence)	M1/ style in full wear.
S-2	(Early Maturity)	M2/ style in full wear, M3/ style not in wear.
S-3	(Full Maturity)	M3/ style in full wear.
S-4	(Old Age)	M1/ and M2/ styles nearly worn away, M3/ style diminishing.

Table 7 (concluded).

Variate	57TS79 (lM/2)	91TS79 (lM/2)	122TS79 (rM/2)	76TS79 (lM/3)	107TS79 (lM/3)	78TS79 (lM/3)	106TS79 (rM/3)	105TS79 (rM/3)
Stage of Wear	A	S-3	S-1	S-1	S-3	S-3	S-1	S-1
Length-								
M/2	40.4	32.8	35.3					
M/3				46.5	47.0	53.2	47.4	46.6
Width-								
M/2	22.3	23.7	20.3					
M/3				18.7e	21.0	22.5	21.1	18.9e

e = estimate.

on average, smaller than *Bison latifrons* and/or *Bison antiquus* from Jones Spring dating to greater than 40,000 years ago. In *Bison* evolution there is a trend towards decreasing size, with antecedent forms being larger than descendent forms (Guthrie 1980). The size differences indicated here suggest that the earlier fauna from Trolinger Spring is nevertheless perhaps several thousands of years younger than the latest period of faunal accumulation in adjacent Jones Spring. The right calcaneum (77TS79) referred to *Bison* sp. from Trolinger Spring is from an individual no larger than living *Bison bison.* Except for small size, it is not distinctive.

Elsewhere in Missouri, *Bison* sp. has been reported in the late Pleistocene faunas from Brynjulfson Cave No. 1, Boone County (Parmalee and Oesch 1972) and from Herculaneum Fissure, Jefferson County (Olson 1940). In addition *Bison latifrons* as well as *Bison latifrons* and/or *Bison antiquus* occur in the Pleistocene fauna from Jones Spring, Hickory County (this report).

Systematic Discussion of Trolinger Spring II Fauna

Class MAMMALIA
Order INSECTIVORA
Family SORICIDAE
Blarina brevicauda (Say, 1823)
Short-tailed shrew

ABUNDANCE. A single individual. Two specimens, right and left lower first incisors, EHL 150, EHL 151.
HABITAT. The Short-tailed shrew presently occurs in deciduous and coniferous forests and in open fields in the eastern United States and southeastern Canada. In the eastern portions of the Great Plains it is limited to westward extensions of deciduous forests along watercourses or to marshy, grassy areas near water. It occurs throughout Missouri.
DISCUSSION. The soricid material was recovered during the 1967-1968 period of excavations in Trolinger Spring. This material has been previously reported by this writer (Saunders 1977a). No additional material was recovered during the 1978-1979 period of excavations.

Order RODENTIA
Family CRICETIDAE
Peromyscus spp. Gloger, 1841
White-footed mice

ABUNDANCE. Two individuals. Two specimens, right upper and lower first molars, EHL 151, EHL 151.
HABITAT. Except for the northern parts of the Arctic, *Peromyscus* is found in almost every possible terrestrial habitat in North America.
DISCUSSION. The *Peromyscus* material was recovered during the 1967-1968 period of excavations in Trolinger Spring and no additional material was recovered during the more recent period of excavations. These specimens have been previously reported by Lindsay (in Mehringer, King and Lindsay 1970 and in King and Lindsay 1976) and by this writer (Saunders 1977a). Except that two sizes (probably different species) are represented, the specimens are not distinctive.

Synaptomys sp. Baird, 1858
Bog lemming

ABUNDANCE. A single individual. One specimen, incisor enamel reported by Lindsay (in Mehringer, King and Lindsay 1970), without specimen number.
HABITAT. Southern bog lemmings (*S. cooperi*) presently occur in damp bogs and meadows with thick vegetation in the eastern United States and southeastern Canada. Northern bog lemmings (*S. borealis*) presently occur in wet alpine and sub-alpine meadows with muskeg, heaths and sedges in boreal Canada and the northeasternmost United States. The Southern bog lemming presently occurs throughout Missouri.
DISCUSSION. The single specimen referred to this genus was recovered during the 1967-1968 period of excavations. It was previously reported by Lindsay (in Mehringer, King and Lindsay 1970) and by this writer (Saunders 1977a). No additional material was recovered during the 1978-1979 period of excavations reported here.

Order PROBOSCIDEA
Family MAMMUTIDAE
Mammut americanum (Kerr, 1792)
American mastodon

ABUNDANCE. Fifteen individuals, based on assembled dentitions, are represented in the combined 1967-1968 and 1978-1979 Trolinger Spring collection. There is a combined total of 323 specimens referred to this taxon in the Trolinger Spring collection (Table 8). Specific abundance reported here for renewed excavations is 205 specimens, including 13 isolated complete and incomplete upper tusks; nine skull fragments, including seven petrosals; three isolated complete and incomplete lower tusks; four left mandibular rami containing eight cheek teeth; one right mandibular ramus containing three teeth; 15 isolated upper teeth; 14 isolated lower teeth; 17 tooth fragments; 17 complete and incomplete vertebrae; 12 incomplete ribs; five incomplete scapulae, including two glenoid portions and three fragments; three incomplete innominates; six incomplete humeri, including one distal epiphysis; one distal epiphysis of an ulna; one distal epiphysis of a radius; eight incomplete femora, including three proximal and one distal epiphyses; one patella; three incomplete tibiae, including one proximal epiphysis; one distal epiphysis of a fibula; 28 complete and incomplete foot elements; 38 indeterminable bone fragments.
HABITAT. *Mammut americanum* is one of the most common fossil vertebrates found in Pleistocene deposits throughout North America. It occurs from the Atlantic to the Pacific coasts and from the Valley of Mexico to Alaska. In Missouri *Mammut americanum* is known from records in 37 counties. It is the most common fossil mammal in spring deposits in the Ozark Highland (Saunders 1977a and this report).

Pollen associated with the mastodon and other Trolinger Spring II fossils indicate that *Mammut americanum* here occupied an open pine-parkland (King 1973). Elsewhere in Missouri, for example at Jones Spring (King 1973; this report), *Mammut americanum*, during an earlier period, also occupied an open pine-parkland in addition to presumably earlier deciduous or mixed deciduous-coniferous forest, woodland or savanna transitional to pine-parkland. At Boney Spring in Benton County *Mammut americanum* occupied a forest of spruce containing deciduous elements during the closing phase of the Pleistocene (King 1973; Saunders 1977a). Elsewhere in eastern North America,

TABLE 8

Abundance of *Mammut americanum*
in the Trolinger Spring II fauna.

Element	1967-1968[1]	1978-1979
Upper tusks	5 (incomplete)	13 (complete and incomplete)
Lower tusks	7 (incomplete)	3 (complete and incomplete)
Skulls		
Complete	0	0
Maxillae	1	0
Fragments	7	9
Mandibles		
Complete	0	0
Rami	4	5
Fragments	0	5
Isolated cheek teeth	45	29
Cheek tooth fragments	-	17
Vertebrae	11 (incomplete)	17 (incomplete)
Ribs	8 (incomplete)	12 (incomplete)
Scapulae	1 (nearly complete)	5 (incomplete and fragments)
Innominates	3 (one complete)	3 (incomplete and fragments)
Humeri	5 (incomplete)	6 (incomplete and fragments)
Ulna	3 (incomplete	1 (distal epiphysis)
Radii	1 (incomplete)	1 (distal epiphysis)
Femora	4 (incomplete)	8 (incomplete and fragments)
Patellae	0	1 (complete)
Tibiae	1 (incomplete)	3 (incomplete and fragments)
Fibulae	0	1 (distal epiphysis)
Foot elements	7	28 (complete and incomplete)
Indeterminable bone fragments	5	38

[1] as reported in Saunders 1977a:26.

where much of the mastodon-associated paleoenvironmental record has been obtained, *Mammut americanum* occupied spruce forests or open woodlands of spruce and associated trees (Dreimanis 1968). The American mastodon was a browser on trees, shrubs and/or other plants associated with these forests, woodlands or savannas.

DISCUSSION. During the earlier period of excavations, 118 specimens of *Mammut americanum* were recovered and have been previously reported (Saunders 1977a). Detailed study of the 205 additional mastodon specimens recovered during the more recent period of excavations under contract by the U.S. Army Corps of Engineers lags behind study of all other groups reported here. This is primarily due to 1) their recent recovery relative to those from Jones Spring for which analyses are more advanced, 2) their abundance, relative to other Trolinger Spring II taxa and 3) their great potential for detailed study.

Fossils of *Mammut americanum* occurred abundantly in the primarily organic sediments containing the Trolinger Spring II fauna. As previously mentioned these sediments were set within dominantly inorganic sediments that contained the Trolinger Spring I fauna which lacked mastodon.

More so than in Jones Spring, but less so than in Boney Spring, the Trolinger Spring II fossils, and especially those of *Mammut americanum*, occurred in dense concentration and comprised a distinct bonebed (Fig. 11). In this concentration there were no articulated series of mastodon (or other taxa) elements uncovered and dissociation of skeletal materials was complete.

Figure 12 presents the age structure of the 15 individuals comprising the *Mammut americanum* sample from Trolinger Spring II. When individual ages of mastodons are determined, following the method of Laws (1966) for African elephants based on an analysis of eruption, wear and elimination of the lower cheek teeth (see Saunders 1977a for a discussion of Laws' procedures applied to mastodon dentitions), and their frequency plotted, an age structure histogram can be constructed. Age structure has been demonstrated to reveal the cause of mortality reflected in fossil accumulations, including attritional mortality, catastrophic mortality or a combination of the two termed mixed. An understanding of the cause of mortality has, in turn, important implications for paleoecological reconstruction as well as inferred duration of accumulation reflected in fossil deposits.

It is apparent from the figure that mastodon age structure at Trolinger Spring is unimodal, that is, individuals in the 20-22 year age class occur most frequently in the sample. Attritional mortality, which is the normal type, affects mainly the very young and the very old. While this can be inferred for the extremes of the histogram distribution (the two individuals in the 2-4 year age class and perhaps the single individual in the 46-48 year age class) some other component of mortality is indicated by the abundance of mature and presumably vigorous individuals in the 24-40 year age classes, as well as by the frequency of young adult individuals in the modal age class (20-22 years). Mortality of the individual in the 10-12 year age class can be interpreted as normal attrition, perhaps reflecting a combination of adventurism and naivety associated with late adolescence. However, it is not possible to explain mortality in the 20-40 year age classes as the normal attrition of contemporary individuals. Mastodons in this young adult and mature interval would be expected, under normal conditions, to be vigorous and in their prime and thus unrepresented in fossil accumulations deriving from normal attritional processes. Age structures showing numerous vigorous, prime

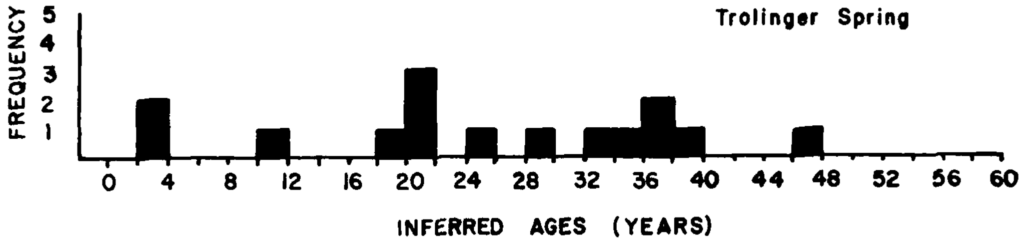

Figure 12. Histogram of inferred age structure of *Mammut americanum* from the Trolinger Spring II fossil assemblage.

individuals are usually interpreted as reflecting some catastrophic, or non-selective and non-attritional, mortality (Voorhies 1969; Saunders 1977a).

There is another potentially possible interpretation of the age structure inferred for *Mammut americanum* from Trolinger Spring, i.e., that it reflects a natural herd of individuals that perished together. This form of mortality is strictly catastrophic and has been suggested to account for the accumulation of mastodons in adjacent Boney Spring (Saunders 1977a). However, from point of view of age structure inferred for the *Mammut americanum* sample in Trolinger Spring, when compared with sample age structures in living African elephants, *Loxodonta africana*, which are matriarchal family units comprising, generally, between 5 and 15 individuals, there are important points of contrast. For example, among samples of living elephants in Murchison Falls National Park, Uganda, reported by Laws and Parker (1968) and figured and tabulated previously by me (Saunders 1980:91-93, Figures 2 and 3 and Table 4), the mean age of the matriarchs was 44 years, with a range for 14 samples of 28-56 years. This range does include the inferred age of the oldest individual in the Trolinger Spring sample (46-48 years of age, sex unknown). The mean inferred age of the Trolinger Spring sample is 25 years. For the African elephant data, the mean for this sample variate is 17 years, with a range for 14 samples of 12-25 years (Saunders 1980:92, Table 4). This suggests that the mean inferred age in the Trolinger Spring sample is high, compared to African elephant family units (=herds) today. The median inferred age for the Trolinger Spring sample occurs in the 24-26 year age class and, as previously noted, the modal inferred age class for this sample is 20-22 years. The median age of 135 African elephants, occurring naturally as 14 family units, is 14-16 years and the modal age class for the same sample is 2-4 years (Saunders 1980:Table 4). Both of these variates contrast markedly with the sample inferred age data for *Mammut americanum* from Trolinger Spring. Recruitment into the Trolinger Spring sample, if naturally derived, is 13% (=the percentage of individuals that are suckling, or those 3 years of age of less; Sikes 1971). For the 14 family units of African elephants, the grouped mean recruitment was, using this criteria, 16% (22/135), with a sample range of from 0% to 33% (Saunders 1980:Table 3). Finally, the percentage of immatures (=those individuals 14 years of age and younger) in the samples may be compared. For the *Mammut americanum* sample from Trolinger Spring there are three individuals inferred to have been immature, or 20% of the sample. For the 14 family units of African elephants, the grouped mean percentage of immatures is 50%, and ranged from 33% to 60% in individual samples (Saunders 1980:92, Table 4). In summary, from point of view of comparison of sample mean ages, median ages and modal age classes, as well as percentages of immature individuals in the samples, it can be concluded that a natural herd, organized as in living elephants, is not reflected in the inferred age structure data for *Mammut americanum* from Trolinger Spring. Rather, it appears from analysis of inferred age structure that mastodon mortality reflected in the Trolinger Spring sample was mixed, with both attritional as well as catastrophic components. Mixed mortality usually indicates a long duration of faunal accumulation resulting in the accumulation of animals not truly contemporaneous and such a situation may be indicated for Trolinger Spring.

Table 9 gives metrical data on molars of *Mammut americanum* from Trolinger Spring. In general these teeth compare, in size and variability, with those from Jones Spring (see table below) but contrast in size with those from Boney Spring which are generally larger.

TABLE 9

Metrical data[1] on molars of *Mammut americanum* from Trolinger Spring.

Variate	n	OR	$\bar{x}$	s	CV
LM1/	8	78- 97	88.9±2.3	6.6	7.4
WM1/	8	68- 77	71.6±0.9	2.6	3.7
LM2/	8	106-124	115.0±2.2	6.3	5.5
WM2/	8	84- 96	90.8±1.4	3.9	4.3
LM3/	10	144-180	160.3±4.4	13.9	8.7
WM3/	9	87-106	94.0±2.5	7.4	7.9
LM/1	11	84-101	91.8±1.7	5.7	6.2
WM/1	11	64- 75	69.3±1.1	3.8	5.5
LM/2	13	101-124	113.9±2.3	8.2	7.2
WM/2	13	79- 95	85.5±1.6	5.7	6.6
LM/3	9	157-196	172.7±4.5	13.6	7.9
WM/3	9	86-110	93.0±2.5	7.6	8.2

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[1] measurements and statistics:
L, length measured along median sulcus
W, greatest transverse width
n, number of specimens
OR, observed range
$\bar{x}$, mean
s, standard deviation
CV, coefficient of variation
±, precedes standard error of the sample mean

measurements are in millimeters

Order ARTIODACTYLA
Family CERVIDAE
Sangamona fugitiva Hay, 1920
Stilt-legged deer

ABUNDANCE. A single individual. Two specimens, left M/3, 2TS78; antler fragment (with burr), 29TS78, provisionally referred.

HABITAT. Very little is known regarding habitat preferences of *Sangamona fugitiva*. Kurtén (1979) has mentioned that the cursorial adaptation pointed to be the length and slenderness of the limbs, indicating a very light body, suggests an open habitat. This, he points out, is also indicated by the occurrence of *Sangamona fugitiva* in loess deposits near Alton, Illinois (Hay 1920:111). Pollen associated with these fossils in Trolinger Spring (King 1973) indicates that *Sangamona fugitiva* here occupied an open pine-parkland where it was presumably a browser.

DISCUSSION. The fossils here assigned to *Sangamona fugitiva* came from contexts distinct from the clay and mixed sands and gravels that contained the fossils attributed to the earlier, grazing or steppe fauna in Trolinger Spring. The lower molar was recovered from dark brown peat (unit d_3). The antler fragment occurred in variegated brown peat and light gray sand (unit c). Together with the light gray sand of the feeder (unit b), these units contained a fauna dominated by mastodon and muskoxen, distinct from the earlier fauna contained in conduit sands and gravels, and attributed here to a later browsing or woodland fauna, based on associated pollen.

Sangamona fugitiva, the sole described species of the genus, is one of the most enigmatic animals in the Pleistocene fauna of North America. As stated recently by Kurtén (1979:313), "the characters of *Sangamona* have continued to be uncertain and the genus has served as a waste-basket for Pleistocene cervids in the size range intermediate between mule deer and wapiti in North America." The fossils from Trolinger Spring are important specimens that add to our understanding of the morphology and paleoenvironment of this poorly known cervid.

Measurements of the Trolinger Spring M/3 are given in Table 10. For purposes of comparison, the table also gives sample range and mean values for *Sangamona* and for *Odocoileus*. It is apparent from values in the table that the Trolinger Spring specimen is too large to be assigned to one or the other species of extant *Odocoileus*; length and width measurements of M/3 are both well above the range of these variates in *Odocoileus* measured by me. The Trolinger Spring specimen does agree well with the *Sangamona* sample, however. The length of the Trolinger Spring molar is near the upper limit for this variate in reported *Sangamona* while the width falls well within the range, and quite near the mean, of this variate in the *Sangamona* sample. The Trolinger Spring M/3 agrees with M/3's of *Sangamona* in details of morphology as well as size. The inner surface of each lobe is relatively flat, with only reduced stylid development, as in *Sangamona fugitiva* (Hay 1920:111). On the outer surface of the tooth there are conspicuous accessory pillars in the valleys separating the lobes. While these are variable but usually only incipient to weak in M/3's of *Odocoileus* examined by me, their strong development characterizes lower molars of *Sangamona fugitiva* (Hay 1920:111).

TABLE 10

Measurements (in millimeters) of *Sangamona* M/3 from Trolinger Spring compared with sample ranges and means of *Sangamona*[1] and *Odocoileus*[2].

		Sangamona	*O. virginianus*	*O. hemionus*
Variate	2TS78	range: mean	range: mean	range; mean
M/3		n = 5 (4)	n = 10	n = 10
lg:	26.9	22.0-27.0; 24.9	21.0-23.7; 22.7	20.8-24.9; 22.9
w:	13.0	(12.0-13.5; 12.9)	10.7-12.2; 11.4	10.2-11.8; 11.1

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[1] Sangamona sample includes two specimens from Brynjulfson Cave No. 1, Missouri (Parmalee and Oesch 1972), two from Alton, Illinois (Hay 1920; Kurtén 1979) and one from Little Bluff Cave, Missouri (undescribed left mandibular ramus with P/2-M/3).

[2] *O. virginianus* and *O. hemionus* are from the Illinois State Museum osteological collections. Each sample consists of five mature mandibles, with left and right teeth treated independently.

The antler fragment provisionally referred here to *Sangamona fugitiva* is an especially interesting specimen. Antlers of *Sangamona fugitiva* have not previously been described (Kurtén 1979:314). The most completely known skeleton of this animal, from Frankstown Cave, Pennsylvania, is anterless and presumably a female (Kurtén 1979:314). The antler from Trolinger Spring is referred to *S. fugitiva* on the basis of stratigraphic association with the M/3 described above, as well as on the basis of unique form (Fig. 13). The specimen is fragmentary and preserves only the burr and two closely proximal major but subequal branches: an incomplete anterior brow tine and an incomplete posterior beam. On the basis of curvature and orientation the specimen is inferred to be from the right side. It represents a naturally shed antler. The transverse diameter of the burr is 39.1 mm; above the burr, transverse diameter is 34.7 mm. The anteroposterior diameter of the burr, 40.9 mm, is a minimum value only as the burr is abraded posteriorly; above the burr, minimum anteroposterior diameter is 41.8 mm. The depth of the antler, measured from the base of the specimen to the saddle of the bifurcation above, is 40.0 mm. The preserved portion of the brow tine measures 71.4 mm. The cross section has the form of a compressed oval, with the major axis rotated approximately 45° laterally (Fig. 13). The brow tine has been slightly abraded medially. Nevertheless, the transverse diameter of the brow tine at its base, 20.0 mm, is a close estimate of the original value. The dorsoventral diameter, measured along the rotated major axis at the base of the brow tine, is 27.0 mm. The brow tine measures, minimally, 82.0 mm in circumference at its base. The posterior edge of the main beam is incomplete. The preserved portion measures 84.2 mm in length. The fossil indicates that the main beam was subcircular in cross section at its base. The angle of bifurcation measures approximately 82° (Fig. 13).

Comparison of the fossil with antlers in living and fossil North American Pleistocene cervids demonstrates its unique character. The presence of a markedly pronounced brow tine of the fossil is completely unlike *Odocoileus* spp. antlers examined by me in the collections of the Illinois State Museum. In overall shape, the Trolinger Spring fossil is like antlers in elk (*Cervus canadensis*) but is without doubt significantly smaller. There is a set of antlers from a small elk in the collections of the Illinois State Museum that compares rather well in general size with the fossil specimen though they too are larger. This modern antler is thicker transversely and anteroposteriorly through, as well as above, the burr (on the right burr: transverse diameter = 50.6 mm, anteroposterior diameter = 56.7 mm, above the right burr: transverse diameter = 38.3 mm, anteroposterior diameter = 49.0 mm). Also, the modern antler has, relative to the main beam, a much reduced brow tine (at the base of the right tine: transverse diameter = 19.0 mm, dorsoventral diameter = 26.1 mm) as in elk generally. In addition, the angle of bifurcation in this modern elk antler measures approximately 100°. Observations by me on 5.5 pairs of elk antlers (*Cervus canadensis*) in the Illinois State Museum collections indicate that the angle of bifurcation of the brow tine from the main beam in elk is consistently and appreciably greater than 90°. Caribou and reindeer antlers also possess a prominent brow tine but here again the tine projects forward at a low and oblique angle. Comparison of this fossil antler can be made with only one form of extinct Pleistocene cervid (discounting *Cervalces*, the Stag-moose, for which antlers are common, distinctive and quite unlike the Trolinger Spring specimen). *Navahoceros*, the Mountain deer of Pleistocene western North America, has simple forked antlers (Kurtén 1975) which do not appear to compare with the fossil from Trolinger Spring. *Navahoceros* is often contrasted with *Sangamona* (Kurtén 1975; 1979). The former was a large deer with heavy proportions restricted to western North America. The latter was a large deer with light proportions distributed throughout central and eastern North America. The unique form of a fossil antler

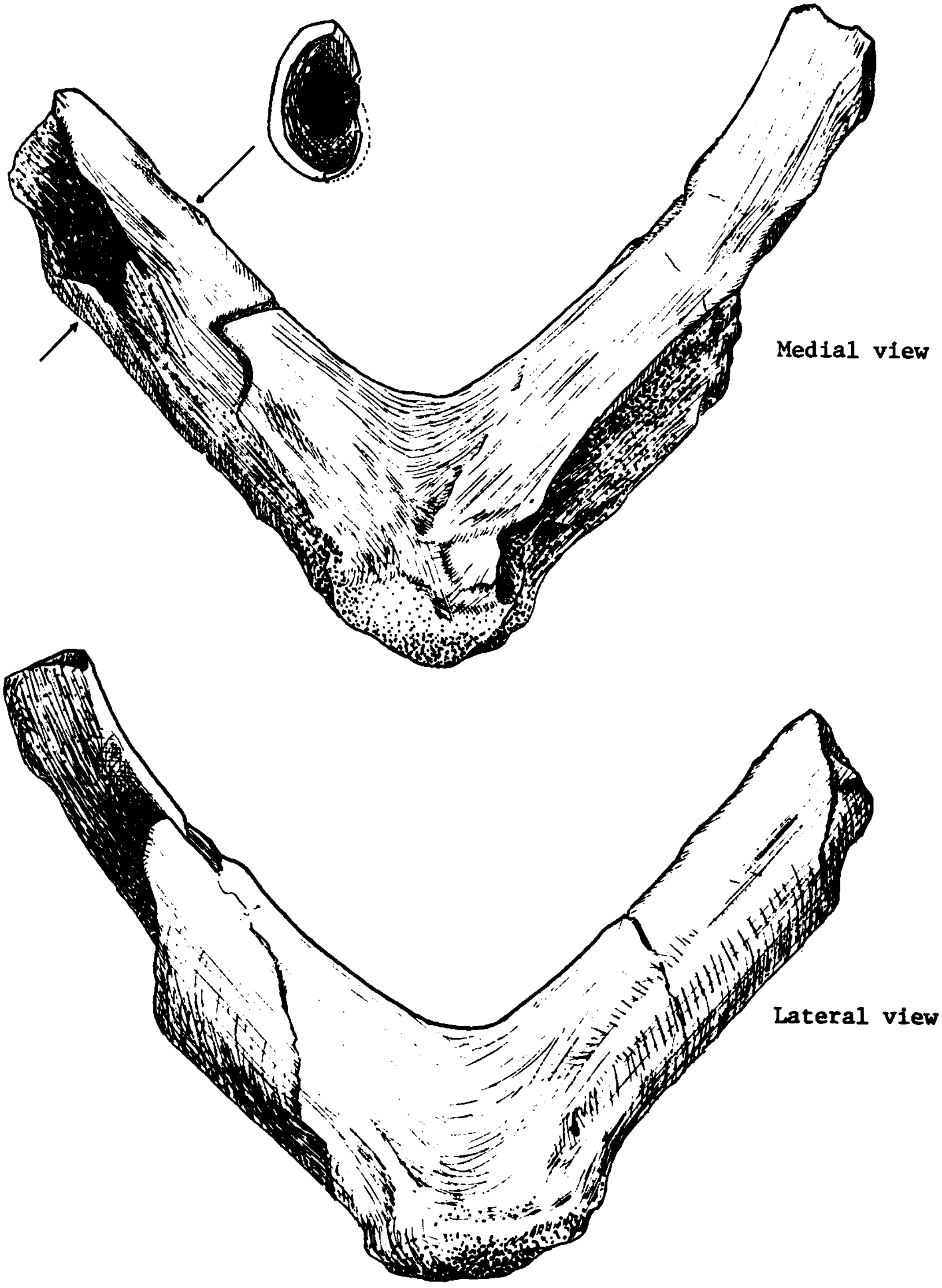

Figure 13. Right antler fragment (29TS78) provisionally referred to *Sangamona fugitiva* from the Trolinger Spring II fossil assemblage. X1.

from Trolinger Spring, its association there with a tooth indistinquishable from *Sangamona fugitiva* as well as the geographical distribution of this large deer, all suggest that the fossil is probably referable to *Sangamona fugitiva*.

Comparing the fossil antler with antlers in other cervids, closest agreement in shape, brow tine development and angle of bifurcation is observed with antlers of *Hippocamelus* spp. (the Andean deer of South America), which are characterized by possessing small, simple antlers, including a pronounced brow tine forming an acute angle with the main beam (Walker 1964:1397). Hay (1920: 91), in his diagnosis of the new genus *Sangamona*, suggested that its teeth most closely resemble, among living cervids, those of *Dama dama*, the Fallow deer of Europe and Asia Minor. Fallow deer possess antlers with a pronounced brow tine, as does the antler referred here to *Sangamona*. However, in *Dama dama* examined by me (n = 4) the brow tines have an oblique bifurcation from the main beam and are nearly circular in cross section.

The Trolinger Spring antler is a proximal fragment and nothing definitive can be stated regarding the shape or characters of the more distal portions. As mentioned previously, however, the brow tine on the fossil is conspicuously and unusually flattened, perhaps reflecting a distal palmation.

Elsewhere in Missouri, cf. *Sangamona* has been reported by Parmalee and Oesch (1972) in the fauna from Brynjulfson Cave No. 1 in Boone County. In addition, an undescribed mandibular ramus of a large deer, almost certainly *Sangamona fugitiva*, was recently recovered in Little Bluff Cave in Shannon County.

Family BOVIDAE

Symbos cavifrons (Leidy, 1852)

Woodland muskox

ABUNDANCE. One Juvenile and three adult individuals, based on one right dP/4 and three left M3/'s. Fifty-six specimens, right P3/, EHL 210; right M1/, EHL 162; right M1/, 216TS78; left M2/, 25TS78; right M2/, EHL 203; right M2/-M3/, 164TS78; left M3/, 78TS78; left M3/, 136TS78; left M3/, 99TS79; eight complete and incomplete incisors, EHL 191-193, 173TS78, 207TS78, TS78, TS78 and 55TS79; right dP/4, 141TS78; right P/4, TS78; right P/4, 32TS79; left M/1, 118TS79; left M/1, TS79; right M/1, 23HI-210; left M/2, EHL 157; right M/2, 56TS79; left M/3, 64TS79; right M/3, 254TS78; 16 upper and lower cheek tooth fragments, 23HI-210, TS67, EHL 180, 217TS78, TS78, TS78, TS78, TS78, TS78, TS78, TS78, TS78, TS78, TS78, 46TS79, TS79; partial skull, edentulous, 238TS78; immature skull fragments, 255/256TS78; left horn core fragment, 4TS78; thoracic vertebral centrum, TS78; glenoid portion of a right scapula, 89TS78; two metacarpal epicondyles, associated, EHL 194 and 124TS78; right femur shaft, 17TS-68; femur condyle, 127TS78; left and right astragali, associated, 240TS78 and 1TS78, respectively; distal portion of a proximal, lateral phalanx, 62TS78.

HABITAT. Pollen associated with the fossil remains in Trolinger Spring (King 1973) indicate that *Symbos cavifrons* inhabited an open pine-parkland where it was probably a browser. Elsewhere in eastern North America Woodland muskoxen apparently inhabited boreal forest or woodland of spruce and fir in addition to pine (Semken, Miller and Stevens 1964; Ray, Cooper and Benninghoff 1967). In western North America, for example Utah (Nelson and Madsen 1978), Woodland muskoxen (*Symbos* sp. and *Bootherium* sp.) are common but are not associated with evidence indicative of habitat preferences. Elsewhere in Missouri, *Symbos* sp. or *Bootherium* sp. occur in the fauna from Jones Spring, Hickory County, where it is also associated with an open pine-parkland (Van Devender and King 1975; this report).

DISCUSSION. During the period of initial excavations 11 specimens, representing two individuals, were recovered that I previously imprecisely referred to *Symbos* sp. or *Bootherium* sp. (Saunders 1977a). The recovery in 1978 of a partial adult skull with characters unique to *Symbos cavifrons* enables me now to assign the entire muskoxen sample from Trolinger Spring to *Symbos cavifrons* with good confidence. I include the entire muskoxen sample from Trolinger Spring in the present discussion, including materials (prefixed EHL or 23HI-210 or suffixed TS67 or TS68) recovered during 1967 and 1968 that have previously been reported by Mehringer, King and Lindsay (1970) and Saunders (1977a).

Thirteen specimens were recovered from dark brown sandy clayey peat or dark brown organic clay (unit d_3), six specimens occurred in underlying variegated organic sand (unit c) and 19 specimens were recovered from light gray sand or light gray sand and fine blue chert gravel (unit b) filling the feeder in Trolinger Spring and underlying both dark brown sandy clayey peat or dark brown organic clay and variegated organic sand. A single specimen occurred in fine blue chert gravel (unit b) of the feeder, at its contact with gray mixed sand and gravel of the older spring conduit. Another single specimen (partial adult skull, 238TS78) occurred in dark brown sandy peat (unit d_3) at its contact with variegated organic sand (unit c) and three specimens occurred at the contact of dark brown sandy clayey peat or dark brown organic clay (unit d_3) and light gray sand (unit b). Thirteen specimens were recovered without provenience information. It is worthy of mention that upper teeth representing a single individual occurred in both unit d_3 (EHL 191, right M1/; EHL 210, right P3/; 25TS78, left M2/; 78TS78, left M3/) and unit c (164TS78, right M2/-M3/) indicating either that no significant hiatus is represented by the contact separating these two units or that intrusion of later fossils into earlier sediments occurred.

The fossils referred here to *Symbos cavifrons* were all recovered either in peat, brown organic clay, variegated organic sand, light gray sand or light gray sand and fine blue chert gravel (units d_3, c, b) that also contained fossil remains of *Mammut americanum* and *Sangamona fugitiva* and which are distinct from gray mixed sand and gravel, brown mixed sand and gravel and gray organic clay containing fossils of *Mammuthus jeffersonii*, *Equus* spp., *Odocoileus* sp., *Bison* sp. and others. As previously discussed, this complete separation is interpreted as revealing two distinct periods of faunal accumulation in Trolinger Spring, each under quite different climatic regimes. As interpreted here, an earlier grazing or savanna-steppe fauna, dominantly mammoth, horse and bison, reflecting relatively dry conditions approximately 35,000 years ago, is succeeded by a browsing or woodland fauna, dominantly mastodon and muskoxen, reflecting wetter conditions approximately 25,000 years ago.

The skull from Trolinger Spring is incomplete from the posterior edge of the orbits forward (Fig. 14). The tip of the left horn core and the distal half of the right horn core are missing. The roughened central region between the horn cores (the exostosis) is well preserved. The dorsal region of the specimen is well preserved and exhibits sharp detail. On the other hand, the occiput, the occipital condyles as well as the ventral region of the skull are eroded, presumably by spring action. The Trolinger Spring skull exhibits the following morphological characters that are, following Harington (1975:911), characteristic of *Symbos cavifrons*: 1) the presence of a deep, roughened trough between the horn core bases; 2) the high lateral flare of the horn cores, compared to living muskoxen; 3) the great occipital height of the specimen; 4) the presence of a deep median

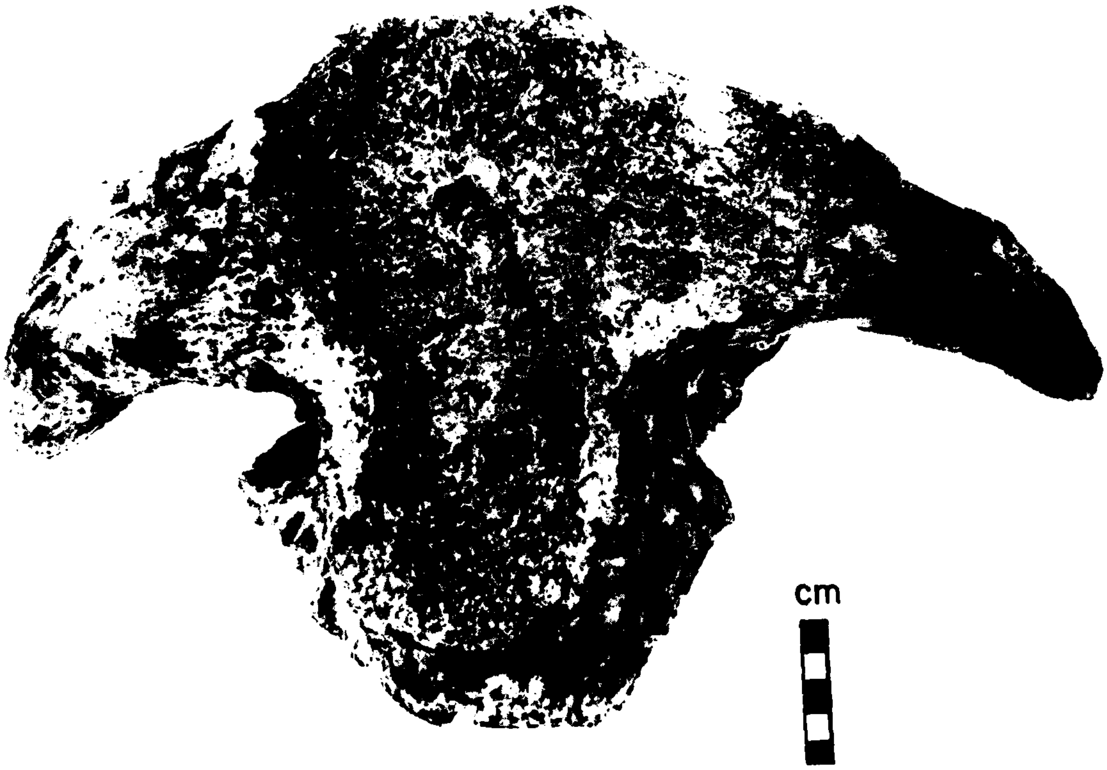

Figure 14. Dorsal view, *Symbos cavifrons* skull fragment (238TS78) from the Trolinger Spring II fossil assemblage. Anterior border of specimen faces base of page.

groove on the basioccipital bone. The specimen is large and compares in size with other specimens that are inferred to be adult males (for example, a male skull from Fort Saskatchewan, Alberta, reported by Harington 1975:911, Table 2). Table 11 gives measurements of the *Symbos cavifrons* skull from Trolinger Spring.

TABLE 11

Skull measurements (in millimeters) of *Symbos cavifrons* from Trolinger Spring.

Variate*	
Exostosis length:	248.2
Exostosis width anterior to horn cores:	103.5
Anteroposterior diameter of horn core at base:	108.9 (left); 106.2 (right)
Dorsoventral diameter of horn core at base:	55.1 (left); 57.4 (right)
Width of skull at constriction between horn cores and orbits:	140.5
Width between horn core tips (estimated):	475.0+
Width at constriction above nuchal crest:	141.6
Height from upper rim of foramen magnum to mid-line on dorsal surface of skull:	155.6e
Height from ventral border of occipital condyle to dorsal surface of skull:	197.9e
Height from upper rim of foramen magnum to top of nuchal crest:	155.6e
Height of foramen magnum:	46.9
Width of foramen magnum:	58.3
Width across occipital condyles:	175.3
Width of left occipital condyle:	64.1
Maximum width of skull above auditory meatus:	202.0+
Basioccipital breadth:	96.1

* variates are those of C. R. Harington (1975).
\+ implies a minimum value.
e estimate.

Both upper and lower cheek teeth of *Symbos* (which includes the single species *S. cavifrons*) differ from teeth of *Ovibos moschatus*, the living musk-ox, in being wider relative to their length. The upper teeth of *Symbos* generally lack endostyles (a variable feature on Missouri specimens, as evidenced by endostyles on two specimens assigned to *Symbos* sp. or *Bootherium* sp. from Jones Spring, this report, as well as the presence of an endostyle on a specimen from Trolinger Spring, 99TS79, left M3/) which are small or absent in *Ovibos* but well developed in *Bison*. In addition, the M1/ of *Symbos* exhibits a well developed mesostyle but only weak parastyle and metastyle, unlike teeth of *Ovibos* or *Bison* where the latter two features are better developed. In all these morphological features the teeth from Trolinger Spring differ in no way from teeth of *Symbos cavifrons*. Table 12 gives measurements of cheek teeth of adult *Symbos cavifrons* from Trolinger Spring.

Length and width of M2/ and width of M/2 and M/3 of *Symbos cavifrons* from Trolinger Spring agree well with values reported by Brown (1908:204) for *Symbos australis* (=*S. cavifrons*) from Conard Fissure, Arkansas (M2/ length = 32 mm, M2/ width = 30 mm, M/2 width = 23 mm, M/3 width = 22 mm).

TABLE 12

Measurements (in millimeters) of cheek teeth of adult *Symbos cavifrons* from Trolinger Spring.

Variate		EHL 210 (rP3/)	EHL 162 (rM1/)	216TS78 (rM1/)	25TS78 (lM2/)	164TS78 (rM2/)	78TS78 (lM3/)	136TS78 (lM3/)	164TS78 (rM3/)
P3/	lg.	18.9							
	w.	18.2							
	ht.[1]	14.4							
M1/	lg.		26.3	32.6					
	w.		28.8	27.4					
	ht.		15.8	35.7					
M2/	lg.				33.6	34.5			
	w.				30.9	32.0			
	ht.				22.4	21.2			
M3/	lg.						43.8	44.4	42.9
	w.						32.7	32.8	32.8
	ht.						25.3	22.9	23.4

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[1] measured from the base of the enamel to the highest point of the tooth crown on the labial side.

TABLE 12 (concluded).

Variate		TS78 (rP/4)	32TS79 (rP/4)	118TS79 (1M/1)	TS79 (1M/1)	23HI-210 (rM/1)	EHL 157 (1M/2)	56TS79 (rM/2)	64TS79 (1M/3)	254TS78 (rM/3)
P/4	lg.	21.3	26.1							
	w.	14.4	17.3							
	ht.[2]	23.1	36.5							
M/1	lg.			30.5	-	32.3				
	w.			20.9	24.2	23.4				
	ht.			31.1	27.0	26.5				
M/2	lg.						36.0	35.6		
	w.						23.2	22.9		
	ht.						42.6	49.8		
M/3	lg.								58.1	53.1
	w.								21.6	21.6
	ht.								57.1	35.1

---

[2] measured from the base of the enamel to the highest point of the tooth crown on the lingual side.

M/2 and M/3 in the Trolinger Spring sample are however appreciably longer than those reported by Brown (1908:204) for Conard Fissure *Symbos* (M/2 length = 36.0 and 35.6 mm vs. 30 mm, M/3 length = 58.1 and 53.1 mm vs. 49 mm). In addition, length of M1/ and M2/ of *Symbos cavifrons* from Trolinger Spring agree well with values reported by Nelson and Madsen (1978:293) for teeth in a skull of *S. cavifrons* from Utah (M1/ length = 27-28 mm, M2/ length = 35 mm). However the P3/ from Trolinger Spring is shorter than the P3/ in the Utah skull (18.9 mm vs. 22-23 mm) whereas the M3/'s from Trolinger Spring are slightly longer than the M3/'s in the Utah specimen (42.9 mm, 43.8 mm and 44.4 mm vs. 39-40 mm).

The postcranial materials referred here to *Symbos cavifrons* are not distinctive. The astragali are small, compared to other astragali assigned to *Symbos cavifrons*. In size they compare well with astragali from a juvenile *Bos taurus* in which dP/4 was in wear. They presumably were associated in the juvenile *Symbos cavifrons* represented by 141TS78, right dP/4. The associated metacarpal epicondyles are from another, larger, and presumably adult, individual. When joined, the epicondyles indicate a metacarpal that measures approximately 83.0 mm in distal width. The anteroposterior diameter, measured just above the epicondylar articulation facets, is approximately 41.0 mm.

Symbos cavifrons has been previously reported from single localities in seven counties in Missouri (Mehl 1962), including localities in Benton, Jefferson and New Madrid counties that Leidy (1869:375) considered in his discussion of *Ovibos* (now *Symbos*) *cavifrons*. Elsewhere in the Ozark Plateaus, *Symbos australis* (=*S. cavifrons*) was reported in the Pleistocene fauna from Conard Fissure, Arkansas (Brown 1908). The *Symbos cavifrons* sample from Trolinger Spring is, in terms of abundance and unity of sample, currently the most important collection yet known from the Ozark Plateaus.

JONES SPRING

Jones Spring is located approximately 150 m WSW from Trolinger Spring (Fig. 1). The spring occurs 11.5 m above and 1950 m directly west of the Pomme de Terre River at an elevation of 218.5 m above sea level.

Stratigraphy

Though there is some indication of earlier and later periods of faunal accumulation in Jones Spring, distinct and temporally separate fauna could not be documented with certainty based on stratigraphic separation in Jones Spring sediments. As mentioned previously fossil wood and root stock fragments from the base of the fossiliferous units in Jones Spring are entirely of deciduous species whereas pollen from the middle of the fossiliferous sequence, for example from dark brown peat, is indicative of a pine-parkland community. It is probable, based on these considerations that Jones Spring faunal accumulation was continuous over an appreciable interval of time. At the beginning of this interval, at least by 48,900 years ago, deciduous species dominated the immediate site area. The deciduous flora was succeeded later, but before 40,000 years ago, by pine-parkland. This floral readjustment is interpreted as being in response to shifting climatic regimes whereby a dryer, warmer climate gave way to a moister, probably appreciably cooler, climate after 48,900 years ago but before 40,000 years ago. It is probable that significant faunal readjustment occurred as well in the area during this interval and that this readjustment is recorded in Jones Spring fossiliferous sediments. However, as already mentioned, distinct faunas are not yet recognized from Jones Spring fossiliferous sediments.

Jones Spring fossils were concentrated in two peat lenses associated with spring activity as well as in sediments comprising the spring conduit and feeder. The lower peat, a 15 m diameter lens of peat over 1 m thick overlies a 4 m by 7 m conduit filled with roughly concentric fossiliferous strata of gravelly sand, mixed sand and blue chert gravel in addition to white sand occupying the spring's feeder or center. The lower peat lens can be separated into an upper dark brown zone and a lower light brown, gravelly zone. The upper peat lens was less extensive and less organic. It contained fragmented and/or rounded fossils suggesting forceful redeposition from the lower peat lens. Fossils also occurred at the lower contact of the lower peat lens with gray clay of the host alluvium. Some fossils occurred entirely in gray clay, presumably due to forceful intrusion into wet and plastic clay as evidenced in one instance by a fully articulated mastodon forefoot recovered from gray clay at the margin of the lower peat lens (see below).

An east-west stratigraphic cross section of Jones Spring deposits, produced by C. Vance Haynes during the course of the Jones Spring research program (1975-1977) is presented in Figure 15. Figures 16 through 21 (in

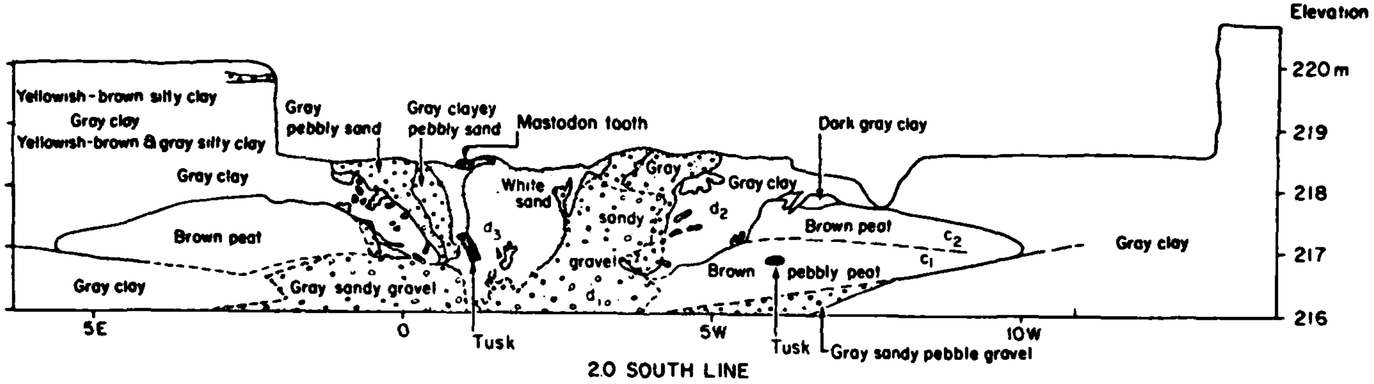

Figure 15. Stratigraphic cross section of Jones Spring along 2.0 South line showing the relationship of the fossil assemblage to the spring-laid sequence. The upper peat lens has been excavated and is not shown. Fossils occurred throughout the spring-associated sediments but were particularly abundant in the Brown peat (=lower peat lens). (From C. V. Haynes 1980.)

separate map volume) are plan maps of the main Jones Spring excavation. These maps show, in order of increasing depth, the six arbitrary levels (Maps 1 through 6) required to fully illustrate the relationship of each major specimen in the fossil deposit. Figure 22 (in separate map volume) is a composite map of the main Jones Spring fossil deposit. In addition, a distinct concentration of mastodon fossils was encountered in the southern section of the fossil deposit and separated from the main fossil concentration. In general these specimens occurred in gray clay of the host alluvium above and peripheral to the level of the lower peat lens. A single bone occurred in a similar context north of the main fossil concentration. These fossils appeared to be the variably dispersed partial remains of a single individual mastodon. Included in this assemblage was the fully articulated forefoot of a mastodon. Figures 23 through 26 (in separate map volume) are plan maps of the specimens in this distinct fossil concentration.

Age and Correlation

The main fossiliferous horizon in Jones Spring, dark brown peat, has been radiometrically age determined. A radiocarbon date on the top of this unit shows it to be more than 40,000 years old (Haynes 1980). A small juniper log (11JEK76) collected from the basal contact of this unit underlying gray clay, which is also fossiliferous, has been dated at 48,900±900 years ago (QL-962, Haynes 1980). These dates make Jones Spring older than Trolinger Spring II fauna. The Jones Spring dates and fauna are consistent with an early Wisconsinan interstadial interval, perhaps correlated with the Altonian substage in Illinois (Haynes 1976). The Altonian substage dates to the interval from approximately 28,000 to 75,000 years ago and was characterized by alternate episodes of glaciation and deglaciation (Willman and Frye 1970). As previously mentioned, the Jones Spring plant fossils suggest an episode of transition from a dry and warm, presumably non-glacial climate, to a wet and cool, presumably glacial climate within this substage after 48,900±900 years ago.

Systematic Discussion of the Jones Spring Fauna

Class REPTILIA
Order CHELONIA
Family TESTUDINIDAE
Chrysemys (Trachemys) scripta
Pond slider

ABUNDANCE. One individual. A single specimen, the medial portion of the first left pleural bone, ISM 490,014 (Moodie and Van Devender 1977:87).
HABITAT. This Pond slider is an aquatic turtle whose presence in the Jones Spring fauna indicates permanent water near the site (Moodie and Van Devender 1977:87). The species has two extant subspecies: *Chrysemys scripta scripta* occurring in the southeastern United States, and *C. s. elegans* occurring from Ohio and Iowa to New Mexico. Today the latter subspecies occurs widely over Missouri, exclusive of the northwestern portion.
DISCUSSION. The fossil was recovered from the main peat body.

Chrysemys is a common Pleistocene fossil. Wisconsinan-aged specimens have been reported from Texas (Johnson 1974) to Illinois (Holman 1966).

Elsewhere in Missouri, *Chrysemys picta*, a Painted turtle, has been reported from the late Pleistocene Brynjulfson Cave No. 2 locality (Parmalee and Oesch 1972:18).

Terrapene carolina putnami
Extinct box turtle

ABUNDANCE. Three individuals based on left hypoplastra. Eighteen specimens, including a nearly complete carapace and two associated cervical vertebrae, ISM 490,000 a, b, c; a carapace fragment with 5-9th peripheral and 5th pleural, of the left side, ISM 490,001; two anterior carapace fragments with peripheral bones, of the right side ISM 490,008 and ISM 490,010; two anterior carapace fragments with nuchal bones and scute impressions, ISM 490,012 and ISM 490,013; posterior carapace fragment with peripheral bones, of the right side, ISM 490,007; two carapace fragments, JS71, JS71; left hypoplastron, ISM 490,002; right and left hypoplastra (fused), ISM 490,005; two left hypoplastra, ISM 490,004 and ISM 490,011; plastron fragment with portions of the xiphiplastron and hypoplastron, of the right side, ISM 490,003; right and left xiphiplastra (fused), ISM 490,006; and a left xiphiplastron, ISM 490, 009.

HABITAT. The paleoenvironmental evidence from Jones Spring (Van Devender and King 1975:211) indicates that *Terrapene carolina putnami* occupied a small spring-fed marsh during an interstadial or stadial period at least 40,000 years ago. The Jones Spring locality was then surrounded by an open pine-parkland community.

Elsewhere in North America, this extinct subspecies occupied habitats similar to the pine-palmetto coastal savanna community of the present day Gulf Coast (Milstead 1969).

DISCUSSION. These turtle remains occurred dominantly at the lower contact of the main peat body with underlying gray clay or light brown gravelly peat.

Terrapene carolina putnami is known from the middle Pliocene to latest Pleistocene in Florida (Auffenberg 1967; Milstead 1969). In Illinoian (Milstead 1969) and Sangamonian (Oelrich 1953, where *T. llanensis* = *T. carolina putnami* fide Van Devender and King 1975) deposits, *Terrapene carolina putnami* has been reported as far north as Meade County, Kansas. The later record is more restricted geographically. For example, the Wisconsinan distribution of *T. c. putnami* ranges from Florida west to Texas (Johnson 1974) and New Mexico (Slaughter 1975). The Jones Spring specimens represent the northermost geographic record for the subspecies (Van Devender and King 1975).

cf. *Terrapene carolina putnami*
Extinct box turtle

ABUNDANCE. Sixteen individuals based on right hypoplastra. In excess of 150 complete and fragmentary specimens.

HABITAT. Box turtles (genus *Terrapene*) are adapted for a terrestrial mode of life. Box turtles, which are strictly North American, range widely over the eastern and central United States and through Mexico. The extinct variety, *T. c. putnami*, presumably had a similar habitat and wide distribution in the southern United States.

DISCUSSION. Numerous (>150 specimens) complete (e.g., whole carapace 6JS76) and fragmentary (e.g., 3 peripheral fragments 115JS77) remains of a large Box turtle, probably *Terrapene carolina putnami* were recovered during the Jones Spring excavation program. These materials compare favorably with identified specimens of *Terrapene carolina putnami* (see above) but because they have not been examined by a herpetologist, they are only provisionally assigned here to that extinct variety.

Family TRIONYCHIDAE
Trionyx sp.
Softshell turtle

ABUNDANCE. One individual. A single specimen, a pleural bone, JS77.
HABITAT. All living species are thoroughly aquatic and the presence of this fossil in the Jones Spring fauna indicates permanent water near the site Conant 1958). The genus has three extant species: *Trionyx muticus*, the Smooth softshell, occurring in the central United States from the Texas Gulf Coast northward along the Mississippi and Missouri rivers to south-central Minnesota and central South Dakota; *T. spinifer*, including 4 varieties of Spiny softshells, the Western Spiny, the Eastern Spiny, the Gulf Coast and Texas softshell, occurring broadly over the central United States, from Texas northward to central Montana and from South Carolina northward to southern Ontario, Canada; and *T. ferox*, the Florida softshell, occurring in peninsular Florida, eastern Georgia and southern South Carolina. Today *Trionyx* and *T. spinifer hartwegi*, the Western Spiny softshell, range throughout Missouri, the former exclusive of the extreme north-central portion of the state. In addition, the Eastern Spiny softshell, *T. spinifer spinifer*, ranges into extreme southeastern and eastern Missouri.
DISCUSSION. Though it was recovered without provenience information, the preservation of the specimen indicates that the fossil came from the main peat body in Jones Spring. The specimen indicates an individual of large size.

Trionyx spp. are not common Pleistocene fossils. *T. ferox* has been reported from the Williston locality, Levy County, west-central Florida, and from the Vero Beach locality, St. Lucie County, east-central Florida (Gehlbach 1965). *T. spinifer* (not differentiated) has been reported from the Holloman locality, Tillman County, southwestern Oklahoma and from the Pittbridge locality, Burleson County, southeastern Texas (Gehlbach 1965).

There are no previously reported fossil records of this genus in Missouri.

Order CROCODILIA
Family CROCODYLIDAE
Alligator mississipiensis
American alligator

ABUNDANCE. Two individuals. Eight specimens, including a terminal phalanx (77JS76), provisionally assigned, a left squamosal (95JS76), and six teeth (85JS76, 101JS76, 236JS77, 318JS77, 328JS77, and 355JS77).
HABITAT. Presently, *Alligator mississipiensis* inhabits the great river swamps, lakes, bayous, and marshes of Florida and the Gulf and lower Atlantic Coastal Plains. In very recent times the American alligator ranged from North Carolina south to the Florida Keys and west through southern Arkansas and extreme southeastern Oklahoma to central Texas.

Plant macrofossils, dominantly fragments of oak, hickory, ash and juniper wood and root stock (F. B. King, pers. comm., 1978) from sediments correlative with those that contained the fossils of *Alligator mississipiensis* in Jones Spring indicate that the alligator here inhabited water bodies and adjacent moist areas in a deciduous forest or woodland community.
DISCUSSION. The fossils were recovered from the base of the lowest peat unit at its contact with either underlying peaty clay (77JS76) or peaty sands and gravels (85JS76, 101JS76, 236JS77, 318JS77, 328JS77); or they

were recovered from the gravel-filled conduit below the lowest peat unit (355JS77) or from undetermined geological context (95JS76).

A fragmentary terminal phalanx is provisionally assigned to this species. The specimen is medial-laterally compressed. Anteriorly the fossil has been broken but would have terminated in a sharp point. Posteriorly, the fossil bears an excavated surface for articulation with the penultimate phalanx. There is a prominent furrow developed longitudinally on the lateral surface as in *Alligator mississipiensis* but not as in the turtles *Terrapene, Chrysemys* or *Macroclemys*. The specimen is robust (posterior height = 9.5 mm) and represents an alligator of moderate size.

The left squamosal is of small size and represents a second, smaller individual. There is no doubt that it is assignable to this taxon. In size it compares favorably to the squamosal in a Recent alligator skull measuring 124.6 mm along the dorsal midline (posterior fused parietals - anterior premaxillae).

Six teeth are assigned to this taxon (Fig. 27). All are relatively short but robust. One is a huge specimen (355JS77). All are finely striated, exhibit distinct anterior and posterior keels and are slightly curved lingually (inferred). Their bases are concave, subcircular in outline and have central pits developed proximally in the dentine. All appear to have been naturally shed and demonstrate that large, mature alligators frequented Jones Spring in western Missouri. Four of the teeth (85JS76, 101JS76, 236JS77, 355JS77) are stout but sharp and appear as those which function anteriorly in the tooth rows. Two of the teeth (318JS77, 328JS77) are short and robust and appear as those which function posteriorly in the tooth rows. Measurements of teeth are provided in Table 13.

TABLE 13

Measurements (in millimeters) of *Alligator mississipiensis* teeth from Jones Spring, Osage Basin, Missouri.

		Basal diameter	
Specimen	Height	anterior/posterior[1]	medial/lateral[2]
85JS76	- -	13.0	12.5
101JS76	13.5	9.3	8.8
236JS77	24.0	14.7	13.7
318JS77	- -	12.4	10.7
328JS77	- -	- -	- -
355JS77	30.6	17.5	18.2

[1] anterior/posterior: measured along the plane determined by the keels.

[2] medial/lateral: measured along the plane at right angles to the above.

The trend toward isothermic compression and cooler climates which culminated in the Pleistocene began, based on *Alligator* distribution, in the middle or late Pliocene. *Alligator* is known from the middle Pliocene in western Nebraska (Mook 1946, where *A. mefferdi* is probably synonymous with *A. mississipiensis*). In late Kansan (Hibbard and Dalquest 1966) and Illinoian (Holman 1969) deposits, *Alligator* sp. (probably *A. mississipiensis*) and *Alligator mississipiensis*, respectively, have been reported no farther

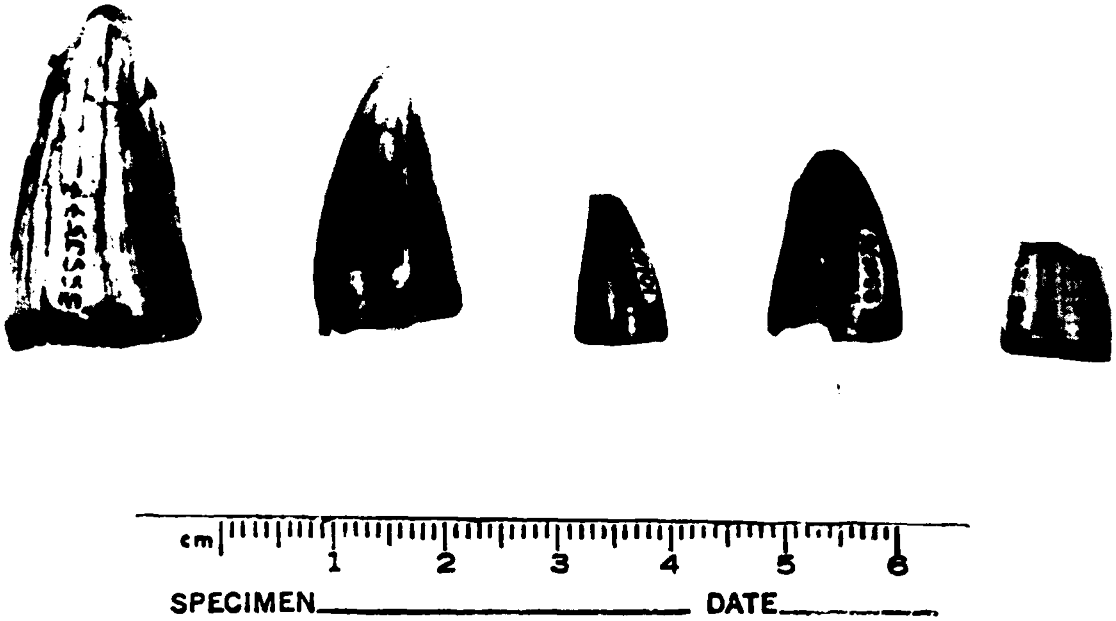

Figure 27. Anterior views of five of the six teeth (355JS77, 236JS77, 101JS76, 85JS76 and 318JS77) of *Alligator mississipiensis* from the Jones Spring fossil assemblage. The sixth tooth (328JS77) is fragmentary and is not shown.

north than the Panhandle of Texas. The later record is still more restricted geographically. For example, the heretofore known Sangamonian (and later) distribution of *Alligator mississipiensis* falls well within its present-day range (Fig. 28). The Jones Spring specimens represent the northernmost Pleistocene geographic record for the species.

The fossils of *Alligator mississipiensis* recovered from Jones Spring demonstrate that large, mature alligators frequented the Osage Basin as far west as the Pomme de Terre River in western Missouri during an interglacial or interstadial period at least 40,000 years ago. The Jones Spring record of this taxon indicates that the climate then was characterized by higher winter temperature extremes than is the climate of the present day.

Elsewhere in Missouri, *Alligator* (?) sp. occurs in the undated Pleistocene fauna from Herculaneum Fissure, Jefferson County, eastern Missouri (Olson 1940).

Class AVES
Order ANSERIFORMES
Family ANATIDAE
cf. *Anas carolinensis*
Green-winged teal

ABUNDANCE. A single individual. Two specimens, including the diaphysis of a humerus (JS75) and the proximal portion of a left scapula (235aJS75).
HABITAT. Species of the genus *Anas* are cosmopolitan in distribution. Ducks of the *Anas* group (the Anatinae, Surface-feeding ducks) are most characteristic of smaller bodies of water, including creeks, ponds, and marshes. *Anas carolinensis* (and others) presently occur statewide in Missouri.
DISCUSSION. The fossils were recovered from the main peat body in Jones Spring.

The Jones Spring avifossils were examined by Paul W. Parmalee of the University of Tennessee. Two of the four specimens which comprise the assemblage represent a teal-size duck. Parmalee (pers. comm., 1979) indicated that the humerus diaphysis (JS75) is probably assignable to *Anas carolinensis*, the Green-winged teal. Both fossils are indistinquishable from recent *Anas carolinensis* osteological material subsequently examined by me and I provisionally assign both specimens to that species.

cf. *Aythya collaris*
Ring-neck duck

ABUNDANCE. A single individual. One specimen, the distal portion of a left humerus (301JS75).
HABITAT. Species of the genus *Aythya* are cosmopolitan in distribution. Ducks of the *Aythya* group (the Aythyinae, Diving ducks) are characteristic of more open bodies of water, although they breed in marshes. Though the Ring-neck does not today breed in Missouri, its migratory distribution does include all of that state.
DISCUSSION. The fossil was recovered from the main peat body in Jones Spring.

Parmalee (pers. comm., 1979) indicated that the distal end of the fossil is too severely eroded to be identified with certainty. He stated that in general proportions and shape the specimen suggests either *Aythya collaris*, the Ring-neck duck, or *Aythya affinis*, the Lesser scaup duck. I have subsequently compared the fossil with series of Recent *A. collaris* and *A. affinis*. On the basis of the less pronounced development of the external condyle the Jones

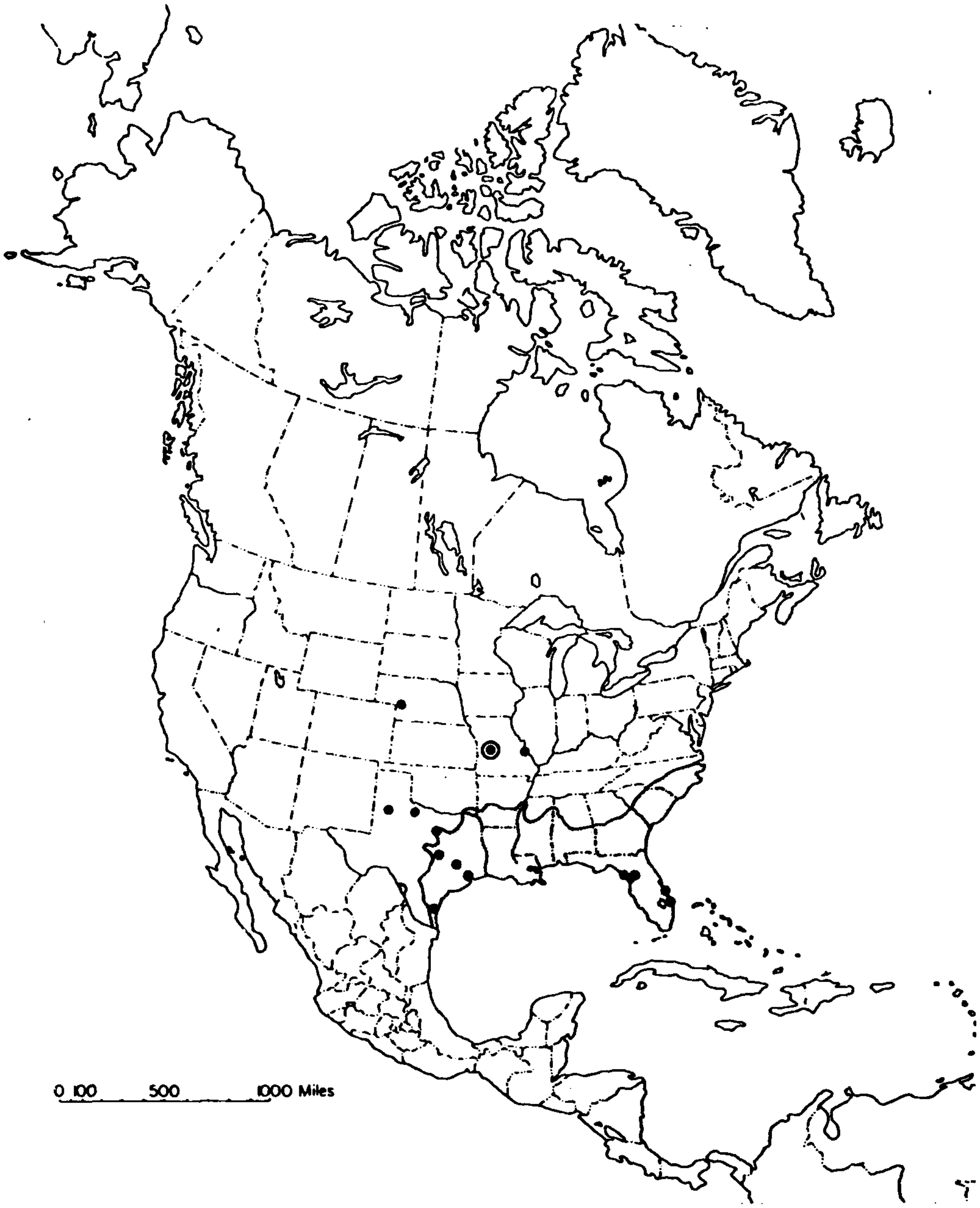

Figure 28. Recent (shaded) and fossil (solid circles) distribution of the American alligator, *Alligator mississipiensis*. The Jones Spring record is indicated by the enclosed solid circle.

Spring specimen compares most favorably with *Aythya collaris*.

Indeterminable sp. - duck

ABUNDANCE. A single individual. A single specimen, the proximal portion of a left coracoid (235bJS75).
HABITAT. Ducks of the family Anatidae are cosmopolitan in distribution. They characterize most marine and terrestrial bodies of water.
DISCUSSION. The fossil was recovered from the main peat body in Jones Spring.

The proximal portion of a left coracoid represents a large duck. The fossil is eroded marginally and can not be identified with certainty beyond the family level (P. W. Parmalee, pers. comm., 1979).

Order EDENTATA
Family MYLODONTIDAE
Glossotherium harlani (Owen, 1840)
Ground sloth

ABUNDANCE. A single individual. Six specimens, left M1/, 141JS77; right M1/, 352JS77; left M/1, 34JS76; three tooth fragments, JS76, 162JS77 and 173JS77.
HABITAT. Plant macrofossils, dominantly fragments of oak, hickory, ash and juniper wood and root stock (F. B. King, pers. comm., 1978) from sediments correlative with those that contained the fossils of *Glossotherium harlani* in Jones Spring indicate that this sloth here inhabited a deciduous, probably in part riparian, forest community. *G. harlani* was probably a grazer in bottomland glades associated with this community. Radiometric ages determined for Jones Spring sediments and fossils indicate that this community existed during a stadial or interstadial period at least 40,000 years ago and probably as much as 49,000 years ago. Elsewhere in Missouri, *Glossotherium harlani* (=*Paramylodon harlani*) has been reported in the late Pleistocene fauna from Boney Spring (Mehringer, King and Lindsay 1970; Saunders 1977a). Pollen associated with the Boney Spring fossil remains (King 1973) indicate that *G. harlani* inhabited a forest of spruce and deciduous elements where it was probably a grazer in open bottomland areas. In addition, *G. harlani* (=*Orycterotherium missouriense* = *Mylodon harlani*) has been reported in the Pleistocene fauna recovered by Albert Koch in 1840 from the Koch Site, Hickory County (Harlan 1843). Elsewhere in North America, this grazing species of ground sloth ranged from the Atlantic to the Pacific coast and from Florida to Washington during the middle and late Pleistocene. It has been reported from nearly 40 localities throughout its range and was presumably quite common (Kurtén and Anderson 1980:143).
DISCUSSION. The fossils of *Glossotherium harlani* were recovered from stratigraphic contexts that suggest it was part of the earliest faunal accumulation in Jones Spring. Other taxa referred to this earliest accumulation, on the basis of stratigraphic context, include *Alligator mississipiensis*, already discussed, as well as *Tapirus veroensis*, *Camelops* sp., *Bison latifrons* and others discussed below. Four of the *G. harlani* specimens were recovered from either light brown peat, sandy peat or gravelly sandy peat that represent the lowermost organic horizon in Jones Spring. One specimen occurred in gravelly sandy clay of the conduit system. One specimen was recovered without provenience information.

The fossils of *Glossotherium harlani* from Jones Spring, though only isolated fragmentary teeth, are nevertheless distinctive and interesting. Two of the specimens are associated (141JS77 and 352JS77) and compare with left and right first upper teeth as described by Stock (1925:129) for *Mylodon (=Glossotherium) harlani*. The crowns of these teeth are curved anteroposteriorly, as is characteristic for M1/ in *G. harlani*. In addition, each tooth is suboval in cross section and the external layer of hard dentine is relatively thick, again as is characteristic of M1/ in this taxon. The occlusal surface of each tooth is beveled only on the posterior portion. Measurements of the teeth are: left M1/ (141JS77) anteroposterior diameter = 18.9 mm, left M1/ transverse diameter = 13.0 mm; right M1/ (352JS77) anteroposterior diameter = 19.5 mm, right M1/ transverse diameter = 13.4 mm. These values compare well with measurements reported by Stock (1925:130) for M1/'s of *Mylodon (= Glossotherium) harlani* from Rancho La Brea, California. Stock reports a range of 14.9-22 mm (mean = 17.9 mm, n = 8) for M1/ anteroposterior diameter and a range of 13.2-21 mm (mean = 16.0 mm, n = 8) for M1/ transverse diameter. The anteroposterior diameter of both Jones Spring M1/'s are within the range but well above the mean of Rancho La Brea specimens. The transverse diameter of 141JS77, left M1/ is outside the range of the Rancho La Brea specimens, being slightly narrower, while the transverse diameter of 352JS77, right M1/ is within the range but well below the mean of the California sample.

Among *Glossotherium harlani* samples generally, the presence or absence of M1/ is highly variable; individuals with it have a compliment of five upper teeth while those in which it is absent have only four upper teeth. The first upper tooth is often absent in *G. harlani* from Rancho La Brea, California. Stock's data (1925:130) indicate that M1/ is present in 8 of 27 upper dentitions (= 30%) from Rancho La Brea. On the other hand, M1/ is usually present in *G. harlani* from Florida (Kurtén and Anderson 1980: 143). The presence of the first upper tooth in the small sample of *Glossotherium harlani* under discussion lends some suggestion of Gulf Coast affinity as was, or will be, noted for *Terrapene, Alligator* and *Tapirus* from Jones Spring and suggests, in sum, that the earliest faunal accumulation in Jones Spring records a fauna resembling those recovered from southern and southeastern Pleistocene localities.

One other tooth, 34JS76, compares favorably with M/1 in a mandible of *Paramylodon (= Glossotherium) harlani* from Boney Spring, Benton County, Missouri (489BS71) in the Illinois State Museum vertebrate paleontology collections and is identified as a right M/1 on that basis. The tooth is curved both anteroposteriorly and transversely. The internal border of the crown bears a prominent groove or sulcus. The occlusal surface consists of a major beveled facet on the inner posterior side of the crown. There is some evidence that a much less prominent beveled facet was developed on the inner anterior side of the crown as well. This beveling pattern is similar to that described for M/1 by Stock (1925:131), though the anterior beveled surface is reduced or less mature. Measurements of this specimens are: M/1 anteroposterior diameter = 19.8+ mm, M/1 transverse diameter = 14.2 mm. These values agree with measurements reported by Stock (1925:130) for M/1's of *Mylodon* (= *Glossotherium*) *harlani* from Rancho La Brea. He reports a range of 13.2-26.1 mm (mean = 21.5 mm, n = 19) for M/1 anteroposterior diameter and a range of 12.5-20.2 mm (mean = 16.0 mm, n = 19) for M/1 transverse diameter. The anteroposterior diameter of the M/1 from Jones Spring is well within the range, and considering that a minimum value is recorded, probably near the mean, of the Rancho La Brea specimens. The transverse diameter of the M/1 from Jones Spring is within the range but well below the mean of the Rancho La Brea sample.

Order RODENTIA

Family GEOMYIDAE

Geomys sp. Rafinesque, 1817
Eastern pocket gophers

ABUNDANCE. A single individual. One specimen, the distal end of a right upper incisor (225JS75).
HABITAT. Eastern pocket gophers (*Geomys* spp.) inhabit open prairie grasslands (*G. bursarius*, *G. personatus*) or pine woodlands (*G. pinetis*), where they are fossorial in moist, cohesive soils. *Geomys bursarius*, the Plains pocket gopher, ranges from extreme southern Manitoba, western Wisconsin, central Illinois and northwestern Indiana southward to western Louisiana, and westward to eastern Wyoming, east-central Colorado, central New Mexico and west-central Texas to the Gulf Coast. *Geomys personatus*, the South Texas pocket gopher, is restricted to the southern one third of Texas. *Geomys pinetis*, the Southeastern pocket gopher, occurs from coastal Georgia westward to central Alabama and southward to south-central Florida.
DISCUSSION. The fossil was recovered from a bulk sediment sample collected from the main peat body in Jones Spring.

The incisor is bisulcate as in *Geomys* but not as in *Cratogeomys* (upper incisor unisulcate) or *Thomomys* (upper incisor nonsulcate). The specimen is not diagnostic at the species level. It is improbable that the fossil represents the presently geographically restricted South Texas pocket gopher (*G. personatus*). The Plains pocket gopher on the other hand is abundant in midwestern Pleistocene fossil assemblages, including that from Boney Spring, Benton County, Missouri (Saunders 1977a). However, given the presence in the Jones Spring fauna of such typically southeastern forms as *Alligator mississipiensis* (middle and late Pleistocene to Recent) and *Terrapene carolina putnami* (late Pleistocene), the occurrence of the Southeastern pocket gopher (*G. pinetis*) in the fauna would not be unexpected.

Family CASTORIDAE

Castoroides ohioensis Foster, 1838
Giant beaver

ABUNDANCE. A single individual. One specimen, left P4/, 258JS77.
HABITAT. Pollen associated with the fossil remains in Jones Spring (Van Devender and King 1975) indicates that *Castoroides ohioensis* inhabited a pine woodland with deciduous elements. Elsewhere in Missouri, the Giant beaver inhabited a forest of spruce with deciduous elements (Saunders 1977a:45). Elsewhere in middle and eastern United States, Lundelius (1967:298) characterized *C. ohioensis* as an inhabitant of forested areas with a cool, humid climate.

I have previously noted (Saunders 1977a:45) that the Giant beaver was closely associated with extensive lakes, ponds and swamps of the Pleistocene and is recorded in Pleistocene deposits from New York to Florida and westward to estern Nebraska; there is a single record from Oregon. It is most commonly found east of the Mississippi River and north of 37° N latitude. The Jones Spring fossil represents the second record of *Castoroides ohioensis* from Missouri; both are from the lower Pomme de Terre River valley.
DISCUSSION. The fossil was recovered *in situ* from brownish-gray sandy, peaty clay at the base of the lower-most peat in Jones Spring.

The tooth is strongly curved anteroposteriorly and medio-laterally along its vertical axis. The occlusal surface is convex and is cut obliquely (anteroposteriorly) across the enamel pillars, as in upper molars of *Castoroides ohioensis*. The tooth is composed of three well-cemented, anteroposteriorly compressed, enamel pillars. Viewed at the grinding surface where the pillars are truncated by wear, the tooth is shown to consist of quantities of dentine enclosed by loops of generally thin enamel, producing an occlusal device composed of three repeated series of enamel, dentine, enamel, cement. Measurements at the occlusal surface are: lg. = 14.4 mm, w. (across the second pillar) = 19.1 mm.

Family CRICETIDAE
cf. *Microtus* sp.
Vole

ABUNDANCE. A single individual. One specimen, the proximal portion of a left femur, 219JS75.
HABITAT. Voles occur today throughout Canada and the United States where there is good grass cover.
DISCUSSION. The fossil was recovered in a bulk sediment sample collected from the main peat body in Jones Spring.

The specimen is broken just above the epicondyles. It compares, in general proportions and shape of shaft, trochanter, neck and head, with the femur of modern voles of the genus *Microtus (M. pennsylvanicus, M. ochrogaster, M. pinetorum)*. The fossil's proportions are either greater, or the shaft more gracile, than are those of the femur in the taxa *Synaptomys, Clethrionomys* and *Peromyscus*. In the absence of skeletal series and microtine molar teeth from Jones Spring, the species represented is indeterminate.

Order CARNIVORA
Family PROCYONIDAE
Procyon lotor (Linnaeus, 1758)
Raccoon

ABUNDANCE. One individual. A single specimen, fragmentary left P2/, 301JS75.
HABITAT. The raccoon inhabits stream and lake borders where there are wooded or rocky cliffs nearby. The wide-ranging *P. lotor* occurs from peninsular Quebec southward to the Florida Keys and Panama and westward to northwestern Saskatchewan, northeastern Alberta, southwestern British Columbia, Washington, Oregon, California and Baja California. It avoids the west-central desert regions. *Procyon lotor* is presently ubiquitous in Missouri.
DISCUSSION. The fossil was recovered in a bulk sediment sample of dark brown sand-streaked peat collected from the main peat body in Jones Spring.

The specimen is fragmentary and consists of the major cusp and a weakly developed labial cingulum. There is a more pronounced cingulum developed anteriorly at the base of the major cusp. These preserved portions compare favorably with the left upper second premolar of recent *Procyon lotor*.

Family FELIDAE
Smilodon cf. *floridanus* (Leidy, 1889)
Sabertooth cat

ABUNDANCE. A single individual. One specimen, the diaphysis of a left humerus of an immature individual, 79JS76.
HABITAT. Pollen associated with the fossil remains in Jones Spring (Van De-

vender and King 1975) suggest that the Sabertooth cat inhabited an open pine woodland or parkland containing deciduous elements. Recently Gonyea (1976) has suggested that *Smilodon* was morphologically adapted to dense forest situations; he suggested that species adapted to more open habitats, e.g., *S. floridanus* (see Merriam and Stock 1932, where *S. californicus* = *S. floridanus*), formed prides.

Smilodon floridanus is abundant in late Pleistocene North America, occurring from Florida (Webb 1974) to California (Merriam and Stock 1932) and from Alaska to central Mexico (Kurten and Anderson 1980, where *S. fatalis* = *S. floridanus*).

The Jones Spring fossil represents the first reported record of *Smilodon* from western Missouri.

DISCUSSION. The humerus was recovered from light brown peat underlying the dark brown peat body which is the main organic unit in Jones Spring. The light brown peat represents the lowest organic unit developed in the spring site.

Though the fossil is from a juvenile individual, there is no doubt that it is referrable to *Smilodon*. The entepicondylar foramen is large; the bridge of bone enclosing this foramen is both narrow and thin. When viewed anteriorly the supracondylar ridge is straight, rather than sinuous. When viewed posteriorly the distal end of the diaphysis widens abruptly below. Finally, the olecranon fossa is wide and deep. In all these features the Jones Spring specimen compares favorably with *Smilodon* and contrasts with true cats (*Felis* spp., *Panthera* spp., etc.), as these features are discussed by Merriam and Stock (1932:113) and observed by me in modern *Panthera leo*.

Measurements of the specimen are provided in Table 14. Compared with a series of measurements of humeri of adult *Smilodon floridanus* provided by Merriam and Stock (1932:114), the Jones Spring individual was half-grown.

TABLE 14

Measurements (in millimeters) of humerus diaphysis of *Smilodon* cf. *floridanus* from Jones Spring, Hickory County, Missouri.

Greatest length of diaphysis measured parallel to longitudinal axis	182.7
Greatest transverse diameter of proximal extremity	43.8
Transverse diameter at middle of shaft	22.3
Anteroposterior diameter at middle of shaft	29.3
Greatest width of distal extremity	67.6

There are three species of *Smilodon*, representing an evolutionary successional series, recognized in the Pleistocene of North America: *S. gracilus* (earliest Pleistocene into middle Pleistocene), *S. fatalis* (middle Pleistocene into the early late Pleistocene), and *S. floridanus* (late Pleistocene) (Webb 1974). Webb (1974:150) suggested that in Florida the late Pleistocene samples of *Smilodon* represent the single species *S. floridanus*, and that it ranged there from Sangamonian through Wisconsinan time.

These species are diagnosed on the basis of dental characters which are not represented in the Jones Spring assemblage. In the absence of teeth, I provisionally assign the *Smilodon* humerus from Jones Spring to the species *S. floridanus* based on nearly identical comparison of this specimen with immature humeri of *Smilodon floridanus* from Rancho La Brea examined by me in the collections of the George C. Page Museum, Los Angeles.

Order PROBOSCIDEA
Family MAMMUTIDAE
Mammut americanum (Kerr, 1792)
American mastodon

ABUNDANCE. Twenty-five individuals, inferred from assembled dentitions. Two hundred and fourty-four specimens, including 14 isolated complete and incomplete upper tusks; six left maxillae containing a total of 12 teeth, one fragmentary; seven right maxillae containing a total of 12 teeth; 16 isolated complete and incomplete lower tusks; two mandibles containing seven cheek teeth, one with two mandibular tusks *in situ* and the other with one; four left mandibular rami containing nine cheek teeth, one with a mandibular tusk *in situ;* three right mandibular rami containing four cheek teeth; 76 isolated upper teeth; 47 isolated lower teeth; 33 tooth fragments; two atlases; an articulated forefoot containing 33 separate elements, including 10 sesmoids; one additional lunar. There are in addition numerous complete and incomplete proboscidean postcranial specimens in the Jones Spring collection some of which are undoubtedly referable to mastodon but they are not generically distinctive and these specimens include mammoth material as well.

HABITAT. Pollen associated with the fossil remains in Jones Spring (Van Devender and King 1975) indicates that the American mastodon here occupied an open pine-parkland community during an interstadial or stadial period at least 40,000 years ago. Mastodon fossils also occur in Jones Spring basal sediments containing wood fragments and root stock of deciduous trees, etc. Radiometric age determination of a fragment of juniper wood (*Juniperus* sp.) from these basal sediments yielded a date of 49,800±900 years ago suggesting that during the initial phase of faunal accumulation in Jones Spring *Mammut americanum* occupied at least partially deciduous forest, woodland or savanna that preceded, or was transitional to, pine-parkland. Elsewhere in Missouri, for example at Trolinger Spring (King 1973; Saunders 1977a and this report), *Mammut americanum* also occupied pine-parkland but during a later period. At Boney Spring in Benton County *Mammut americanum* occupied a forest of spruce with deciduous elements during the closing phase of the Pleistocene (King 1973; Saunders 1977a). Elsewhere in eastern North America *Mammut americanum* occupied spruce forests or open woodlands of spruce and associated trees (Dreimanis 1968). The American mastodon was a browser on trees, shrubs and/or other plants associated with these forests, woodlands or savannas.

DISCUSSION. Fossils of *Mammut americanum* occurred abundantly throughout the fossiliferous sediments in Jones Spring, including basal gray clay that is the host alluvium for spring development, conduit gravel, feeder sand, light brown gravelly peat, dark brown peat as well as overlying sandy, peaty clay. An association, consisting of a right upper tusk (109JS76), semiarticulated left and right maxillae (25BJS76 and 25AJS76, respectively) and left and right mandibular rami (21JS76 and 45JS76, respectively) and probably including the fully articulated forefoot (65JS76) as well as other of the specimens illustrated in Figures 23 through 26 (in separate map volume) is inferred. The maxillae and rami in this association were recovered from either dark brown sandy, gravelly peat adjacent to the conduit and feeder complex or from sandy, gravelly peat in the conduit. The forefoot occurred in gray clay at the southern limit of the faunal concentration in Jones Spring, immediately overlying peat and compressing gray clay into the peat (Fig. 29). With the exception of this association, dissociation and dispersal of mastodon skeletal materials in Jones Spring was complete.

The Jones Spring sample of *Mammut americanum* brings to 71 the total number of mastodons excavated in recent years from three spring sites along the lower Pomme de Terre River valley in western Missouri. This assemblage provides the best currently available base for studies of 1) dental morphology, 2) dental variation within individuals as well as within and among samples and 3) microevolution among populations of this fossil taxon. All of these studies, as well as others, are currently in initial or in developed but uncompleted phases at the Illinois State Museum and they can not be presented in this report of findings. Specifically, the Jones Spring collection represents the oldest available sample from western Missouri and morphologies expressed in this sample are presumably ancestral to other morphologies expressed in such later samples as that from Trolinger Spring II or Boney Spring.

Figure 30 presents the age structure of the *Mammut americanum* sample from Jones Spring. The reader is referred to the section on *Mammut americanum* from Trolinger Spring II for a general discussion of the significance of age structure histograms. It will be noted from the figure that mastodon mortality at Jones Spring is non-modal, that is, no single age class or age class group seems to be over represented. Though normal attritional mortality can be inferred for the extremes of the histogram distribution (the 0-2 year age class = calves and the 52-54 age class = very old individuals) another component of mortality is indicated by the presence of numerous individuals in the mature, presumably vigorous, 24-42 year age classes. As at Trolinger Spring, mortality in the 8-12 year age classes can be interpreted as natural attrition reflecting a combination of adventurism and naivety associated with late adolescence. As at Trolinger Spring, it is not possible to explain mortality in the 24-42 year age classes as normal attrition of contemporary individuals, and it must be concluded from the figure that mastodon mortality in Jones Spring was mixed, reflecting both attritional and catastrophic components. Mixed mortality usually indicates a long duration of faunal accumulation resulting in the accumulation of animals not truly contemporaneous. Such a situation is indicated for Jones Spring. This supports the earlier conclusion drawn from an analysis of radiometric age determination and *Bison* evolution presented under the discussion of *Bison latifrons* and/or *Bison antiquus* that appreciable time is represented by faunal accumulation in Jones Spring.

Table 15 gives metrical data on molars of *Mammut americanum* from Jones Spring. As previously mentioned, these teeth compare, in size and variability, with those from Trolinger Spring (see Table 9 above) but contrast in size with those from Boney Spring which are larger.

Family ELEPHANTIDAE
Mammuthus jeffersonii (Osborn 1922)
Mammoth

ABUNDANCE. Twelve individuals, inferred from assembled dentitions. Eighty-one specimens, including two tusks (one fragmentary), associated left and

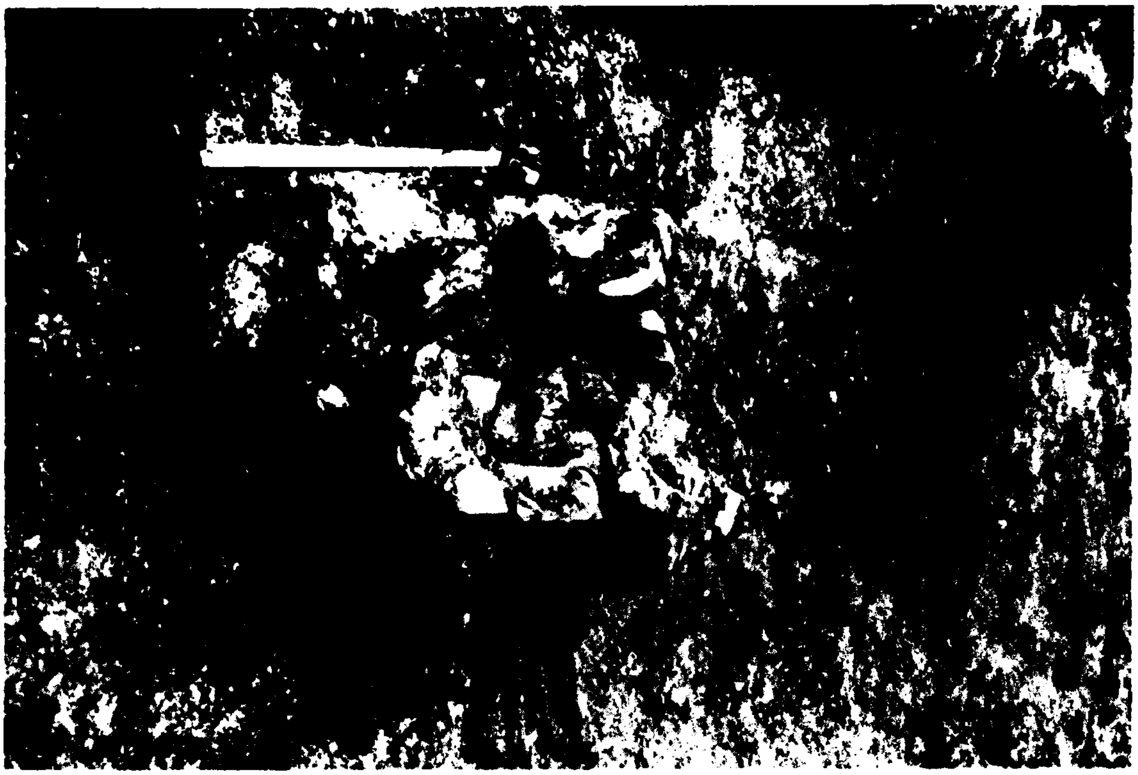

Figure 29. Dorsal view of articulated right forefoot (65JS76) of *Mammut americanum* from the Jones Spring fossil assemblage. Specimen stands on thin clay pedestal overlying the lower peat lens. Anterior edge of specimen faces top of page. Width of foot = 62 cm.

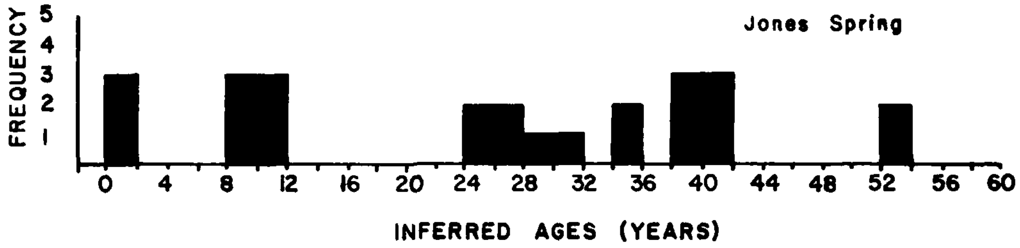

Figure 30. Histogram of inferred age structure of *Mammut americanum* from the Jones Spring fossil assemblage.

TABLE 15

Metrical data[1] on molars of *Mammut americanum* from Jones Spring.

Variate	n	OR	$\bar{x}$	s	CV
LM1/	20	82-100	88.7±1.3	6.0	6.7
WM1/	20	67- 81	71.8±0.8	3.7	5.1
LM2/	28	102-132	112.5±1.5	8.1	7.2
WM2/	28	79-105	88.0±1.5	7.7	8.8
LM3/	23	145-191	167.6±3.0	14.5	8.7
WM3/	23	90-110	97.6±1.4	6.7	6.9
LM/1	14	83- 93	88.6±0.8	3.0	3.4
WM/1	14	61- 74	66.2±1.1	4.1	6.1
LM/2	16	105-127	113.3±1.7	6.8	6.0
WM/2	16	78- 94	85.1±1.3	5.3	6.2
LM/3	11	166-205	186.5±4.4	14.7	7.9
WM/3	11	83-105	95.5±2.3	7.7	8.0

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[1] for abbreviations, see Table 9.

measurements are in millimeters

right M3/, one complete mandible with left and right M/3, 40 isolated upper and lower cheek teeth, 10 thoracic vertebrae, one lumbar vertebra, five caudal vertebrae, 15 complete and incomplete ribs, one scapula, one fragmentary pelvis, one ulna, one femur and one tibia. The tusks, skull, mandible and all the postcranial material are referred to a single individual.
HABITAT. *Mammuthus* is a common fossil in the middle and late Pleistocene deposits of North America. As noted previously, the wide distribution of several species, including *Mammuthus jeffersonii*, suggests diverse habitat preferences. Pollen and plant macrofossils from Jones Spring, together with radiometric age data, indicate that *Mammuthus jeffersonii* here occupied an open pine-parkland community during an interstadial or stadial period at least 40,000 years ago. It was predominantly a grazer on grasses associated with this parkland.

Elsewhere in Missouri, *Mammuthus jeffersonii* occurs in the earlier of two Pleistocene faunas contained in adjacent Trolinger Spring (this report). In addition, Simpson (1945b:71) has provisionally reported *Mammuthus jeffersonii* in the Pleistocene fauna recovered from Enon Sink, Moniteau County.
DISCUSSION. The majority of the isolated mammoth teeth were recovered from the sands and gravels of the conduit complex, either mixed sand and blue chert gravel (nine specimens) that occurred peripheral to the white sand filling the feeder's center, or gravelly sand (18 specimens) that occurred peripheral to the mixed sand and blue chert gravel. One mammoth tooth was recovered from the white sand of the feeder. Three mammoth teeth, as well as the skull, mandible and most of the postcranial remains were recovered from dark brown peat. The ulna, two caudal vertebrae and two teeth were recovered from light brown gravelly peat underlying the dark brown peat. Two teeth were recovered on stratigraphic boundaries, one from the contact of the dark brown peat with underlying light brown gravelly peat and another from the contact of the latter with underlying gray gravelly clay. Two teeth were recovered from a gravel-free facies of the latter. Two teeth were recovered from a lens of sandy, peaty clay above the dark brown peat.

A single tooth was recovered without provenience information.

For a brief discussion of North American mammoths, as well as the probably taxonomically significant variables of mammoth cheek teeth, the reader is referred to the discussion of *Mammuthus jeffersonii* from Trolinger Spring (this report).

Table 16 summarizes measurements of *Mammuthus* cheek teeth from Jones Spring. As mentioned, among the *Mammuthus* material from Jones Spring are the tusks, fragmentary skull (with left and right M3/), mandible (with left and right M/3) and numerous postcranial elements belonging to a single individual. The upper and lower teeth of this individual (No. 8, Table 16) as well as the shape of the mandible agree in most details with descriptions of teeth and mandibles given by Osborn (1942:1083-1087, 1089-1090) for typical *Mammuthus jeffersonii*. Important among these shared features are the pronounced lingual arching of the M3/s (Osborn 1942:1088), the M3 enamel plate formula of 23/24 and, especially, the prominent rostrum developed at the mandibular symphysis (Osborn 1942:1089). On the basis of these features, this individual is clearly assignable to *Mammuthus jeffersonii*.

In addition to the individual discussed above, there are 36 isolated teeth (representing individuals No. 2-5, 7, 9-12, Table 16) that can, on the basis of observed or inferred enamel plate formulae (dP3:8+/ dP4:12/13 M1:11+/ M2:18-19e M3:25/24, Osborn 1942:1083), enamel plate frequency (typically 7-9 in 100 mm, Osborn 1942:1087, 1088) and form (enamel plates of upper teeth transverse or concave posteriorly, enamel plates of lower teeth transverse or concave anteriorly, Osborn 1942:1088), be assigned with good certainty to *Mammuthus jeffersonii*.

Among the remaining, less certainly assignable, teeth is a left dP/2 (individual No. 1, Table 16), a tooth for which specific characterization is lacking in the literature. It is probably assignable to *M. jeffersonii*. Another tooth (77JS77, left M/2, Table 16) is very well worn. It may be a tooth lost naturally through normal wear and progression. Enamel plate frequency is low, but this may be due to extreme wear of the specimen. It nevertheless gives some suggestion that this specimen is referrable to *M. jeffersonii*. Two isolated teeth comprise, provisionally, another individual (No. 6, Table 16). Specimen 232JS77 is a portion of a left M/2 about which nothing definitive can be stated. Specimen 69JS76, left M2/, is somewhat enigmatic. This is a short, well worn tooth with generally crimped enamel and relatively thick marginal cement. Its enamel frequency is 5-6½-6½ (average = 6) which is low when compared with other M2/s in the Jones Spring *Mammuthus* sample (average values for five specimens range from 6 to 8½, with a mean of 8). This low value may however be a function of advanced wear and this individual is also probably assignable to *Mammuthus jeffersonii*.

Order PERISSODACTYLA
Family EQUIDAE
Equus complicatus Leidy, 1858
Horse

ABUNDANCE. Ten individuals, based on two left dP3/'s in earliest wear, seven right M/3's in various stages of development, eruption and wear, and one left P3/ in extreme advanced wear. One hundred and fifty-four specimens, including a single petrosal; eight upper and 14 lower incisor teeth; three upper and five lower deciduous premolars; 20 upper and 26 lower premolars; 21 upper and 29 lower molars; 22 upper and lower cheek tooth fragments; one cervical vertebra; two glenoid portions of scapulae; one right intermediate carpal; one terminal

TABLE 16

Measurements (in millimeters) of *Mammuthus jeffersonii* teeth from Jones Spring, Hickory County, Missouri.

Ind. No.	Specimen	Pos.	Pl.	A.	Lg.	Ht.	W.	En.	Lf.							
									occ.*			m.c.**		base**		c.
1.	16JS76	ldP/2	4	4	26.2	- -	26.2e	0.9	-	-	-	-	-	-	-	1
2.	JS77	ldP/3	+ 6	+ 6	58.1e	- -	- -	1.2	-	-	-	-	-	-	-	-
	136JS76	rdP/3	+ 6	+ 6	65.5	- -	53.4	1.6	-	-	-	-	-	-	-	-
	140JS73	ldP/4	11+	7	- -	118.7	65.6	1.6	9	9	9½	8	9	7	8	-
	312JS77	rdP/4	12+	8	- -	113.1	66.0	1.5	9	9½	9½	8	9	7½	8	-
3.	122JS76	lM1/	+11	+10	139.5	- -	71.4	1.8-2.1	6½	6½	6½	9	9	9	9	-
	32JS73	rM1/	+12	+11	148.0	- -	71.8	2.1	7	7	6½	8½	8	-	-	3.1-5.4
	58JS73	lM2/	14+	2e	- -	176.0	84.6	-	8	8	8	8½	8	8½	9	-
	45JS73	rM2/	14+	2	- -	177.8	83.5	1.8	8	8	8½	8	9	9		1.5
	93JS73	lM/1	+ 9	+ 9	118.5	- -	71.8	1.8-2.3	6½	5½	5½	-	-	7½	-	2.3
	151JS73	lM/2	10+	2	- -	147.0	70.7	2.0	8	8	8	7	8	-	7½	-
	62JS73	rM/2	10+	3	- -	147.9	71.1	2.3	7	8	8	8	8	-	-	2.5
4.	105JS76	lM2/	+14+	+ 6	- -	159.6	85.0	2.2-2.5	8	8	8	7½	7½	8	7½	-
	142JS73	rM/1	+ 9	+ 9	108.4e	- -	65.8	2.1-2.3	8	7	9	-	-	-	-	1
	124JS76	lM/2	13+	8	- -	138.2	76.3	2.2-2.5	7	7	8	6	7	6	6½	-
5.	148/216JS77	lM2/	+16	+11	189.0	173.4	90.4	2.4	8	8	7½	9	8	9	8	-
6.	69JS76	lM2/	+13	+ 9	181.0e	- -	81.4	2.4	5	5	5	7	6	6½	6½	1.5-6.4
	232JS77	lM/2	+ 4+	+ 4+	- -	- -	79.3	2.5	-	-	-	-	-	-	-	0.9
7.	220JS77	rM2/	+ 8	+ 8	142.5	- -	94.5	2.3-2.6	6	5½	5½	-	-	6½	6	-
	332/356JS77	lM3/	17+	5	- -	199.4	100.6	2.6	6½	7	7	6½	6½	6½	6	-
	231aJS77	rM/2	+10	+10	192.6	- -	94.4	2.3-2.5	4½	4½	4½	5	5	5½	5	-
	231aJS77	lM/3	14+	5	- -	169.5e	92.9	2.4-2.7	7½	8	8	6	6	5½	5	-
	231aJS77	rM/3	17+	2+	- -	177.1	98.7	2.5	6½	8	8	6	6½	5	6	1

TABLE 16 (concluded).

									Lf.							
Ind. No.	Specimen	Pos.	Pl.	A.	Lg.	Ht.	W.	En.	occ.*			m.c.**		base**		c.
8.	201JS77	lM3/	23	13	313.0	198.5e	88.2	2.3	6½	7	6	7½	6½	9	7	3.4-11.0
	8JS73	rM3/	+22	10	308.0	211.5	95.2	2.4	6	6	5½	8	6½	8	7	2.1-5.4
	338JS75	lM/3	24	14	- -	- -	90.6	2.5	5½	6	5	-	-	-	-	2.8-3.2
	338JS75	rM/3	-	13	- -	- -	91.7	2.7	5½	5½	5	-	-	-	-	2.6-3.0
9.	108JS76	lM3/	+16+	+ 9	246.0	192.5	100.4	2.5-2.7	6½	8	7	6½	6½	6	5½	-
	22JS77	rM3/	+ 7+	+ 7+	- -	- -	107.0	2.4-2.7	-	-	-	-	-	-	-	-
	244JS75/245aJS77	rM/3	+16	+ 9	336.5	158.2	105.0	2.4	5	5½	5½	5	5½	-	5	-
10.	243JS75/305JS77/263JS75	lM3/	+11+	+ 5	- -	202.3e	105.9e	2.3-2.5	-	-	-	5½	5½	5½	5½	-
	153JS77	rM3/	+20	+12	331.0	209.2	109.8	2.4	5	5	4½	5½	5½	6	5½	-
	320JS77	lM/3	-	-	- -	- -	- -	2.4	-	-	-	-	-	-	-	-
	215JS77	rM/3	15+	14+	- -	- -	110.2e	2.3-2.7	4	5	5	4	5	4½	5	3.3
11.	70JS75	lM/3	17	15	321.8	- -	92.3	2.8	5	5	5	5	5	5	4½	1.5-7.5
	65JS75	rM/3	+16	14	304.0e	- -	87.0	2.8	4	5	5	4½	5½	4½	6	-
12.	112JS75	lM/3	+11	+ 9	234.5e	- -	70.7	3.4	4½	4½	5	5	5	5	4½	-
	240JS75	rM/3	+11	+10	264.7	- -	79.4	3.1	4½	4½	5	5	5	5	-	1.2-2.2
--.	77JS77	lM/2	+11	+11	180.0	- -	- -	2.5	6	6	-	-	-	-	-	4.1

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* values recorded are lingual, medial and labial, respectively.

** values recorded are lingual and labial, respectively.

phalanx.

HABITAT. Pleistocene *Equus* was a grazer occurring abundantly in steppe habitats throughout North America and elsewhere. *Equus complicatus* was the common moderate to large-sized horse of the eastern United States during the middle and late Pleistocene. It ranged from the Gulf Coast of Texas eastward to Florida and northward to South Carolina, Kentucky and Missouri (Kurtén and Anderson 1980). Elsewhere in Missouri, *Equus complicatus* also occurs in the fauna from Trolinger Spring (this report). Hay (1924: 139) reports that *Equus complicatus* occurs in the late Pleistocene fauna from Kimmswick, Jefferson County. In addition, *Equus* cf. *complicatus* has been reported by Simpson (1945b:71) in the Pleistocene fauna from Enon Sink, Moniteau County.

The paleoenvironmental evidence from Jones Spring (Van Devender and King 1975:211) indicates that *Equus complicatus* occupied openings in a pine-parkland community during an interstadial or stadial period at least 40,000 years ago. Fossil wood fragments and seeds from Trolinger Spring conduit sediments that also contained fossils of *Equus complicatus* indicate that *Equus complicatus* also inhabited openings in deciduous savanna or woodland.

DISCUSSION. The fossils assigned here to *Equus complicatus*, almost entirely isolated upper and lower teeth, occurred abundantly throughout the fossiliferous sediments in Jones Spring. Two specimens were recovered from white sand filling the Jones Spring feeder. Nearly the majority of the *Equus complicatus* fossils were recovered from mixed sand and gravel contexts representing the conduit system in Jones Spring, either from mixed sand and blue chert gravel (24 specimens) or gravelly sand (37 specimens) occuring generally peripheral to the latter. Ten specimens were recovered from gray sandy or gravelly clay, generally within the conduit and feeder complex. Twenty-nine specimens occurred in dark brown, often sandy and/or gravelly, peat comprising the main organic unit in Jones Spring. Seventeen specimens were recovered from light brown sandy, gravelly peat underlying the dark brown peat. Four specimens occurred in gray clay at the base of the lower, light brown sandy, gravelly peat horizon. Three specimens were recovered from stratigraphic contacts, one from the contact of white sand with peripheral mixed sand and blue chert gravel, and another from the contact of light brown sandy, gravelly peat with underlying gray clay. One specimen occurred in a lens of dark gray peaty clay containing abundant snails that occurred above the dark brown peat. Finally, 27 specimens were recovered from either unknown or imprecisely recorded stratigraphic proveniences.

The incisor teeth are under represented in the *Equus complicatus* sample from Jones Spring, relative to their recovery at Trolinger Spring (i.e., teeth per individual). This is interpreted as being due to the differential destruction of these smaller teeth by prolonged exposure to mechanical abrasion produced during spring discharge. They all bear a central, enamel-bordered and cement-filled, infundibulum but are otherwise not distinctive. They are assigned to *Equus complicatus* on the basis of individual predominance relative to the other horse taxon present (see below) as well as on the basis of similarity to incisor teeth assigned to *Equus complicatus* from Trolinger Spring.

The cheek teeth assigned here to *Equus complicatus* are quite variable in size as well as complexity of the enamel exposed on worn occlusal surfaces. Nevertheless, all teeth compare satisfactorily with teeth assigned to this taxon from Trolinger Spring (this report) as well as from Ingleside, Texas (Lundelius 1972:63-68). Some of this variability is explained by the larger sample available from Jones Spring relative to samples from Trolinger

Spring or reported from Texas. Additional variability is probably due to morphological change with time, i.e., microevolution within resident populations, or to the immigration of transient populations from elsewhere. As discussed below under *Bison latifrons* and/or *Bison antiquus* from Jones Spring, it appears that appreciable time is represented by faunal accumulation in Jones Spring. The range of variation for length and width of cheek teeth of *Equus complicatus* from Jones Spring are given in Table 17.

TABLE 17

Range of variation observed in cheek teeth of *Equus complicatus* from Jones Spring. Only teeth showing wear are recorded. Measurements are in millimeters.

		Length[1]		Width[2]	
n.	Position	range ;	mean	range ;	mean
7(5)	P2/	(37.0-40.3;	38.6)	23.4-28.3;	26.2
5(4)	P3/	(29.2-35.7;	32.6)	27.4-30.9;	28.9
4	P4/	28.7-31.2;	30.0	27.1-30.8;	29.0
5	M1/	24.0-28.0;	25.8	25.3-28.9;	26.8
5	M2/	26.5-32.3;	29.2	23.3-27.0;	25.8
3	M3/	30.3-31.2;	30.6	23.0-24.5;	23.6
10	P/2	33.8-38.1;	36.1	14.4-17.4;	15.7
8	P/3	30.1-34.7;	32.8	15.0-18.2;	16.6
6	P/4	27.6-31.6;	30.2	16.7-19.3;	17.9
7(6)	M/1	(26.5-29.6;	28.2)	14.1-17.1;	16.2
12	M/2	28.4-32.5;	29.8	13.4-16.4;	15.1
7(6)	M/3	(35.6-36.3;	35.9)	13.6-14.8;	14.0

[1] for upper teeth, length equals length along the ectoloph; for lower teeth length equals total length along anteroposterior axis.

[2] for upper teeth, width equals width normal to parastyle-mesostyle; for lower teeth width equals total width normal to protoconid-hypoconid.

The upper cheek teeth are generally large and are, with the exception of P2/, nearly square in cross section. The protocones are elongated, with a pronounced groove on their inner-surfaces. There is a relatively small to relatively large pli caballin present near the anterior, inner border of the post protoconal groove on the premolars and, frequently, on the molars as well. The hypocone is separated from the rest of the tooth by a hypoconal groove that is closed off in the third molars to form a separate, circular, lake in the posterior-internal portion of the tooth. The parastyle and mesostyle tend to be large and, in the premolars, conspicuously bifurcated. The enamel surrounding the fossettes or lakes on the occlusal surface is variably but generally complexly folded. The posterior side of the anterior lake and the anterior side of the posterior lake possess the greater number of secondary folds. The lower cheek teeth are more complicated than those of the Recent horse but are of a similar size. The metaconid is rounded and expanded and the adjoining metastylid is oval in shape, with the posterior-internal end drawn out to form a variably oriented, characteristic point. The metaconid-metastylid connect with the protoconid and hypoconid via a simple isthmus that is not parallel-sided. The protoconid and hypoconid are flattened or, more usually, somewhat concave on their outer surfaces. The paralophid does not extend as far toward the inner anterior margin of the tooth as the metaconid and its posterior surface bulges variably into the fold between the metaconid and protoconid.

The cervical vertebra, intermediate carpal and terminal phalanx compare in size with similar specimens of Recent horse in the Illinois State Museum osteology collections. They all indicate a horse of moderate size but are otherwise not distinctive. The two glenoid portions of scapulae compare both with similar material of Recent horse and with the scapula referred to *Equus complicatus* from Trolinger Spring. Fossil horse skeletal material is extremely under represented in the Jones Spring collection, comparing in this regard with all other taxa, generally.

Equus calobatus Troxell, 1915 or *Equus hemionus* Pallas, 1775
Onagers

ABUNDANCE. A single individual, based on associated left and right rami, each with P/2-M/3 preserved, and a presumably associated, assembled partial upper dentition. Seven specimens, including left P2/, 285JS77; right P2/, 81JS76; right P3/, 275JS76; right M1/, 82JS77; right M3/, 63JS76; left ramus with P/2-M/3, 301JS77; right ramus with P/2-M/3, 319JS77.

HABITAT. Living onagers are most frequently found in desert plains covered with low shrubs. The present distribution of onagers includes the steppes of Mongolia, southward to Tibet and Syria and the north and east portions of Africa. Extinct as well as living onagers had a wide distribution in Eurasia and on the High Plains of North America throughout the Pleistocene. Onagers are separated from other horses on the basis of skull and lower dental characters as well as on the proportions of the long and slender limbs. With these long, slender legs, light build and minimum food and water requirements, onagers are better suited to more rigorous habitats than are other horse species.

Plant macrofossils, dominantly fragments of oak (*Quercus* spp.), hickory (*Carya* sp.), ash (*Fraxinus* sp.) and juniper (*Juniperus* sp.) wood and root stock (F. B. King, pers. comm., 1978), from sediments correlative with those containing the majority of the *Equus calobatus* or *Equus hemionus* fossils in Jones Spring indicate that this horse here was associated with a deciduous, probably in part riparian, forest, woodland or savanna community. Radiometric ages determined for Jones Spring sediments and fossils indicate that this community existed during a stadial or interstadial period at least 40,000, and perhaps as long as 50,000, years ago. Onagers were probably both browsers and grazers in open grassy or low shrub-covered areas.

DISCUSSION. There are in the Jones Spring collection the left and right rami, each with P/2-M/3 preserved and in wear, as well as an assembled, inferred upper dentition that is presumably associated with the rami. These fossils represent a horse other than *Equus complicatus* or *Equus scotti*, previously reported from western Missouri (this report).

Two of the fossils were recovered from dark brown peat or dark brown, gravelly clayey peat (63JS76, right M3/ and 285JS77, left P2/, respectively). One specimen (81JS76, right P2/, the bilateral mate of 285JS77, above) occurred in light brown gravelly peat underlying dark brown peat or dark brown, gravelly, clayey peat and comprising the lowest organic horizon in Jones Spring. One specimen (82JS77, right M1/) occurred in gray gravelly clay beneath light brown gravelly peat and another (27JS76, right P3/) was recovered on the contact between these two stratigraphic units. The left ramus (301JS77) occurred in gravelly sand of the conduit complex; the right ramus (319JS77) was recovered from gravelly, sandy peaty clay that occurred generally in the conduit complex.

The upper teeth are less distinctive than the lower dentition. The fossettes are relatively simple. The anterior and posterior border of each fossette are equally, and only weakly, folded, unlike fossettes in upper teeth of *Equus complicatus* and *Equus scotti*. The protocones are relatively short and, except for that in M3/, broad. The preprotoconal groove is short, narrow and V-shaped, not deep, wide and U-shaped as in *Equus complicatus*. A simple pli caballin is present in premolars as well as molars. Except for P2/, where the mesostyle is broad and somewhat bifuracated, there is no further tendency for bifurcation of either parastyle or mesostyle. The hypoconal groove is simple and rather insignificant relative to the size of each tooth. Terminalization of the M3/ is strong and the hypoconal groove is closed-off, forming a small isolated lake behind the posterior fossette.

The lower teeth are smaller than those of the Recent horse. In the premolars the metaconid is laterally compressed and drop-shaped while in the molars there is a tendency for the metaconid to be more rounded and in M/1 and M/2 somewhat expanded towards the inner margin of each tooth. The metastylids are oval and pointed posteriorly but not drawn out as in *Equus complicatus*. The valley between the metaconid and metastylid is symmetrical and V-shaped with a sharp bottom. This valley is narrower in the premolars than in the molars. The entoconids are laterally compressed and subrectangular. The protoconids and hypoconids of the premolars tend to be slightly concave on their outer margins while those of the molars are convex. The pli caballinid is small but present in both premolars and molars near the middle of generally deep and very narrow ectoflexids. The left and right rami from Jones Spring are illustrated in Figure 31. Table 18 gives measurements of this lower dentition from Jones Spring. The lower border of the left ramus (301JS77) is strongly convex. Though the posterior portions, including the angle and ascending ramus, of the jaw are missing it is apparent from preserved portions that the convex lower border of the mandible, with greatest curvature beneath the M/1, would interupt and be beneath a straight line drawn from the base of the angle to the base of the symphysis. This contrasts with the condition in the Recent horse and compares with the condition in living onagers.

The groove (ectoflexid) separating the protoconid and hypoconid in the lower molars from Jones Spring does not extend into the isthmus uniting the metaconid-metastylid with the protoconid and hypoconid. In this feature these teeth are unlike the Recent horse and living zebras but are like teeth in living and extinct asses. The symmetrical, V-shaped and sharp-bottomed groove (linguaflexid) between the metaconid and metastylid, however, separates this dentition from those in other extinct ass-like horses, including *E. complicatus* and *E. scotti* and unites the dentition with those in living Asiatic onagers as well as extinct allied forms which together comprise a group of horses termed hemiones. There are, according to recent authors (for example, Skinner et al. 1972 and Kurtén and Anderson 1980), only three species of horses (hemiones) with dental patterns like those of the Jones Spring lower dentition: 1) *Equus calobatus*, the stilt-legged onager, relatively common in North America throughout the Pleistocene; 2) *Equus hemionus*, the onager, currently living in Asia but with a Pleistocene history in Eurasia and North America; and 3) *Equus tau*, the Pygmy onager, with a Pleistocene distribution from the Valley of Mexico to Texas, Oklahoma and Florida. *Equus tau* is the

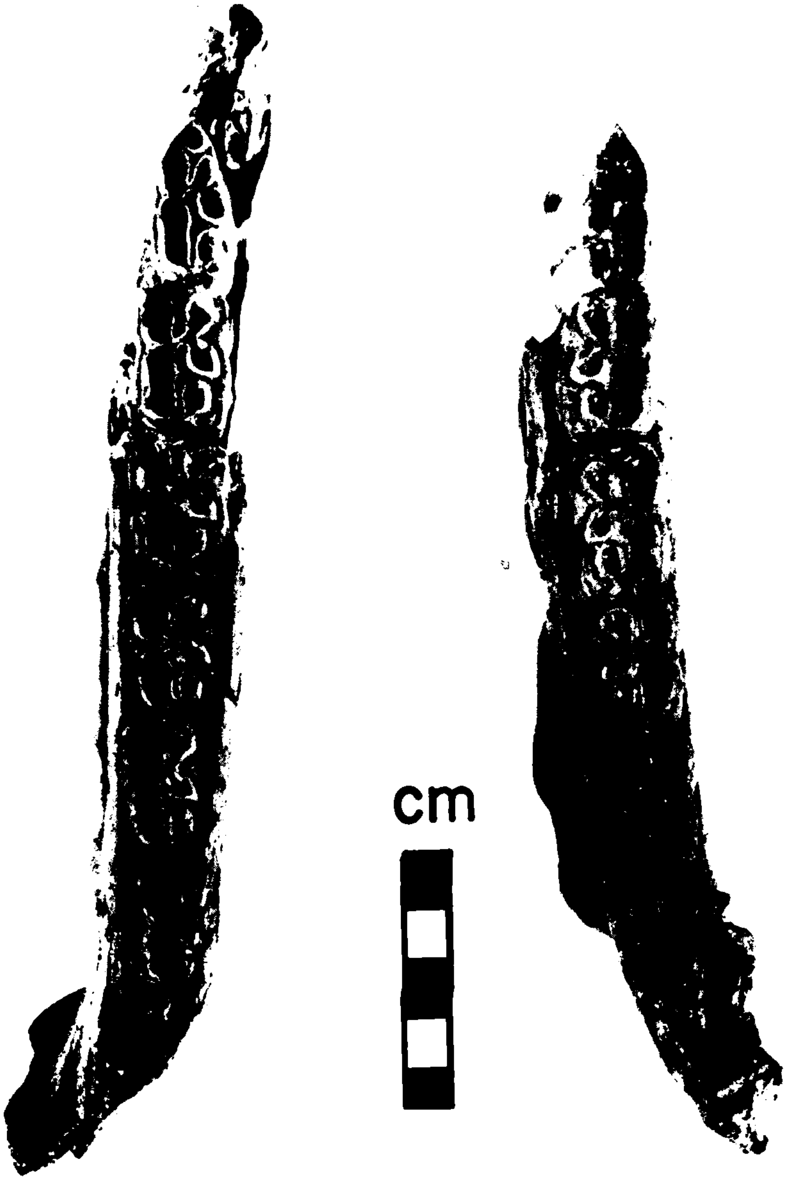

Figure 31. Occlusal view of left (301JS77) and right (319JS77) mandibular rami of *Equus calobatus* or *Equus hemionus* from the Jones Spring fossil assemblage.

TABLE 18

Measurements (in millimeters) of the *Equus calobatus* or *Equus hemionus* lower dentition from Jones Spring.

Variate	301JS77 (left ramus)	319JS77 (right ramus)
Depth of jaw anterior to M/1*:	89.9	- -
Thickness of jaw anterior to M/1:	25.1	25.1
Alveolar length, P/2-M/3:	172.5	171.9
Length		
P/2	30.9	31.7
P/3	26.5	27.5
P/4	- -	28.3
M/1	25.7	25.2
M/2	27.3	26.5
M/3	28.6	27.2
Width		
P/2	14.3	14.1
P/3	15.2	15.7
P/4	15.0	15.3
M/1	14.5	14.8
M/2	14.4	14.5
M/3	11.9	11.7

*measured normal to the occlusal surface on the labial side.

smallest species of North American horse, with cheek tooth rows usually less than 120 mm in length (Kurtén and Anderson 1980:288). Small size eliminates this form from further discussion here (see Table 18). *Equus calobatus* on the other hand is the largest species of North American hemione, with lower cheek tooth rows usually exceeding 180 mm in length (Kurtén and Anderson 1980: 288). *Equus hemionus* is a species intermediate in size between these two extremes.

The Jones Spring rami under discussion have a dental pattern (Fig. 31) and are of a size (Table 18) that together suggest *Equus hemionus* (Skinner et al. 1972:122, Fig. 58A) but in terms of dental pattern alone compare as well with *Equus calobatus* (Skinner et al. 1972:122, Fig. 58D). In the absence of additional referred materials from Jones Spring it is not possible to assess size variability in this taxon, or to draw more than tentative conclusions regarding taxonomic affinities. For this reason the hemione from Jones Spring is imprecisely referred to *Equus calobatus* or *Equus hemionus*.

Family TAPIRIDAE
Tapirus veroensis
Tapir

ABUNDANCE. A single individual. Two specimens, an incomplete right mandibular ramus with P/2-anterior lophid of M/1, 314JS77; a left femur, 307JS77, is provisionally assigned to this taxon.
HABITAT. There is a single living genus of tapirs, *Tapirus*, containing the following four species: *T. terrestris* and *T. roulini* inhabit South America,

T. bairdii ranges from Central America into southern Mexico, and *T. indicus* occurs in southeastern Asia.

Today tapirs live in wooded or grassy habitat near permanent sources of water. They conceal themselves in forests and thickets during the day and emerge at night to feed in forest border areas. Living tapirs are browsers of aquatic and low-growing, terrestrial vegetation in forest border, riparian or shrubby areas. When threatened, tapirs seek refuge in water or in dense underbrush.

During the Pleistocene *Tapirus* ranged widely in North America, from Florida north to Pennsylvania and west to Missouri, Arkansas, southern Oklahoma and Texas to southern Arizona. There are several records from California and a single occurrence known from southwestern Oregon. This distribution indicates that Pleistocene North American *Tapirus* was a browser in temperate as well as subtropical forests. The record from Arizona and probably that from Missouri as well (this report) suggest that Pleistocene North American *Tapirus* frequented forested river valleys. A network of such forests, fostered and maintained under moister Pleistocene stadial or interstadial climatic regimes, probably accounts for the past distribution of *Tapirus* in North America.

Plant macrofossils, dominantly fragments of oak, hickory, ash and juniper wood (F. B. King, pers. comm., 1978), from sediments correlative with those that contained the *Tapirus* fossils in Jones Spring, indicate that *Tapirus* here occupied a deciduous riparian forest community. Radiometric ages determined for Jones Spring sediments and fossils indicate that this community existed during a stadial or interstadial period at least 40,000 years ago.

DISCUSSION. Both fossils were recovered from gray sandy clay underlying the lowermost peat lens in Jones Spring.

The incomplete right mandibular ramus consists of a portion of an anterior diastema followed by alveoli for P/2-M/1. The P/2 was recovered but is broken through the roots and can not now be reattached. The P/3, P/4 and anterior lophid of M/1 are in place in the jaw. The teeth are extremely worn and are surrounded by a generally thick layer of cement, deposited as separate laminae, indicating a very aged individual. As a result of extreme tooth wear the anterior and posterior lophids of P/3 are confluent. In addition the anterior and posterior lophids of P/4 as well as the preserved anterior lophid of M/1 occur as isolated enamel-enclosed, or nearly enamel-less, stubs each rooted in a separate alveolus.

The Jones Spring *Tapirus* fossils indicate that this individual was much larger than any living tapir. Among fossil tapirs, only two demonstrably valid Pleistocene species are known to occur in eastern North America: *T. veroensis* and *T. copei*. A recent study of Pleistocene North American tapirs by Lundelius and Slaughter (1976) has suggested that the widely recognized but inadequately known *Tapirus excelsus*, a species described by Simpson (1945b) for tapir remains recovered from Enon Sink, Moniteau County, Missouri, is actually at most a subspecies of *Tapirus veroensis*.

The *Tapirus* ramus from Jones Spring is massive compared with Recent tapir materials. The thickness of the jaw at a point between P/4 and M/1 is 34.4 mm. Similarly, the teeth are larger. Measurements of the Jones Spring *Tapirus* teeth, excluding marginal cement, are given in Table 19. Also excluded from the table is the severely worn P/2 for which no useful measurements can be obtained. Included in the table are sample ranges and means for *T. veroensis* from Seminole Field, Florida and for *T. copei* from Port Kennedy Cave, Pennsylvania as given by Simpson (1945b:62, 63, 68).

TABLE 19

Measurements (in millimeters) of *Tapirus* from Jones Spring compared with hypodigm ranges and means of *T. veroensis* and *T. copei.*

		*T. veroensis**			*T. copei**		
Variate	314JS77	N	Range	Mean	N	Range	Mean
P/3 L	19.0e	4	20.6-20.9	20.78	9	23.0-25.1	24.22
WA	17.3	4	16.8-17.6	17.12	9	16.1-18.0	17.01
WP	17.6	4	18.3-18.9	18.50	9	17.8-20.2	19.19
P/4 L	27.1e	5	22.0-24.6	22.72	6	24.1-24.9	24.60
WA	16.8e	5	17.7-20.9	19.06	8	18.3-21.7	20.41
WP	19.1	5	19.5-22.2	20.72	8	19.5-22.8	21.28
M/1 L	-		-	-		-	-
WA	15.5	8	17.6-19.3	18.46	7	19.8-22.9	20.83
WP	-		-	-		-	-

* *T. veroensis* and *T. copei* are taken from Simpson (1945b:62, 63, 68).

The P/3 from Jones Spring has undergone wear attrition anteriorly and length recorded for this tooth in Table 19 is a minimum value only. The anterior width of this tooth falls well within the range, and quite close to the mean, of this variate in the sample of *T. veroensis*. The posterior width of this tooth is outside the range of either sample although the value recorded here is closer to the mean of *T. veroensis*. The anterior and posterior lophids of the P/4 from Jones Spring are completely isolated and each is surrounded by cement, phenomena of extreme wear that has probably altered (i.e., increased) the length of this tooth. In addition, wear has removed the enamel from the labial side of the anterior lophid, effectively narrowing this portion of the tooth, and the value reported for this variate in the table is a minimum estimate only. The posterior width of P/4 is unaltered, however, and though outside the range of either sample this variate compares most closely with the mean of *T. veroensis*. The anterior lophid of the Jones Spring M/1 is narrow, compared to either sample, but compares best with the range and mean of *T. veroensis*. Thus, those variates of Jones Spring *Tapirus* teeth that have been least affected by wear compare most closely with those reported by Simpson (1945b) for *Tapirus veroensis* from Seminole Field, Florida, and it is to this species that the Jones Spring tapir is referred. This assignment is supported by variate ranges and means reported by Lundelius and Slaughter (1976:238) for lower dentitions of *Tapirus veroensis* from various Florida localities. For example, Jones Spring P/3 posterior width (17.6 mm), outside the range of either sample reported in Simpson (1945b) and in Table 19, is well within the range (16.0-21.4 mm) though still well below the mean (18.23 mm) of their broader sample. Similarly, Jones Spring P/4 posterior width (19.1 mm), also outside the range of either sample reported in Simpson (1945b) and in Table 19, is well within the range (15.9-22.0 mm) and quite near the mean (18.7 mm) of *T. veroensis* reported by Lundelius and Slaughter (1976:238).

A left femur is provisionally referred to this taxon. The shaft of the specimen is broken through proximally and distally and is somewhat distorted proximally. The fossil is as large as some modern horse femora. The medial ridge of the patellar surface, though broken and incomplete, lacks any indication whatever of the prominent expansion observed on horse femora but absent on those of tapirs. The head of the femur, though somewhat restored, shows no indication of the wide and shallow medial pit that characterizes horse femora. Rather, this pit on the fossil would have been less prominent, apparently, as on tapir femora. Measurements of the femur are: width of the distal end = 100.0 mm, least diameter of the shaft = 43.8 mm., least circumference of the shaft = 158 mm.

Elsewhere in Missouri, *Tapirus excelsus* (=*T. veroensis*, see above) has been reported in the Pleistocene fauna from Enon Sink, Moniteau County (Simpson 1945b) and, provisionally, in the Pleistocene fauna from Crankshaft Cave, Jefferson County (Oesch 1967, Parmalee, Oesch and Guilday 1969). *Tapirus* sp. (almost certainly *T. veroensis*) has been reported in the Pleistocene fauna from Boney Spring, Benton County (Saunders 1977a).

Order ARTIODACTYLA
Family CAMELIDAE
Camelops sp.
Camel

ABUNDANCE. Four individuals, based on three worn left M/3's and on one unerupted right M/3. Seventeen specimens, including: right dP/3, 97JS76, right and left dP/4, 170JS77 and 275JS77, and right M/3 (unerupted), 155JS-77; right and left M/3, 376JS75 and 134JS75; right M1/, 71JS76, right and left M2/, 313JS77 and 227JS77, right and left I/1, 237JS77 and 98JS77, right and left M/3, 239JS77 and 84JS77; left M/3, JS76.

HABITAT. Camels of the genus *Camelops* are common fossils in Pleistocene sediments of western North America.

Camelops was primarily adapted as a grazer; its long neck and limbs probably gave it an advantage as an occasional browser as well (Webb 1965: 33). Pollen associated with the fossil remains in Jones Spring (Van Devender and King 1975) indicates that *Camelops* sp. inhabited a pine woodland with deciduous elements. Elsewhere in Missouri, Mehl (1962:66) reported that a premolar found in Atchison County, extreme northwestern Missouri, has been referred, with considerable doubt, to *Camelops kansanus*.

DISCUSSION. The isolated teeth can be arranged into four probable dentitions on the basis of wear, fossilization and stratigraphic context, with each dentition representing an individual (Table 20). The first and third dentitions listed in the table (under Associations) were recovered dispersed in the light brown gravelly peat of the lowest peat horizon, or from the feeder in Jones Spring. The second dentition listed was recovered dispersed in the spring feeder or in gray sandy clay beneath the lowest, light brown, organic zone. The fourth dentition, represented by the single left M/3, JS76, is without stratigraphic information. These stratigraphic considerations make it apparent that Jones Spring camelids were part of the earliest faunal accumulation in these spring-associated sediments.

Simpson (1945a) lists the occurrence of three camelid genera existing in the Pleistocene of North America, including: *Titanotylopus* (which includes *Gigantotylopus* fide Webb 1965:36), *Camelops* and *Tanupolama*. Webb (1974) has recently revised the llamas, including *Tanupolama*, and he recognizes in its place the genera *Palaeolama* and *Hemiauchenia*. More recently, Dalquest (1975) has proposed the genus *Blancocamelus* for very large

TABLE 20

Camelops sp. from Jones Spring, Hickory County, Missouri: associations and measurements (in millimeters).

Specimen	Associations	Position	length (grinding)	length (basal)	width (grinding)	width (basal)	height
97JS76		right dP/3	15.8	15.8	8.9	7.6	18.2
170JS77		right dP/4	-	-	13.6	-	-
275JS77		left dP/4	48.9	38.5	13.8	17.4	35.2
155JS77		right M/3	-	-	-	-	-
JS75		right M/1	31.3	28.3	20.0	18.2	28.2
378JS75		right M/2	44.6	36.0	22.5	21.0	55.0
374JS75		left M/2	43.5	36.9	22.1	20.5	55.2e
376JS75		right M/3	60.1	56.3	19.7	20.8	69.4
134JS75		left M/3	60.1	55.8	20.2	21.2	71.7
71JS76		right M1/	-	-	-	-	37.8e
313JS77		right M2/	44.0	34.1	27.6	31.0	56.5e
227JS77		left M2/	43.4	34.4	27.7	29.8	53.3
237JS77		right I/1	8.1	11.3	20.6	13.8	72.7e
98JS77		left I/1	8.5	-	20.4	-	-
239JS77		right M/3	50.2	54.9e	17.8	20.8e	65.3
84JS77		left M/3	-	-	18.1	20.9e	68.4
JS76		left M/3	51.2	52.0	17.0	20.0	67.1

Symbols:
e = estimate

camels from the earliest Pleistocene of Texas.

Titanotylopus and *Blancocamelus* are the largest of all Pleistocene North American camels. *Titanotylopus* is distinquished by having low crowned cheek teeth and by incisors which, unlike many camels, are not spatulate. These features exclude *Titanotylopus* from further consideration as the Jones Spring camelid is characterized by possessing high crowned cheek teeth and spatulate incisors. *Blancocamelus* is distinquished by enormous size and exceedingly long and slender limbs. While camelid limb elements do not occur in the Jones Spring assemblage, I exclude *Blancocamelus* from further discussion here because the size inferred for Jones Spring camels, on the basis of teeth, is only moderate to large.

Camelops is distinquished on the basis of materials (premaxillary and maxillary bones and the position of the canine tooth relative to the third incisor as well as relative proportions of the latter) not represented in the Jones Spring camelid sample, which consists of isolated teeth. Nevertheless, these isolated fossil specimens are of larger proportions than teeth of either *Palaeolama* or *Hemiauchenia* figured and recorded by Webb (1974), and are unlike them in morphology as well. Furthermore, the Jones Spring camelid teeth agree, in proportions and form, with teeth of *Camelops* (e.g., *C. hesternus*) that are available for comparison. On these bases, the Jones Spring camelid sample is assigned to the genus *Camelops*.

Camelops in the Pleistocene of North America is represented by four well-described species (*C. hesternus*, *C. huerfanensis*, *C. sulcatus*, *C. minidokae*) and by two poorly known species (*C. kansanus*, *C. traviswhitei*). These six species ally themselves into a small-size group (*C. sulcatus*, *C. minidokae*) and a large-size group (*C. hesternus*, *C. huerfanensis*, *C. kansanus*, *C. traviswhitei*). The Jones Spring *Camelops* sample belongs in the large-size group of Pleistocene species.

Camelops kansanus, described by Joseph Leidy in 1854, is the type species for the genus. It is based on a fragment of the snout, consisting of portions of the left premaxillary and maxillary containing the root of an incisor and a part of the socket of a canine (Hay 1913). As noted previously, camelid premaxillary and/or maxillary materials are not represented in the Jones Spring sample. *Camelops traviswhitei*, which is known only from the middle Pleistocene of central Mexico, is distinquished most notably by having molars with sharply "V"-shaped lakes without cementum which are enclosed linqually by extremely thin enamel (Mooser and Dalquest 1975). The Jones Spring *Camelops* contrasts totally in having molars with lakes shaped like bent ovals that contain cementum and which are bordered linqually by variable but generally thick enamel. *Camelops huerfanensis* is contrasted with *Camelops hesternus* primarily in possessing a P/4 that is larger relative to the M/1, and which in form is more triangular or wedge-like (Cragin 1892). In addition, these two species differ on the basis of the posterior development of M3/. Because neither the P/4 nor M3/ is represented in the camelid sample considered, it is not possible to assign these materials to one or the other of these larger camel species, nor, for the reason stated above, to *Camelops kansanus*. Thus, the *Camelops* sp. from Jones Spring remains indeterminate. It is not, however, *Camelops traviswhitei*.

Table 20 lists measurements of *Camelops* sp. teeth, associated as four dentitions, from Jones Spring, Missouri.

Family CERVIDAE
Odocoileus virginianus
White-tailed deer

ABUNDANCE. Two individuals. Three specimens, right antler fragment (with burr), 346JS76; proximal portion of a left metacarpal, 9JS76; right metatarsal, 73JS76.
HABITAT. *Odocoileus virginianus*, the White-tailed deer, occurs today in Canada, generally south of 52° N latitude, the United States, exclusive of some southwestern desert regions, Mexico and Central and northern South America.

The White-tailed deer is a browser inhabiting woodlands, forest borders and thickets along streams and around swamps. Pollen associated with the fossil remains in Jones Spring (Van Devender and King 1975) indicates that *Odocoileus virginianus* inhabited a pine woodland with deciduous elements. White-tailed deer presently occur throughout Missouri.
DISCUSSION. The fossils were recovered from dark brown peat which is the main fossiliferous unit developed in Jones Spring. The metatarsal was recovered at the base of this deposit.

The antler fragment, a shed specimen, is from a small and/or young male. It is identical to *O. virginianus* antlers examined by me in the Illinois State Museum osteology collections in such characters as size, brow tine position and main beam form. Measurements are: for the burr (unabraded), anteroposterior diameter = 26.0 mm, transverse diameter = 28.5 mm; for the beam above the brow tine, anteroposterior diameter = 19.9 mm, transverse diameter = 19.5 mm.

The metapodials represent two individuals. One is a mature animal (9JS76), the other is a late pre-natal fetus or very young juvenile (73JS76). Measurements of 73JS76, right metatarsal, are: lg. (exclusive of distal epiphyses which are absent) = 152.4 mm, mid-shaft anteroposterior diameter = 13.7 mm, mid-shaft transverse diameter = 11.0 mm.

Elsewhere in Missouri, *Odocoileus virginianus* has been reported in the Pleistocene faunas from Brynjulfson Caves (Parmalee and Oesch 1972) and Crankshaft Cave (Parmalee, Oesch and Guilday 1969). *Odocoileus* sp. has been reported in the Pleistocene fauna from Boney Spring (Saunders 1977a) as well as in the earlier of the two faunas contained in Trolinger Spring (this report). Elsewhere in the Ozark Plateaus, the White-tailed deer has been reported in the Pleistocene fauna from Conard Fissure, Arkansas (Brown 1908).

Family BOVIDAE
Bison latifrons (Harlan, 1825)
Bison

ABUNDANCE. Five individuals, based on wear differences in lower teeth. Thirty-six specimens, partial skull with horn core bases, 300JS77; condylar fragment of another skull, 128JS76; two petrosals, 89JS77 and 190JS77; right P3/, 68JS77; left M1/, 83JS73; right M1/, 291JS77; left M2/, 81JS73; right M2/, 131JS76; partial right mandibular ramus with P/4-M/3, 272JS75; right P/2 337JS77; left P/4, 185JS77; left M1/, JS75; left M/2 fragment, 98JS76; right M/2, 78JS77; right M/2, 194JS77; right M/2, 3JS77; left M/3, 272JS77; left M/3, 259JS77; partial hyoid, 109JS77; two axes, 182JS75 and 30JS77; six additional cervical vertebrae, provisionally assigned, JS74, 167JS75, 181JS75, 226JS75, 246JS75 and 273JS75; incomplete metacarpal, 122JS73; distal metacarpal fragment, JS77; proximal phalanx, 208JS77; head of a femur, 15JS76; femur shaft, 85JS77; incomplete metatarsal, 117JS76; two distal metapodial fragments, JS76 and 210JS77.
HABITAT. *Bison latifrons* is not a common fossil. The species is known from 49 localities in the United States and from one locality in Mexico (McDonald 1978:103). It has not been reported from Canada or Alaska. Though probably

never abundant, *B. latifrons* was most common on the Great Plains, in the Great Basin, along coastal California and in Florida. In addition, there are isolated records of this species from Missouri (this report), Kentucky (the type specimen for the species) and Ohio. This distribution pattern suggests that *B. latifrons* was probably both a browser and a grazer primarily adapted to forest openings or woodlands.

Plant macrofossils, dominantly fragments of oak, hickory, ash and juniper wood and root stock (F. B. King, pers. comm., 1978), associated with the fossils of *Bison latifrons* in Jones Spring indicate that this species here occupied a deciduous, probably in part riparian, forest community. Radiometric ages determined for Jones Spring sediments and fossils indicate that this community existed during a stadial or interstadial period at least 40,000 years ago.

DISCUSSION. The specimens referred to *Bison latifrons* from Jones Spring were recovered from either light brown gravelly peat forming the basal organic deposit in Jones Spring or from underlying gray clay. The provisionally assigned cervical vertebrae were recovered from either the base of the lower peat just above gray clay or from gray clayey sand of the feeder or from mixed sand and blue chert gravel, also of the feeder or, in one instance, from an unknown provenience.

Bison latifrons is the largest species of fossil bison known to have existed, as inferred from the large skull and immense horn cores and large postcranial skeleton that characterize this species. In addition it is the most poorly known of all species of North American fossil bison due, in part at least, to its relative great antiquity and presumably more or less solitary habits. The specimens from Jones Spring are thus important fossils bearing particularly upon furthering understanding of cranial and dental variation in *B. latifrons*. In addition, radiometric age determinations for Jones Spring sediments and fossils provide another geochronological datum for this poorly known species. Finally, the Jones Spring occurrence is associated with plant macrofossils that enable the reconstruction of *Bison latifrons* habitat.

The skull (300JS77) consists of the posterior portion of the cranium, including the horn core bases. The specimen was recovered from gravelly peaty sand of the feeder complex at a depth of 6.23 meters below the surface of the ground. There is some distortion evident in the asymmetry of the left and right horn core bases. The base of the right horn core (the best preserved and least distorted) is symmetrical about the dorsoventral axis. At its base this horn core is generally elliptical in cross section, with the major axis dorsoventral. This shape probably has resulted from slight deformation, however, and the original shape was most probably that of an isoceles triangle (see below). There is a prominent ventral burr on the horn core just before it joins the frontal bone. The posterior margin of the horn core is straight and the anteroposterior plane is nearly parallel to the frontals. In all these features of the horn cores, the Jones Spring cranium agrees with the male of *B. latifrons* as well as with the male of *B. antiquus antiquus*, as characterized by McDonald (1978:210). The immense size of the Jones Spring specimen suffices however to preclude its identification as a male of *B. a. antiquus*. For example, the basal circumference of the right horn core of the Jones Spring specimen is 507 mm (Table 21). For a sample of 34 male skulls of *B. a. antiquus* reported by McDonald (1978:115) the range of this variate is 267-392 mm, with a mean of 326.6 mm.

Table 21 gives measurements of the *Bison* skull from Jones Spring.

TABLE 21

Skull measurements (in millimeters) of *Bison* from Jones Spring compared with male and female sample ranges and means of *Bison latifrons*.

		B. latifrons, males			*B. latifrons*, females		
Variate	300JS77	N	Range	Mean	N	Range	Mean
Dorsoventral diameter, horn core base	184e*	25	107-171	140.3	5	101-119	108.0
Circumference, horn core base	507*	26	408-753	487.5	5	305-357	325.0
Width of condyles	163	10	140-169	155.6	1	-	135.0
Anteroposterior diameter, horn core base	136e*	26	137-200	162.5	5	93-111	102.2
Least width of frontals, between horn cores and orbits	388	12	299-395	346.5	2	284-291	287.5
Angle of divergence of horn cores, forward from sagittal plane	73°*	10	62°-83°	76.3°	0	-	-

* measured for the right horn core only.

Included in the table are male and female sample ranges and means of *B. latifrons* as given by McDonald (1978:99). From point of view of width across the condyles and least width of frontals, it is evident that the Jones Spring specimen is from a larger than average male of *Bison latifrons*. The dorsoventral and anteroposterior diameters of the right horn core base of the Jones Spring specimen are both outside the ranges reported in the table for *B. latifrons*. Slight deformation, presumably the result of lithostatic pressure, has probably lengthened the former variate and shortened (i.e., compressed) the latter, relative to the unaltered condition, which probably had the shape of an isoceles triangle. The basal circumference of the right horn core of the Jones Spring skull has presumably been little altered by this deformation and consequently is probably close to its original value. It too indicates that the Jones Spring individual was a larger than average male of *B. latifrons*.

Among the fossils recovered from Jones Spring are a partial right mandible with P/4-M/3 and 14 isolated upper and lower cheek teeth that are, on the bases of large relative size and stratigraphic context, assigned with good certainty to this taxon. There are five isolated upper cheek teeth that are, on the basis of M1/ wear differences, assignable to at least two individuals. One upper tooth is a premolar (right P3/, 68JS77), the remainder are molars (right M1/, 291JS77; a left M1/, 83JS73, a left M2/, 81JS73 and a right M2/, 131JS76 are, with the premolar, probably associated). All the upper teeth exhibit heavy wear. Based on wear of the M1/ and M2/ styles, one individual is inferred to have been in full maturity and the other individual (represented by right M1/, 291JS77) is inferred to have been in old age (wear stage S-3 and S-4, respectively; see Skinner and Kaisen, 1947 for a discussion of molar age and wear classes). Because of heavy wear or damage there are no useful measurements that can be obtained from the upper teeth.

The partial right mandible (272JS75) was recovered from light brown peat near its contact with underlying gray clay at a depth of 3.33 meters below the surface of the ground. The M/3 stylid shows full wear, indicating a fully mature individual. It is possible that this partial mandible was associated in life with the partial skull discussed above. Measurements of this specimen are given in Table 22. The M/1-M/3 alveolar length, 122.7 mm, agrees well with values for this variate reported by Miller (1971: 61) for *Bison latifrons* mandibles from California. His reported range of 110-125 mm has a mean of 119 mm (n = 6). Included in the table are maximum length and width measurements of seven isolated cheek teeth. As previously mentioned, these teeth are assigned to *B. latifrons* on the bases of size (agreement with those in the partial right mandible, 272JS75) and stratigraphic context (light brown gravelly peat or underlying gray clay or correlative strata). It is to be noted from the stage of wear of right M/2, that one individual was an early adolescent (wear stage A, 78JS77), another was in early maturity (wear stage S-2, 194JS77) and two were in full maturity (wear stage S-3, 272JS75 and 3JS77). In addition, a fifth individual is indicated to have been in old age (wear stage S-4), based on severe wear of left M/3 (259JS77). There are two additional lower cheek teeth in the collection but they are damaged and neither length nor width measurements can be obtained from them. They do not represent additional individuals, however.

One of the teeth in Table 22 is worthy of note. The left P/4, 185JS-77 (Fig. 32), is an extremely large and morphologically complex tooth, an impression inadequately conveyed in the table by length and width measure-

TABLE 22

Measurements (in millimeters) of *Bison latifrons* lower dentitions from Jones Spring.

Variate	272JS75 (r man.)	337JS77 (rP/2)	185JS77 (lP/4)	JS75 (lM/1)	78JS77 (rM/2)	194JS77 (rM/2)	3JS77 (rM/2)	259JS77 (lM/3)
Stage of wear*	S-3			S-4	A	S-2	S-3	S-4
Alveolar length, M/1-M/3	122.7							
Length-								
P/2		15.7e						
P/3								
P/4	25.3		30.5					
M/1	29.9			27.4				
M/2	37.0				41.4	38.4	37.2	
M/3	53.7							50.5
Width-								
P/2		11.0e						
P/3								
P/4	15.2		19.3					
M/1	20.4			20.2				
M/2	21.2				21.6	26.4	21.9	
M/3	20.8							21.1

* as defined by Skinner and Kaisen (1947) for upper molars; inferred for lower molars.

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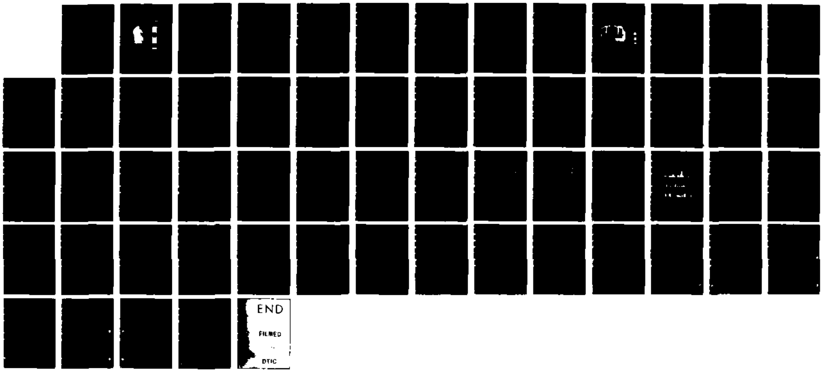

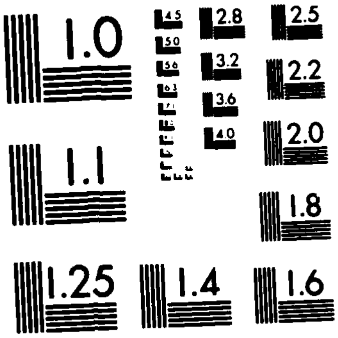

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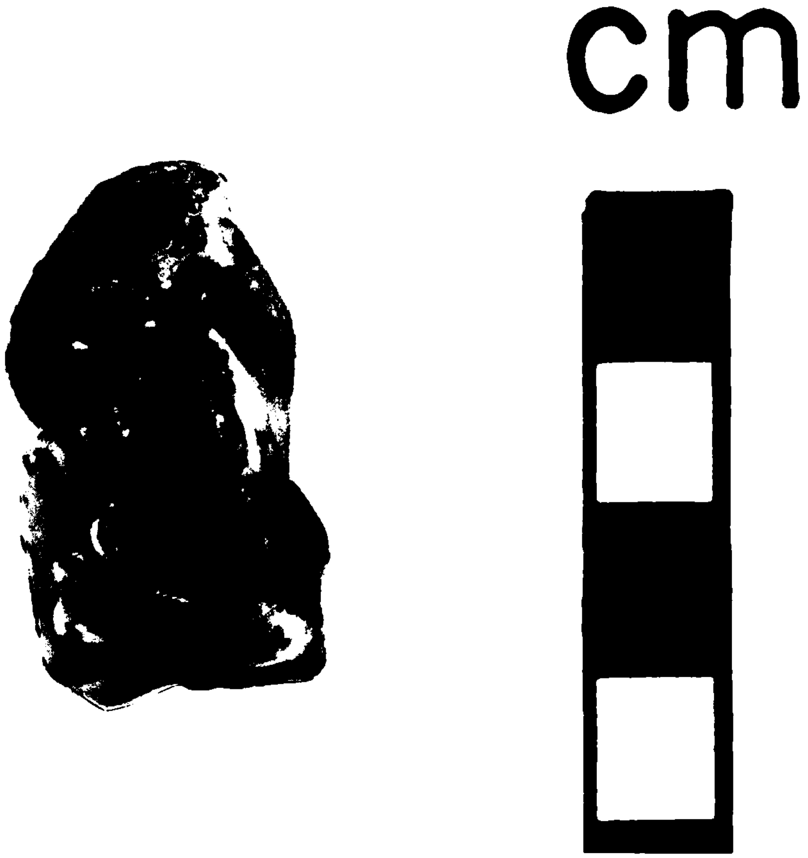

Figure 32. Occlusal view of left P/4 (185JS77) of *Bison latifrons* from the Jones Spring fossil assemblage.

ments only. In size and robustness (i.e., width/length) it is much greater than the P/4 in the partial right mandible which is itself, based on M/1-M/3 alveolar length, a larger than average specimen of *B. latifrons* (compared to the California sample only). This tooth is in fact longer than, and nearly as wide as, either of the two M/1's in the *Bison latifrons* sample from Jones Spring (Table 22).

In addition to the partial skull, partial mandible and isolated cheek teeth just discussed there are 14 other specimens recovered from Jones Spring that are referred to this taxon, including five cervical vertebrae that are only provisionally assigned. With the exception of the metacarpal (122JS73) and the metatarsal (117JS76), none of this material is distinctive. Measurements of the incomplete metacarpal are: minimum anteroposterior diameter of the shaft = 32.8 mm, minimum transverse diameter of the shaft = 58.1 mm. These values compare well with those reported by McDonald (1978:240) for *B. latifrons*. When compared with McDonald's (1978:240) bivariate plot of metacarpal diameters, the Jones Spring specimen falls within the zone of overlap of female and male metacarpals. Measurements of the incomplete metatarsal are: minimum anteroposterior diameter of the shaft = 34.5 mm, minimum transverse diameter of the shaft = 39.3 mm. These values also compare well with those reported by McDonald (1978:252) for *B. latifrons*. When compared with McDonald's (1978:252) bivariate plot of metatarsal diameters, the Jones Spring specimen falls near the middle of the distribution of female *B. latifrons* metatarsals. The metatarsal indicates that both sexes (recall the male skull, 300JS77) are represented in the sample of *Bison latifrons* from Jones Spring. Sexual differences may account for the relatively gracile femur shaft (85JS77; anteroposterior diameter = 53.1 mm, transverse diameter = 45.1 mm) that is, on the basis of stratigraphical context, assigned to this taxon.

Though fossil bison remains are relatively common in Missouri (Mehl 1962), this is the first reported record of *Bison latifrons* for the state.

Bison latifrons (Harlan, 1825) and/or *Bison antiquus* Leidy, 1852
Bison

ABUNDANCE. Four individuals, based on right M/1's. Fifty specimens, right P2/, 64JS75; left P3/, 56JS73; left P3/, JS77; left M1/, 31JS75; left M1/, JS77; left M2/, 106JS76; left M2/, JS76; left M2/, 336JS77; left M3/, 148JS76; left M3/, 348JS77; left M3/, fragment, JS77; right M3/, 254JS75; partial left mandibular ramus with P/2-P/4, 370JS75; left P/2, 128JS75; left P/3, 250JS75; right P/3, 211JS75; right P/3, 222JS75; left P/4, 346JS77; right P/4, 258JS75; right P/4, 130JS76; right P/4, JS76; left M/1, 162JS73; left M/1, 375JS75; left M/1, 35JS76; right M/1, 271JS75; right M/1, 332JS75; right M/1, 335JS77; right M/1, 342JS77; left M/2, 233JS75; left M/2, 364JS75; right M/2, 141JS73; right M/2, 261JS75; right M/2, 311JS75; right M/2 fragment, 338JS75; left M/3, 186JS75; left M/3, 309JS77; right M/3, 89/121JS73; right M/3 fragment, 202JS75; right M/3, 284JS77; right M/3, 303JS77; four lower incisors, 348JS75, JS75, JS77, JS77; thoracic vertebra, 235JS77; thoracic vertebral centrum, 134JS73; partial right scapula, 140JS76; two podials, 114JS73 and 91JS76; indeterminable long bone fragment, 94JS73.

HABITAT. Whereas living *Bison* are almost exclusively grazers adapted to life on the open plains, earlier forms had other adaptations. *Bison latifrons* was both a browser and a grazer in forest and/or woodland situations. *Bison antiquus*, which had evolved from *B. latifrons* by 42,000 years ago (McDonald 1978:121) during the late Pleistocene, was adapted to more open savanna and/or steppe situations (McDonald 1978:112).

The paleoenvironmental evidence from Jones Spring (Van Devender and King 1975:211) indicates that *Bison latifrons* and/or *Bison antiquus* occupied an open pine-parkland community during an interstadial or stadial period at least 40,000 years ago.

DISCUSSION. The fossil specimens here referred imprecisely to *Bison latifrons* and/or *Bison antiquus* came from stratigraphic contexts indicative of later age than the fossils previously assigned to *B. latifrons*. Eighteen of these specimens were recovered from dark brown peat that formed the most extensive organic horizon in Jones Spring. Four specimens were recovered from sandy or gravelly gray clay either above, lateral to, or, adjacent to the spring feeder, commingled with, the dark brown peat. Twenty-five specimens were recovered from the spring feeder complex, either from generally fine white sand (seven specimens) that formed the center of the spring or from mixed sand and blue chert gravel (nine specimens) peripheral to the white sand or from gravelly sand (nine specimens) generally peripheral to the mixed sand and blue chert gravel. Four specimens were recovered as "float," i.e., are of unknown stratigraphic context.

The presence of additional bison remains in later deposits in Jones Spring presents an interesting problem with perhaps significant implications for *Bison* evolution generally. *Bison latifrons* is well represented in Jones Spring deposits dating from greater than 40,000 years ago (Tx-1628, for light brown gravelly peat) to 48,900±900 years ago (QL-962, for gray clay underlying light brown gravelly peat). The identification of *B. latifrons* from these sediments is unequivocal, based on a partial skull with horn core bases (300JS77), a partial right mandibular ramus (272JS75) and other fossil specimens.

There is one finite age determination for overlying dark brown peat which also contains *Bison* (not *B. latifrons senso stricto*) remains: 39,700 ±2600 years (Tx-1622). In addition, there are two infinite age determinations for this unit: >40,000 years (Tx-1627, Tx-1628). These latter suggest that Tx-1622 may be contaminated with younger carbon and that the actual age for this dark brown peat unit is probably greater than 40,000 years. Nevertheless, subtracting the youngest of these finite determinations (Tx-1622, 39,070 years) from the oldest finite determination (QL-962, 48,900 years) establishes a maximum limit to the duration of *Bison* (all species) accumulation in Jones Spring: 9,830 years. Presently, there is no means to calculate a minimum limit for the duration of *Bison* (all species) accumulation in Jones Spring. In addition, the maximum duration reported here is based on present understanding and could conceivably be significantly altered (presumably shortened) by age determinations that are pending or by better understanding of Jones Spring stratigraphy or by both. In summary, however, bison evolution (or stasis) represented by fossils in Jones Spring took place at most over a 10,000 year time span.

The specific identification of *Bison* represented by fossils in later units in Jones Spring is enigmatic. There are no skulls with (or without) horn cores represented in the *Bison* sample from the dark brown peat and correlative strata. Skulls and horn cores are considered to be the most important diagnostic materials in *Bison* systematics. There is however an interesting partial left mandibular ramus (370JS75), with P/2-P/4, of *Bison* recovered from sandy, gravelly clay of the Jones Spring feeder complex at a position above dark brown peat and possible derived from a primary deposition in the latter. The P/4 of this specimen contrasts markedly, in size and robustness, with P/4 in the mandibular ramus of *Bison latifrons* (272JS75) and is highly suggestive of specific difference.

Measurements of this specimen are given in Table 23. The P/2-P/4 alveolar length, 61.3 mm, is close to the value for this variate reported by Miller (1970:61) for a *Bison antiquus* mandible from Rancho La Brea, California (61.0 mm, Y-6711). It is however much less than the values for the same variate reported by Miller (1971:61) for *Bison latifrons* from southwestern California (range: 65-73 mm, mean of 6 observations = 68.3 mm). In addition, P/3 and P/4 length, 21.2 mm and 24.6 mm, respectively, of the Jones Spring specimen (370JS75) agree well with values reported by Lundelius (1972:59) for *Bison antiquus* from Ingleside, Texas. His reported range of 20.6-21.9 mm for P/3 length has a mean of 21.2 mm (n=3), the reported range of 22.0-26.0 mm for P/4 length has a mean of 23.7 mm (n=3).

The range of variation for length and width of isolated cheek teeth of adult *Bison latifrons* and/or *Bison antiquus* from Jones Spring are given in Table 24. It is to be noted, in comparison with values for length presented in the previous table for lower dentitions of *Bison antiquus* from Ingleside, Texas, that Jones Spring cheek teeth are generally longer, P/3-M/3. In addition, these isolated cheek teeth of adult *Bison latifrons* and/or *Bison antiquus* from Jones Spring are generally shorter and narrower, P/2-P/4 and M/3, but are as long or longer and as wide or nearly as wide, M/1-M/2, as lower teeth assigned to adult *Bison latifrons* from Jones Spring (Table 22, exclusive of 78JS77, right M/2, which is from a subadult individual). These differences observed in teeth of adult *Bison latifrons* and/or *Bison antiquus* from Jones Spring when compared with *Bison antiquus* on the one hand and with *Bison latifrons* on the other are satisfactorily explained if they are considered to be from individuals that were evolutionarily intermediate between ancestral *Bison latifrons* and descendent *Bison antiquus*. This evolutionary transition is associated in western Missouri, as evidence in Jones Spring indicates, with a period of environmental change. During this event, an earlier deciduous forest, dated to at least 49,000 years ago and containing *Bison latifrons* senso stricto, gave way, presumably before 40,000 years ago, to a more open, savanna-like coniferous parkland containing a form transitional between *Bison latifrons* and *Bison antiquus* here termed *Bison latifrons* and/or *Bison antiquus*.

Symbos sp. Osgood, 1905, or *Bootherium* sp. Leidy, 1852
Woodland muskoxen

ABUNDANCE. Four individuals based on wear differences of cheek teeth. Twenty-five specimens, left P3/, 9JS75; right P4/, JS73; right P4/, JS75; right P4/ fragment, 347JS75; left M2/, 53/54JS73; left M2/, 2JS75; left M2/, 368JS75; right M2/, 39JS75; left M3/, 108JS75; right M3/, 48JS73; right M3/, 1JS77; left P/4, 25JS73; righ- P/4, JS75; left M/1, 382JS75; left M/1, JS75; left M/2, 88JS75; right M/2, 147JS73; left M/3, 279JS77; left squamosal, 191JS75; two left petrosals, 27JS73 and 149JS73; left astragalus, 34JS75; right astragalus, JS75; proximal metatarsal fragment, 85JS75.

HABITAT. Pollen evidence from Jones Spring (Van Devender and King 1975) indicates that the woodland muskoxen occupied an open pine-parkland community during an interstadial or stadial period at least 40,000 years ago. Woodland muskoxen were presumably browsers in this habitat. Elsewhere in eastern North America, they apparently occupied boreal forest or woodland of spruce and fir in addition to pine (Semken, Miller and Stevens 1964; Ray, Cooper and Benninghoff 1967). Elsewhere in Missouri, *Symbos cavifrons* has been reported (initially as *Symbos* sp. or *Bootherium* sp.) in the fauna from Trolinger Spring, Hickory County, where it was also associated with an open pine-parkland (Saunders 1977a and this report).

TABLE 23

Measurements (in millimeters) of the *Bison latifrons* and/or *Bison antiquus* mandible from Jones Spring compared with measurements of mandibles of *Bison antiquus* from Rancho La Brea, California (Y)[1] and Ingleside, Texas (TMM)[2].

Variate	370JS75 (left)	Y-6711 (-)	TMM 30967-408 (left)	TMM 30967-1128 (left)	TMM 30967-1055 (left)
Stage of wear*	S-2 (inferred)	-	S-2	S-4 (early)	S-4
Depth of jaw at antero-internal border of P/2 alveolus	46.1	43	-	-	-
Alveolar length, P/2-P/4	61.3	61	-	-	-
Length-					
P/2	14.4	-	-	-	-
P/3	21.2	-	21.2	21.9	20.6
P/4	24.6	-	26.0	23.1	22.0
M/1	-	-	29.6	27.6	26.7
M/2	-	-	37.1	32.5	31.9
M/3	-	-	47.8	49.5	49.0
Width-					
P/2	9.4	-	-	-	-
P/3	13.5	-	-	-	-
P/4	16.2	-	-	-	-
M/1	-	-	-	-	-
M/2	-	-	-	-	-
M/3	-	-	-	-	-

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* as defined by Skinner and Kaisen (1947) for upper molars; inferred for lower molars.

[1] Miller (1971:61).

[2] Lundelius (1972:59).

TABLE 24

Range of variation observed in adult cheek teeth of
Bison latifrons and/or *Bison antiquus* from Jones Spring.
Measurements are in millimeters.

		Maximum Length		Maximum Width	
N*	Position	range ;	mean	range ;	mean
1	P2/	19.0		15.7	
1	P3/	22.7e		21.2	
0	P4/	-		-	
1	M1/	32.4e		25.4	
2 (1)	M2/	(37.9)		30.6-31.0;	30.8
3 (2)	M3/	37.2-38.4;	37.9	(30.3-31.7;	31.0)
2	P/2	14.4-15.6;	15.0	9.6-10.0;	9.8
4	P/3	20.9-25.9;	23.0	13.3-14.2;	13.6
5	P/4	24.6-26.6;	25.6	14.2-16.2;	15.1
1**	M/1	30.7e		19.2	
4	M/2	36.5-40.3;	38.2	21.4-24.2;	22.4
5 (4)	M/3	(48.8-49.8;	49.4)	19.3-20.3;	19.9

* only adult specimens used, i.e., wear stages S-1, S-2, S-3 and S-4 of Skinner and Kaisen (1947).

** there are six additional M/1's in the collection but their stylids are unworn and they are judged to be from subadult individuals.

DISCUSSION. The majority (15 specimens) of the muskoxen fossils were recovered from the dark brown peat unit in Jones Spring. Single specimens were recovered from light brown, coarse gravelly peat below, but at the contact with, dark brown peat and from gravelly sand of the feeder complex. Two specimens were recovered from fine, well sorted, white sand that occupied the center of the spring. Two specimens were recovered from gray sandy clay in the upper portion of the feeder. One specimen occurred in gray sandy, gravelly clay, also of the feeder. Three specimens were recovered without provenience information.

The Jones Spring muskoxen sample consists primarily of isolated teeth, measurements of which are given in Table 25. Length and width measurements of muskoxen cheek teeth from Jones Spring agree with values for these variates for *Symbos cavifrons* teeth from adjacent Trolinger Spring (Saunders 1977a:38 and this report). Also, width of M/2 and length and width of M/3 agree with values reported by Brown (1908:204) for *Symbos australis* (=*S. cavifrons*) from Conard Fissure, Arkansas (M/2 width at base = 23 mm; M/3 length at base = 49 mm, width at base = 22 mm. Length and width of M2/ and length of M/2 of Jones Spring muskoxen are appreciably greater than values reported by Brown (1908:204) for Conard Fissure *Symbos* however (M2/ length at base = 32 mm, M2/ width at base = 30 mm; M/2 length at base = 30 mm). Length measurements of isolated P4/, M2/ and M3/ of muskoxen from Jones Spring agree with values (23 mm, 35 mm and 39-40 mm, respectively) reported by Nelson and Madsen (1978: 293) for teeth in a skull of *Symbos cavifrons* from Utah. The P3/ in the Jones Spring sample however is much shorter than the P3/ in the *Symbos cavifrons* skull from Utah (17.3 mm vs. 22-23 mm).

In summary, in such features as size and length vs. width proportions, the muskoxen teeth from Jones Spring are like those of *Symbos cavifrons* observed by me from Trolinger Spring as well as those described in the liter-

TABLE 25

Measurements (in millimeters) of cheek teeth of *Symbos* sp. or *Bootherium* sp. from Jones Spring.*

Variate	9JS75 (1P3/)	JS73 (rP4/)	JS75 (rP4/)	347JS75 (rP4/)	39JS73 (rM2/)	53/54JS73 (1M2/)	2JS75 (1M2/)	368JS75 (1M2/)	48JS73[1] (rM3/)	108JS75[1] (1M3/)	1JS77 (rM3/)
Length											
P3/	17.3										
P4/		23.4	23.3	-							
M2/					34.9	43.0	35.7	38.2			
M3/									39.9	39.3	40.0
Width											
P3/	18.4										
P4/		25.4	26.0	24.0							
M2/					-	34.6	36.3	35.7			
M3/									30.5	32.5	30.3

	25JS73 (1P/4)	JS75 (rP/4)	JS75 (1M/1)	147JS73 (rM/2)	88JS75 (1M/2)	279JS77 (1M/3)
Length						
P/4	22.4	21.9				
M/1			-			
M/2				39.6	32.8	
M/3						53.0
Width						
P/4	15.5	15.6				
M/1			19.4			
M/2				22.8	22.6	
M/3						21.5

* measurements obtained at base of specimen.

[1] specimens with endostyles.

ature. Other features of these teeth from Jones Spring, however, are not like those of *Symbos cavifrons* observed by me from Trolinger Spring, or as generally characterized in the literature, and are worthy of additional discussion. Most notably is the presence of well developed endostyles on two of the three M3/'s in the Jones Spring muskoxen sample (left M3/, 108JS75 and right M3/, 48JS73, which were associated in life in a single individual; Figure 33). It has generally been stated that cheek teeth of *Symbos* (as well as those of *Euceratherium*, another, more enigmatic, fossil muskox that is smaller than Jones Spring muskoxen and so not considered further here) lack endostyles, features that are small or absent in *Ovibos*, the living muskox, but well developed in *Bison* (e.g., Brown 1908:203; Semken, Miller and Stevens 1964:829; C. R. Harington, pers. comm., 1980). Though the endostyles on the Jones Spring M3/'s are broken at mid-height, they demonstrate that strong median styles were at least occasionally developed between the major crescents of Jones Spring muskoxen upper molars. The Jones Spring specimens are like teeth of *Ovibos* in other ways as well. External ribs and styles, especially the mesostyle, are well developed on all upper cheek teeth in the Jones Spring muskoxen sample, as in usual characterizations of *Ovibos* teeth (Brown 1908; Semken, Miller and Stevens 1964). Also, the anterior face of 368JS75, left M2/ and 1JS77, right M3/ each contain an especially pronounced depression that receives the posterior portion of the tooth directly to the front. This depression is also evident, though not so markedly, in other upper teeth of muskoxen from Jones Spring. It has been stated by Semken, Miller and Stevens (1964:829) that "the posterior loop of the premolars and molars of *Symbos* is very small and consequently there is no...depression [corresponding to that in *Ovibos* teeth]." Thus, except for size and robustness which are *Symbos*-like, the Jones Spring muskoxen teeth are very much like teeth of *Ovibos*, based on differential characterizations from literature sources.

Bootherium is regarded by some authors as the female of *Symbos* (e.g., Hibbard and Hinds 1960), but this is considered currently by others to be undemonstrated and unlikely (e.g., Semken, Miller and Stevens 1964; Nelson and Madsen 1978). Teeth of *Bootherium* have not been described, to my knowledge, and there is currently no means, other than a comparison of crania with horn cores, to distinquish *Symbos* from *Bootherium* with certainty. In light of this, differences between Jones Spring muskoxen cheek teeth and *Symbos* on the one hand, and similarities between Jones Spring muskoxen cheek teeth and *Ovibos* on the other, may be explained if *Bootherium*, though unrecognized, is represented in the Jones Spring muskoxen sample. In the absence of critical cranial material from Jones Spring, it is not possible to determine which of the woodland muskoxen, *Symbos* or *Bootherium*, is represented.

The other cranial (three specimens) and postcranial (three specimens) materials referred here to woodland muskoxen are not distinctive and do not aid to resolve specific identity.

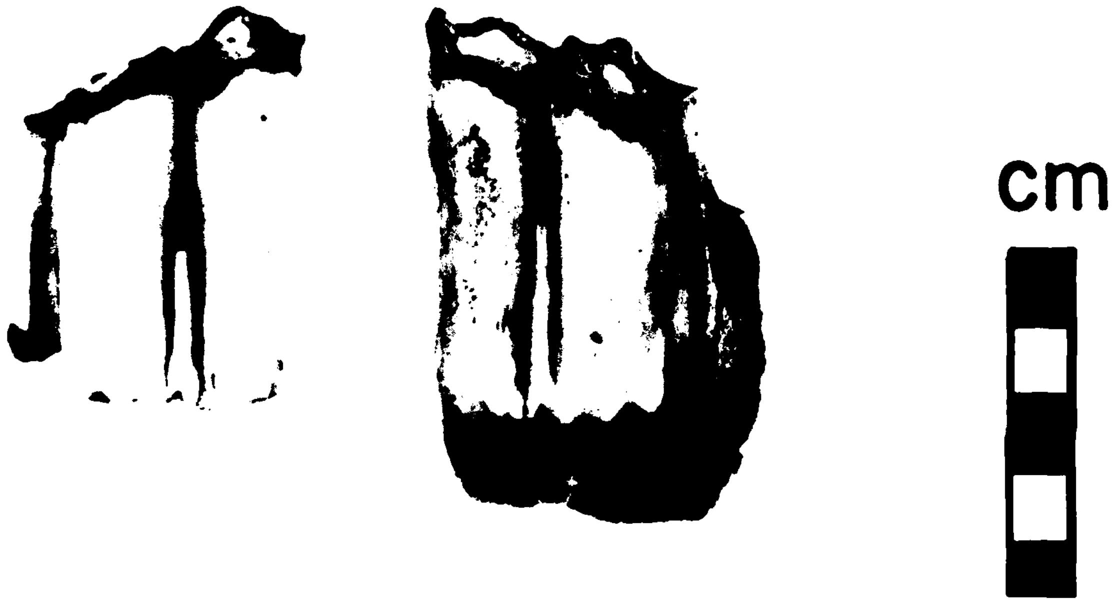

Figure 33. Lingual view of associated right (48JS73) and left (108JS75) M3/ of *Symbos* sp. or *Bootherium* sp. from the Jones Spring fossil assemblage showing well developed endostyles.

CHARACTERIZATION OF SPRING SITE FOSSIL ASSEMBLAGES

The geological and biological characterization of spring sites as sedimentary environments have received little previous attention. I have previously discussed this from point of view of current orientations in taphonomy, which is the branch of paleontology that focuses on understanding the processes involved in fossil accumulation and preservation (Saunders 1977a:68-69). I have previously provided a detailed taphonomic study of Boney Spring (Saunders 1977a). The spring sites reported here for the first time now provide a base for more adequately founded characterization of spring site sedimentary environments.

Geological Framework of Spring Site Fossil Assemblages

Stratigraphic contexts

Figure 34 is a schematic cross section across the lower Pomme de Terre River valley establishing the stratigraphic relationship of each spring site reported here to alluvial terraces and other buried fossiliferous spring sites. Stratigraphic cross sections of Trolinger and Jones springs have previously been presented here (Figs. 2, 3 and 15) and that for Boney Spring schematically presented elsewhere (Saunders 1977a:Fig. 16).

Trolinger Spring I. Trolinger Spring I fossils occurred dispersed in three units, dominately mixed sands and gravels, comprising the conduit complex in Trolinger Spring. These fossils, primarily isolated teeth, were scattered throughout these coarse sediments and, unlike the other faunas reported here, they did not occur in sedimentary lenses.

Trolinger Spring II. The sediments containing the Trolinger Spring II fossil assemblage were highly organic, dominantly peat, and set within the primarily inorganic sediments containing the Trolinger Spring I fauna and flora. The peat lens containing the Trolinger Spring II bone bed was encountered 2 m below the present day land surface. This unit was lenticular in cross section and roughly circular in plan. This peat lens was ≈10 m in diameter and had a maximum thickness of 2.5 m, reached near its center. Fossils were concentrated near the base of this peat lens; they occurred over a lateral distance of approximately 8.5 m and occurred dispersed vertically through the peat near its center.

Jones Spring. Jones Spring fossils were concentrated in two peat lenses associated with artesian spring activity and in sediments comprising the spring conduit and feeder as well as in adjacent host alluvium (Fig. 29, mastodon forefoot). The lower peat, which was the main fossiliferous horizon, overlaid a conduit filled with roughly concentric fossiliferous strata of gravelly sand, mixed sand and blue chert gravel in addition to white sand occupying the spring's center. This lower peat lens was separated into an upper dark brown sandy zone and a lower light brown gravelly zone. An upper peat lens was less extensive and less organic. It contained fragmented, often rounded fossils suggesting forceful redeposition from the lower peat lens (Haynes 1980).

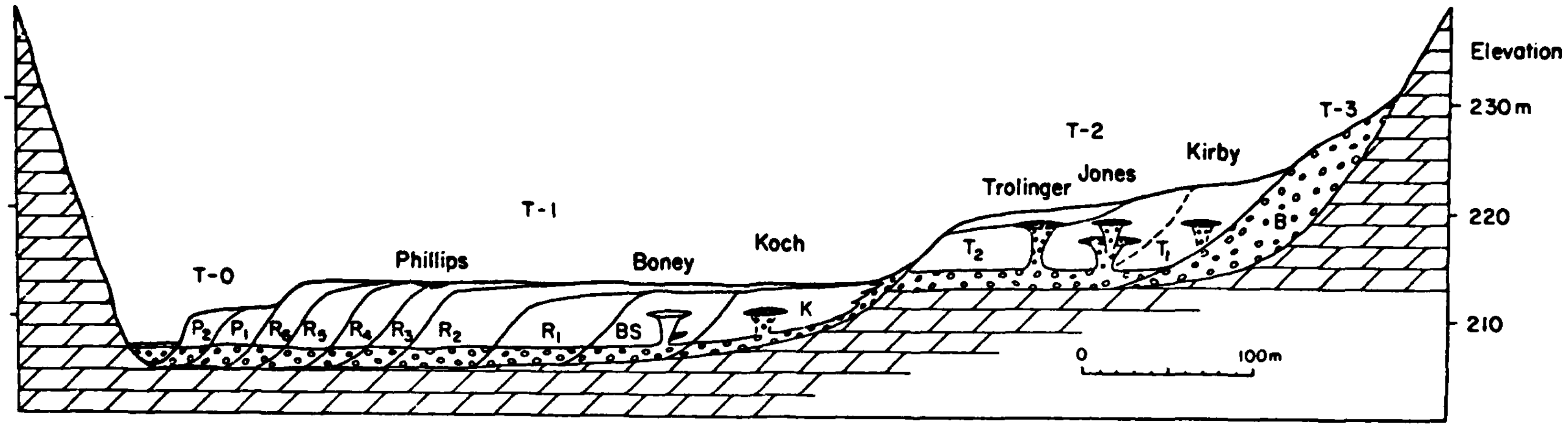

Figure 34. Diagrammatic cross section of the lower Pomme de Terre River valley showing the stratigraphic relationship of Trolinger, Jones and Boney springs to alluvial terraces (T-0, T-1, T-2, T-3), fill sequences (P=Pippins, R=Rodgers, BS=Boney Spring, K=Koch, T=Trolinger, B=Breshears) and additional buried, fauna-containing, spring sites. (From C. V. Haynes 1980.)

Apparently subsequent to the deposition of the lower, main, peat unit, spring discharge was renewed forcing an intrusive mixture of sediments and fossils from the lower peat unit into a higher, somewhat younger, stratigraphic position within the spring.

The upper peat lens in Jones Spring occurred approximately 1 m below the present day land surface when first encountered. The lower peat lens, containing the bulk of the fossil remains at this locality, was encountered 3.18 m below the present day surface in the same test trench. Both of these peat lenses were roughly to nearly circular in plan. The lower peat lens was 16 m in diameter and had a maximum thickness near its center of 2 m. The upper peat lens was not the focus of major systematic excavation and its vertical and horizontal limits were not precisely defined.

Orientation analyses

Trolinger Spring I. The Trolinger Spring I fossil assemblage consisted primarily of highly dispersed isolated teeth and wood fragments and no attempt has been made to analyze the orientation of these scattered remains.

Trolinger Spring II. The disarticulated fossil remains comprising the Trolinger Spring II fauna occurred in a true bone bed and compares in this regard with the Boney Spring accumulation (see Saunders 1977a). In both of these assemblages bones rested directly on each other and the matrix (clay at Boney Spring; variegated sand or dark brown, sandy, clayey peat and dark brown clay at Trolinger Spring II) was often restricted to thin seams between fossil specimens. Figures 4 and 11 (in separate map volume) are plan maps of the Trolinger Spring (undifferentiated) excavations. The bone bed arrangement of the dissociated fossil remains is apparent from these maps, as is the roughly circular plan of the concentration.

Figure 35 is a polar co-ordinate plot of specimen long axes in the Trolinger Spring II fossil accumulation. The figure shows long axis direction, dip angle and dip direction of 180 elongate specimens in the accumulation. In these plots points near the periphery indicate specimens that were more nearly horizontal whereas points toward the center represent those that were more nearly vertical. The figure shows that the fossils lacked a preferred long axes direction (= orientation). In addition, it is apparent from the figure that the majority of the long axis dips (=attitude) were within 12^{o} of the horizontal. Both the orientation and the attitude of Trolinger Spring II specimens compare with specimens recovered from Boney Spring (Saunders 1977a: 76). Though the orientation compares with specimens recovered from Jones Spring (see below), the attitude contrasts. In summary, while the elongate specimens in the Trolinger Spring II accumulation lacked a preferential orientation along any compass direction(s), they had a preferential attitude near the horizontal plane.

Jones Spring. The disarticulated fossil remains in Jones Spring were dispersed throughout the fossiliferous deposits, and no true bone bed was developed. The specimens usually occurred as isolated elements, widely separated from one another. Figures 16 through 22 (in separate map volume) are plan maps of the Jones Spring excavation. The complete dispersal of the fossil remains is apparent from these maps, as is the roughly to nearly circular plan of the concentration.

Figure 36 is the polar co-ordinate plot of specimen long axes in the Jones Spring fossil accumulation. The figure shows long axis direction, dip angle and dip direction of 528 elongate specimens in the accumulation. It is apparent in the figure that the highly dispersed fossil remains in Jones Spring

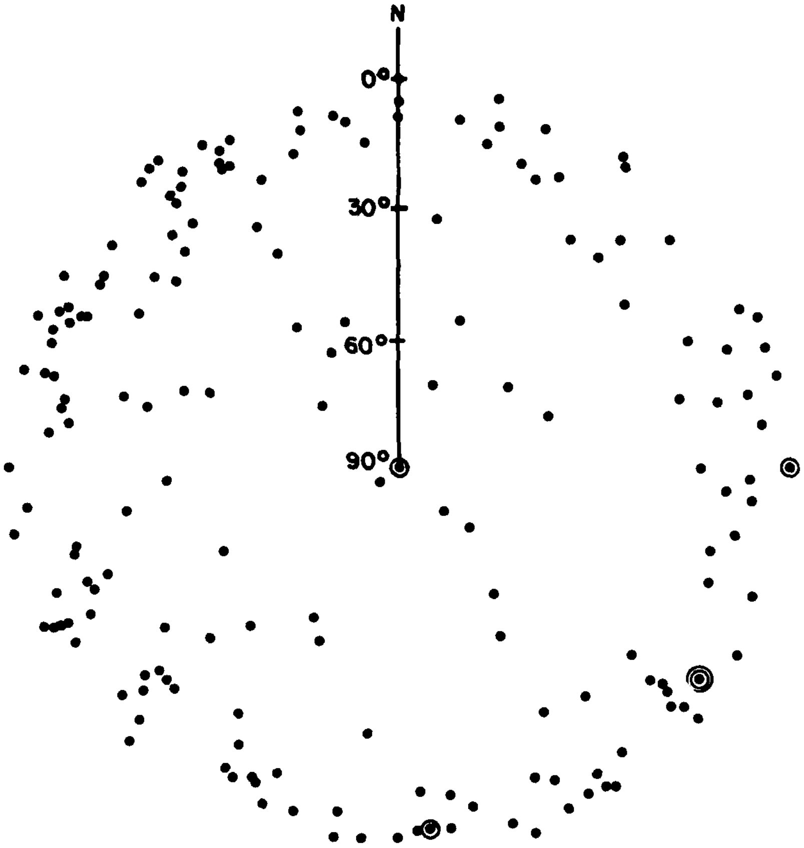

Figure 35. Polar co-ordinate plot of specimen long axes in the Trolinger Spring II fossil assemblage. N=180. Circles enclosing a point represent specimens with coincident orientations and attitudes.

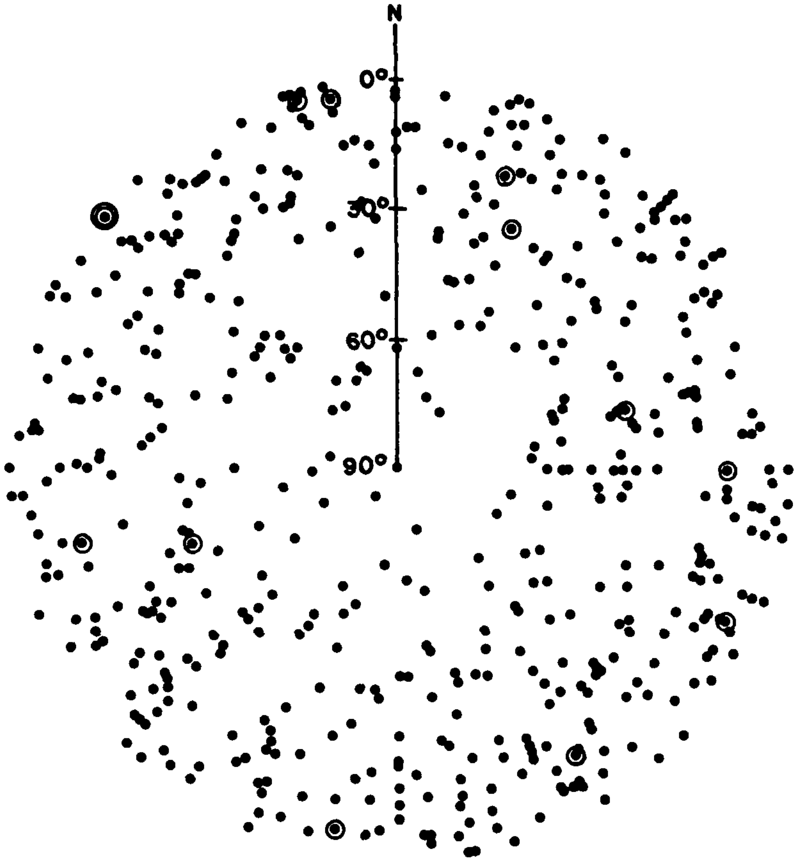

Figure 36. Polar co-ordinate plot of specimen long axes in the Jones Spring fossil assemblage. N=528. Circles enclosing a point represent specimens with coincident orientations and attitudes.

lacked either a preferred orientation or preferred attitude.

Biological Framework of Spring Site Fossil Assemblages

Composition of the faunas

Trolinger Spring I. The Trolinger Spring I fauna is summarized in Table 26. This fauna lacks mastodon but mammoth remains were recovered in some abundance and this animal co-dominates the fauna (five individuals represented). The fauna, containing six genera and seven species, is not diverse but nevertheless reflects both aquatic and terrestrial elements. The aquatic turtle, *Chrysemys scripta*, indicates the presence of permanent water near the site of deposition and is not unexpected in a spring-site fossil assemblage. The terrestrial element is, with two exceptions, composed of animals which are, based on known or inferred habits, almost exclusively grazers. The exceptions include an omnivore (*Ursus americanus amplidens*) and a browser (*Odocoileus* sp). The Trolinger Spring I fauna is, in sum, a decidedly grazing fauna.

TABLE 26

The late Pleistocene vertebrate fauna
from Trolinger Spring I.

Taxon	No. of Specimens	MNI
Class Reptilia		
Order Chelonia		
Chrysemys scripta	1	1
Class Mammalia		
Order Carnivora		
Ursus americanus amplidens	3	1
Order Proboscidea		
Mammuthus jeffersonii	15	5
Order Perissodctyla		
Equus complicatus	65	4
Equus cf. *scotti*	5	2
Order Artiodactyla		
Odocoileus sp.	3	3
Bison sp.	26	5

Trolinger Spring II. Table 27 summarizes the Trolinger Spring II fauna. Like the previous fauna the Trolinger Spring II fauna is not diverse. Coincidentally, this fauna also includes 6 genera and 7 species. Unlike the Trolinger Spring I fauna just discussed, however, the Trolinger Spring II fauna reflects only a terrestrial element. This element is composed almost entirely of animals which are, based on known or inferred habits, browsers (*Mammut americanum*, *Sangamona fugitiva*, and *Symbos cavifrons*). The Trolinger

Spring II faunal assemblage is dominated by *Mammut americanum*.

TABLE 27.

The late Pleistocene vertebrate fauna from Trolinger Spring II.

Taxon	No. of Specimens	MNI
Class Mammalia		
Order Insectivora		
Blarina brevicauda	2	1
Order Rodentia		
Peromyscus spp.	2	2
Synaptomys sp.	1	1
Order Proboscidea		
Mammut americanum	323	15
Order Artiodactyla		
Sangamona fugitiva	2	1
Symbos cavifrons	56	4

Jones Spring. The Jones Spring fauna is summarized in Table 28. As with the fauna just discussed, *Mammut americanum* overwhelmingly dominates the Jones Spring fauna which, unlike the preceeding fauna, also contains abundant associated mammoth (*Mammuthus jeffersonii*) remains. The Jones Spring fauna contrasts further in being relatively diverse.

The reptilian fauna contains four genera and as many species and, with the exception of *Terrapene carolina putnami*, modern varieties of which are terrestrial, reflects a decidely aquatic element. This element is also reflected in the avifauna which includes, exclusively, both diving and surface feeding ducks. These forms, together with *Castoroides ohioensis*, the Giant beaver, indicate the presence of permanent and probably relatively extensive open water at the site of deposition.

The mammalian fauna includes 14 genera and 16 species. Seven genera (*Glossotherium, Castoroides, Smilodon, Mammut, Mammuthus, Camelops* and *Symbos* or *Bootherium*) and 11 species (*Glossotherium harlani, Castoroides ohioensis, Smilodon* cf. *floridanus, Mammut americanum, Mammuthus jeffersonii, Equus complicatus, Tapirus veroensis, Camelops* sp., *Bison latifrons, Bison latifrons* and/or *Bison antiquus,* and *Symbos* sp or *Bootherium* sp) are extinct.

Dissociations of skeletal elements

Trolinger Spring I. There were no instances of articulated specimens in the Trolinger Spring I faunal accumulation. The fossils, almost exclusively isolated teeth, occurred dispersed throughout the mixed sands and gravels comprising the conduit complex in Trolinger Spring.

Trolinger Spring II. The Trolinger Spring II fauna occurred both in a bone bed developed in peat as well as dispersed in variegated organic sand or white sand and blue chert gravel of the spring feeder. As for the Trolinger Spring I fauna, there were no instances of articulated skeletal elements in the Trolinger Spring II accumulation. However, while dissociation of the skeletal elements

TABLE 28

The late Pleistocene vertebrate fauna from Jones Spring.

Taxon	No. of Specimens	MNI
Class Reptilia		
Order Chelonia		
Chrysemys scripta	1	1
Terrapene carolina putnami	18	3
cf. *Terrapene carolina putnami*	>150	16
Trionyx sp.	1	1
Order Crocodilia		
Alligator mississipiensis	8	2
Class Aves		
Order Aseriformes		
cf. *Anas carolinensis*	2	1
cf. *Aythya collaris*	1	1
indeterminate duck sp.	1	1
Class Mammalia		
Order Edentata		
Glossotherium harlani	6	1
Order Rodentia		
Geomys sp.	1	1
Castoroides ohioensis	1	1
cf. *Microtus* sp.	1	1
Order Carnivora		
Procyon lotor	1	1
Smilodon cf. *floridanus*	1	1
Order Proboscidea		
Mammut americanum	244	25
Mammuthus jeffersonii	81	12
Order Perrisodactyla		
Equus complicatus	154	10
Equus calobatus or *Equus hemionus*	7	1
Tapirus veroensis	2	1
Order Artiodactyla		
Camelops sp.	17	4
Odocoileus virginianus	3	2
Bison latifrons	36	5
Bison latifrons and/or *Bison antiquus*	50	4
Symbos or *Bootherium*	25	4

was complete, the dispersal of once articulated specimens was highly variable both horizontally and vertically in the Trolinger Spring II sediments.

Two examples can be cited as illustrative of the various degrees of dispersal of previously articulated or associated specimens. Two mandibular rami, representing the left and right halves of a mandible, were broken adjacent to the symphysis and were only slightly dispersed (170TS78, left ramus, Fig. 6; 137TS78, right ramus, Fig. 7). It is apparent from the positions of these specimens on the maps (in separate map volume) that, though the two specimens were nearly in contact, the left ramus had been turned 180° about its long axis relative to the right ramus prior to final burial. Field notebook entries for these specimens indicate that the left ramus occurred only 3 inches (= 76 mm) higher in the sediments (dark brown sandy peat) than the right ramus. Two associated mastodon upper tusks (249TS79, left tusk, Fig. 10; 203TS79, right tusk, Fig. 9) provide an example of more extreme (but not most extreme) dispersal in Trolinger Spring. These two specimens had a least horizontal separation of 4 feet (= 1.2 m), a greatest horizontal separation of 5.3 feet (= 1.6 m) and a mean horizontal sparation of 4.7 feet (= 1.4 m). The left tusk had been rotated 180° horizontally relative to the right tusk prior to final burial. Field notebook entries for these specimens indicate that the left tusk occurred horizontally in white sand of the feeder at a depth of 40.6 inches below site datum. The right tusk occurred with a 6° dip (to the NW) in dark brown sandy, gravelly peat at a depth of 9.25 inches below site datum. Accordingly, these specimens had a vertical separation of 31.35 inches (=0.80 m).

Jones Spring. The Jones Spring fauna occurred in a variety of spring-associated sedimentary matrices. Though complete skeletal dissociation was the rule in Jones Spring fossiliferous deposits several instances of articulated specimens did occur. There were also more numerous examples of once articulated specimens in the very earliest stages of dissociation. The articulated forefoot of a mastodon has already been discussed and figured. This specimen was associated with numerous other closely associated though disarticulated and dissociated remains inferred to be from the same individual. In addition, the closely associated though disarticulated and dissociated remains of a single individual mammoth have been mentioned previously.

The articulated mastodon forefoot (65JS76, Fig. 26), composed of 33 separate elements, occurred in gray clay overlying and compressed into the south edge of the lower peat lens. It occurred in anatomical position with the plantar surface down and indicated locomotion toward the spring's center. As previously mentioned (pp. 60-61, this report) other specimens inferred to have been associated with this forefoot in a single individual include a right upper tusk (109JS76, Fig. 19), left and right maxillae (25BJS76, Fig. 19, and 25AJS76, Fig. 19, respectively), left and right mandibular rami (21JS76, Fig. 19, and 45JS76, Fig. 19, respectively) and other of the specimens illustrated in Figs. 23 through 26 (in separate map volume). It is apparent from Figure 26 and from Figure 19 that the horizontal separation of these cranial, mandibular and forequarter remains measures 5 m (base of right upper tusk to anterior edge of forefoot). Notebook entries for each of these specimens indicate that these associated remains occurred vertically through only 0.6 m of spring associated sediments (2.34 m below excavation pit datum, base of the forefoot--2.94 m below excavation pit datum, right maxillary).

Considered separately the cranial and mandibular portions of this association, including the tusk, had a horizontal separation of 2.5 m (Fig. 19). Notebook entries indicate that these specimens occurred vertically through only 0.11 m of deposit (dark brown sandy gravelly peat adjacent to the feeder sands and gravels). The tusk was oriented N-S with the tip directed to the north, dipping 9° NE. The symphyseal portion of each mandibular ramus was directed to the NNE. The left ramus, partially obscuring (overlying) the right ramus, rested on its lingual surface, dipping 11° NE. The right ramus rested upside down with its long axis dipping 90° NE. The maxillae were in anatomical position with their anterior edges directed toward the south. The long axis of the left maxillary dipped 12° SE while that of the right maxillary dipped 3° SW.

Among the mammoth material from Jones Spring is a tusk (318JS75, Fig. 20), damaged skull (201JS75, Fig. 19) and mandible (338JS75, Fig. 19) assigned with good certainty to a single individual on the basis of the condition of the upper and lower cheek teeth as well as preservation and stratigraphic context. Dissociation of these remains compares with that just discussed for the partial remains of an individual mastodon. From Figures 19 and 20 it is apparent that the greatest horizontal separation of these remains measures 2.5 m (skull border to symphysis of mandible). Notebook entries for these specimens indicate that they occurred vertically through 0.20 m of dominantly dark brown peat (1.97 m below excavation pit datum, top of damaged skull - 2.17 m below excavation pit datum, top of tusk). The tusk occurred horizontally in dark brown sandy peat, with the tip directed toward the south. The skull, damaged by a backhoe during test trenching in 1973, occurred on its occipital bones in dark brown peat with its anterior aspect directed skyward. While orientation and attitude are not precise, the specimen was steeply dipping and resting on its posterior surface. The cheek tooth that remained *in situ* in the skull had a nearly vertical attitude. The mandible had a similar attitude in dark brown peat and gray sandy clay. The specimen occurred on its posterior ramal surfaces, with its symphysis skyward. The ventral border of the mandible was directed to the NE. The specimen's attitude was 74° NE.

Age frequency distributions in *Mammut americanum*

The nature of group organization and behavior in *Mammut americanum* is poorly known. Elsewhere I have suggested that evidence from Boney Spring indicates that mastodons herded together, at least during times of stress (Saunders 1977a). In addition, there is both published (Riggs 1936) and unpublished data from Kendall County, Illinois that supports the view that mastodons herded generally and that herd size was the same as that observed today in living elephants (5-15 individuals, Laws and Parker 1968). Whether or not mastodons were united by family ties and lead by the family matriarch, as are living elephants, is not known.

Trolinger Spring II. Inferred age structure of the Trolinger Spring II mastodon sample has been presented previously as a histogram (Fig. 12) and has been interpreted from point of view of mastodon mortality. From a comparison of this age structure with those in natural herds of African elephants from Murchison Falls, Uganda, it was concluded that a natural herd, organized as in living proboscideans, was not reflected in the Trolinger Spring II mastodon sample. Rather it was concluded from age structure analysis that mortality of mastodons in Trolinger Spring II was probably mixed, containing both attritional and catastrophic components. Mixed mortality can indicate a long duration of faunal accumulation resulting in the accumulation of animals not truly contemporaneous. However, the lack of diversity represented in the Trolinger Spring II fauna argues against this conclusion and suggests instead that a relatively brief interval of accumulation is reflected in the Trolinger Spring II fauna.

Jones Spring. Inferred age structure of the mastodon sample from Jones Spring has been presented previously (Fig. 29) and has been interpreted in regard to mastodon mortality. As was the case for the Trolinger Spring II fauna, it is not possible to explain mortality of mastodons in the Jones Spring fauna as normal attrition of contemporary individuals. Rather, it was concluded that mastodon mortality in Jones Spring was mixed and contained both attritional and catastrophic components. The latter component may have derived principally during the earliest period of mastodon accumulation in Jones Spring when the host alluvium provided a hazardous bottom for animals entering the pond (see the forefoot example under Dissociations of skeletal elements, above). As previously mentioned mixed mortality can indicate a long interval of faunal accumulation that results in the accumulation of animals not truly contemporaneous. This situation is indicated for Jones Spring. This conclusion is supported by the great diversity of taxa represented in the Jones Spring fauna as well as by the previously mentioned independent evidence for floral succession and *Bison* evolution represented by fossils in Jones Spring.

Interpretations from Geological and Biological Frameworks

Interpretation of the local sedimentary environments

C. V. Haynes has conducted stratigraphic analyses in the project area and the interpretations that follow under this heading are primarily his (Haynes 1980).

<u>Trolinger Spring I</u>. The Trolinger Spring I fossil assemblage occurred dispersed in gray and brown clayey, sandy, angular blue chert gravel surrounding the Trolinger Spring feeder (see Trolinger Spring II, below). These gravels are interpreted as a column that had been intruded into the Trolinger Spring host deposits by either stoping action or by injection along a line of weakness in host alluvium (Figs. 2 and 3). As previously noted under the discussion of this fauna, the gravel column is composed of steeply dipping to vertical contacts separating gravels of either different colors and/or grain size. These contacts are interpreted to indicate different episodes of movement during gravel emplacement.

Stratigraphic test trenching during the course of the excavations reported here showed that this gravel column rose from basal gravels underlying the Trolinger Spring host deposits. As such these gravels and contained fossils are appreciably older than the spring-laid deposits containing the Trolinger Spring II fossil assemblage. The Trolinger Spring I fossils could have been incorporated by the gravels from a dark gray organic layer overlying the basal gravels. The occurrence of this deeply buried organic layer was determined during coring adjacent to Trolinger Spring conducted during the early 1970's.

The enigmatic nature of the gravels and the uncertain association of the fossils in this gravel or in the deeply buried organic layer preclude a definitive statement regarding an interpretation of the local sedimentary environment during the accumulation of the Trolinger Spring I fossil assemblage. If this assemblage was brought up by the gravel in the manner proposed above these fossils are, based on stratigraphic considerations, older than the Jones Spring fossil assemblage and would thus date to greater than 49,000 years ago. Alternatively, if these fossils were accumulated during spring development, i.e., at the surface during the stoping and widening or injection period, they may be younger than the Jones Spring fossil assemblage. It can be concluded with certainty that the Trolinger Spring I fossil assemblage is considerably older than the Trolinger Spring II fossil assemblage.

<u>Trolinger Spring II</u>. The majority of the specimens comprising the Trolinger

Spring II fossil assemblage occurred at the base of a dark brown sandy peat lens dating between approximately 29,000 and 34,000 years ago. This peat and contained fossils was overlain by unfossiliferous dark brown clayey peat dating to 20,500 years ago. A variegated layer of peat and white feeder sand lenses occurred between the peat and underlying white sand and fine blue chert gravel filling the feeder. Both the variegated peat and sand and the white sand and fine blue chert gravel of the feeder were fossiliferous and together with the dark brown sandy peat contained the Trolinger Spring II fossil assemblage. All of these spring-laid deposits were buried by overlying gray silty clay (Figs. 2 and 3).

The sand and fine blue chert gravel filling the feeder is the result of artesian discharge through the basal gravels concurrent with the stoping or injection of the gravel column (see Trolinger Spring I, above). At this stage the local sedimentary environment was an open pool of clear water overlying a bed of roily white sand and fine gravel. The borders of this open pool were undoubtedly surrounded by vegetation, including moss and emergent plants in the near-shore shallows. As this vegetation died and decayed, fragments became water-logged and sank to the bottom to become accumulated in near shore areas of quiet water. This formed a raised rim about the pond that broke the wind and trapped aeolian sediment. As discharge decreased, the feeder areas diminished in size and number, roily ceased and quiet water conditions commenced. Vegetation encroached on the inactive areas until eventually a lens of peat covered the entire spring. The much diminished discharge reached the surface through small feeders that penetrated the peat. The final stage in spring history occurred when discharge was reduced to the degree that vegetation no longer accrued as a mat or organic deposit. At this stage overbank flooding by the adjacent Pomme de Terre River began to bury the locality in gray alluvial clay.

Trolinger Spring II fossils were accumulated at all stages during this spring history but their remains were particularly abundant at the base of the peat. The feeder sands and fine blue chert gravels contained specimens that were undoubtedly deposited there originally as well as others probably winnowed from developing peat. The fossils recovered from the variegated peat and sand represent accumulation during an interval of spring fluctuation subsequent to discharge reduction and the cessation of roily conditions.

Jones Spring. The bulk of the Jones Spring fossil assemblage was recovered from the lowest of two peat lenses associated with artesian spring activity. This lowest peat was a lens 15 m in diameter and over 1 m thick. As mentioned previously under faunal discussions, a weak gradational contact between an upper dark brown fine-grained or sandy peat and a lower light brown gravelly peat within this lower peat lens stratigraphically separate two different species of *Bison*. The lower peat was underlain by gray clay of the host alluvium which was also fossiliferous in the zone of contact. The lower peat overlaid a 4 m x 7 m diameter fossiliferous conduit filled with concentric strata of sandy chert gravel. The inner core or feeder consisted of fossiliferous white, well sorted medium sand. The upper peat lens, composed of a very dark brown to black organic clay, overlaid conduit gravels which contained a feeder core and which passed completely through the lower peat lens and were for this reason, at least in part, redeposited from the earlier conduit gravels (Fig. 15). The forceful nature of this intrusion is indicated by small faults in the lower peat where it contacts the conduit gravels. It is interpreted from their abraded conditions that some of the fossils that occurred in this upper peat lens were redeposited from the lower peat lens while others, in a better state of preservation, were contemporaneous with the development of the upper peat.

Jones Spring deposits indicate a local sedimentary environment similar to but earlier than that just interpreted for the Trolinger Spring II fossil assemblage. The succession of artesian spring-associated sedimentary environments began sometime before 49,000 years ago with the development, through stoping or intrusion along a plane of weakness, of a spring-fed pond or open pool, containing a sticky clay bottom and centered about a gravel-filled conduit with a perhaps roily sand feeder. Vegetation developed, died and decayed around the margins of this pond. As discharge was reduced, the vegetation succeeded toward the center of the pond, producing the lower light brown gravelly portion of the lower peat lens. A stratigraphic break within the lower peat lens, though not very pronounced, nevertheless appears to mark a significant faunal and floral change and implies a time break during which peat deposition ceased and during which the previously developed peat weathered. This implies that discharge of the spring was extremely reduced or stopped entirely. After an unknown though appreciable duration there was renewed peat accumulation on top of the previously developed and weathered peat. This renewed deposition, represented by the dark brown fine-grained or sandy portion of the lower peat lens, was presumably in response to renewed spring discharge. Eventually this peat deposition was also interupted as discharge again declined or possibly stopped altogether. Pressure on the underground water system later increased to the point where spring discharge burst through the center of the lower peat lens and swept fossiliferous sand and gravel through it to establish a new conduit with sand-filled feeders discharging at a higher level on the terrace surface. This rejuvenation produced a small spring-fed pond which underwent an independent succession and in which mastodon and other remains accumulated. The final phase of Jones Spring appears to have been a small pond over the upper peat lens that eventually was buried under at least 1 m of alluvium.

Intrasite contemporaneity of spring site fossil assemblages

Trolinger Spring I. It is apparent from the discussion of the Trolinger Spring I fossil assemblage just presented that nothing definitive can be stated regarding the contemporaneity of this sample. As has been previously mentioned, the Trolinger Spring I fauna is a decidedly grazing fauna. That the fauna is not mixed in this regard but is, rather, well intergrated, suggests a temporal /environmental unity of the sample as would be expected to occur in a savanna-steppe environment. This in turn suggests a contemporaneity of the taxa composing the fauna.

Trolinger Spring II. The Trolinger Spring II fauna occurred in a peat lens and underlying white sand and fine blue chert gravel of the spring feeder as well as in intervening variegated peat and sand. The stratigraphic unity of occurrence of the fossil assemblage as well as the sedimentary environment history discussed above indicate a good temporal/environmental unity for the Trolinger Spring II fossil assemblage. This conclusion is supported by the concentration of the fossils near the base of the peat which suggests a relatively brief interval of accumulation for the remains as well as by pollen studies which indicate a stable environment during this interval. In sum, this evidence suggests contemporaneity of the taxa composing the fauna and suggests further that the accumulation of these taxa was restricted within the 29,000 - 34,000 interval indicated by radiocarbon age determinations of the sediments that contained the Trolinger Spring II fauna.

Jones Spring. As stated previously there is indication that fossil accumulation in Jones Spring was punctuated over an appreciable span of time. The occurrence of a stratigraphic contact within the lower peat lens at Jones Spring has been discussed previously. Fossils of *Bison latifrons* occurred below this contact whereas fossils of a form very near *Bison antiquus* occurred only in sediments above this contact. In addition, fossils of *Alligator mississipiensis* occurred only in the basal fossiliferous sediments in Jones Spring. The *Bison* evidence indicates that a temporal hiatus existed between two episodes of faunal accumulation in the lower peat at Jones Spring. Both the *Bison* and *Alligator* evidence indicate a succession of environments during the interval of accumulation of the lower peat lens which in turn indicates a temporal/environmental disunity and noncontemporaneity of taxa in the assemblage as a whole. Independently, a succession of environments is indicated by floral transition, based on the recovery of plant macrofossils of exclusively deciduous species from the base of the lower peat lens that contrast with coniferous pollen recovered from the upper portion of this unit. In sum the evidence bearing most directly on unity and contemporaneity indicate strongly that the Jones Spring fossil assemblage lacked temporal/environmental unity and that the taxa which comprised the assemblage were not truly contemporary.

Formational mode of spring site fossil assemblages

Trolinger Spring I. Little concerning the formational mode of the Trolinger Spring I fossil assemblage can be ascertained from the geological and biological frameworks, both of which are extremely equivocal for this fauna. Cause of death is greatly speculative. The bear was a young individual, based on the slight wear observed on the molar teeth. Of the five mammoths, one individual was mature but younger than the other four. One of the latter was nearing old age, based on wear of left M/3. The *Equus complicatus* sample includes one colt and three mature but not aged individuals, based on eruption and wear of cheek teeth. The teeth assigned to *Equus* cf. *scotti* are worn permanent premolars that indicate two mature but not aged individuals. *Odocoileus* sp. is represented by three fully mature individuals. The *Bison* sample from Trolinger Spring I consisted of one early adolescent and four adult individuals. Two of the adults were late adolescents and the other two were in only early maturity, based on cheek tooth eruption and wear. From these considerations it is apparent that attritional mortality is not reflected exclusively in the Trolinger Spring I fauna and that some catastrophic mortality is indicated.

Because of the equivocal nature of the geological and biological frameworks of the Trolinger Spring I fossil assemblage nothing definitive can be learned regarding decomposition, selective actions in fossil preservation or final burial and biodiagentic events.

Trolinger Spring II. The Trolinger Spring II fauna was dominated by 15 individuals of *Mammut americanum*. Age structure analysis has suggested that mastodon mortality at Trolinger Spring was probably mixed, with both attritional and catastrophic mortalities represented. The occurrence of the bulk of the fossils in a bone bed, and the occurrence of this bone bed near the base of the peat lens argue for rapid accumulation and probably imply a mass mortality for numerous of the individuals represented. Cause of death is not known but probably did not include trapping as no mastodon limb bones were either vertical or articulated in the sediments.

The sedimentary environment indicated for Trolinger Spring during the accumulation of the Trolinger Spring II fauna suggests that decomposition occurred *in situ*. The fossils represent the remains of animals that visited the spring during their normal activities and do not represent remains transported to the locality by fluvial or artesian processes. Animal remains apparently accumulated on the surface of the ground during the early phases of peat formation where they came under the influence of decomposers. After the decomposition of soft tissues but before final burial of the fossil remains in peat other processes combined to disarticulate and disperse the remains. Though undemonstrated in the record these probably included the activities of carnivores and scavengers and perhaps especially the trampling and curosity of other large animals in addition to natural weathering. Final burial of the fossil remains occurred during continued peat deposition.

Jones Spring. The Jones Spring fauna was dominated by 25 individuals of *Mammut americanum*. As was the case for the Trolinger Spring II fauna, age structure analysis has suggested that mastodon mortality was mixed and included both attritional and catastrophic components. This is to be expected given the long duration and episodic nature of faunal accumulation interpreted for Jones Spring. Catastrophic mortality, presumably miring, explains the death of at least one individual mastodon, previously discussed, the partial remains of which occurred both in the lower portion of the lower peat lens and in underlying gray clay. The sedimentary environment interpreted above for Jones Spring during the initial period of spring development and peat deposition apparently included an open pond with a treacherously soft and sticky clay bottom which may have trapped other mastodons, in addition to the individual just mentioned. The cause of death of other mastodons whose dispersed remains occurred in the lower and upper portions of the lower peat lens is not known nor inferrable. As previously mentioned a bone bed was not developed in Jones Spring and thus mass deaths, from whatever cause, are not indicated for Jones Spring mastodons or other animals.

The dark brown upper portion of the lower peat horizon contained the partial remains of a mammoth, including the skull and mandible. These latter specimens had attitudes that suggest a struggle subsequent to miring in peat. In each instance where miring is to be inferred, the animals were represented by associated partial skeletons which is suggestive of rapid burial and independently supportive of the inferred cause of death.

Exclusive of these mastodon and mammoth remains for which miring can be inferred as leading to the cause of death there are few other examples of fossil remains for which a cause of death can be determined. The occurrence of numerous turtle remains has been noted. Several of these occurred as complete carapace and plastron units in the lower peat lens and may have died in dens or burrows. Another such unit occurred squashed and flattened in gray clay of the host alluvium at the south margin of the lower peat lens. The damage to this specimen suggests that it may have been trampled upon, or alternatively, lithostatically distorted. Other remains of turtles found scattered throughout the lower peat lens, and especially those from the lower portion of this lens, may represent *Alligator* prey, as may other animals, e.g. *Castoroides ohioensis*, the Giant beaver, represented in the Jones Spring fauna. The *Tapirus veroensis* remains from Jones Spring represent an extremely aged individual, based on severely worn teeth, that probably died of natural causes at a locality adjacent to food and water.

Decomposition of fossil remains in Jones Spring occurred *in situ*. Many of the plant macrofossils recovered near the base of the lower peat lens are root stock material that leave little doubt that trees grew, died and decayed peripheral to Jones Spring, at least during its earlier history. The fauna represents the remains of animals that either visited the spring during their normal activities or inhabited the locality. They do not represent remains brought to the locality by fluvial or, exclusive perhaps of the remains of insects or small molluscs in the upper peat lens, artesian processes. As previously mentioned, individuals inferred to have been mired are represented by more nearly complete and less dispersed remains presumably due to rapid burial. The scattered nature of most of the remains in Jones Spring suggests decomposition near the surface and their subsequent disarticulation and dispersal by the same selective agents proposed for the Trolinger Spring II fauna. At Jones Spring, however, the role of carnivores in the disarticulation, dispersal and transfer of animal remains is more clearly indicated.

The final burial of the lower peat lens at Jones Spring was by gray alluvial clay deposited by the adjacent Pomme de Terre River. As previously interpreted, subsequent to final burial of the lower peat lens the spring was rejuvenated and burst through the center of the lower peat lens, carrying fossiliferous sand and gravel through it to establish a new spring at a higher level on the ground surface. This rejuvenation formed a spring-fed pond that underwent an independent succession, including peat deposition and the accumulation of faunal remains. Eventually discharge here declined and stopped and the upper peat lens was buried under alluvial clay deposited by the Pomme de Terre River.

PALEOECOLOGY

This section examines the evidence reported above from a paleoecological viewpoint. Recent research has demonstrated that more meaningful conclusions regarding paleoenvironmental reconstruction and paleoecology can be drawn once the data have been analysed from point of view of understanding the processes involved in fossil accumulation and preservation (Behrensmeyer and Hill 1980). This has been the purpose of the preceding section. Because mastodons dominated the fauna from three of the spring sites reported here, a better understanding of this taxon will be especially emphasized in this section.

Paleoenvironmental Overview of Western Missouri

The late Pleistocene faunal and floral record from the project area in western Missouri includes the mid-Wisconsinan interstadial and the late full-glacial periods. A faunal record from the intervening early (= maximum) full-glacial period is not known in the project area though the floral record for this interval is well represented. This fossil record, though punctuated, encompasses much of the last 50,000 years. Figure 37 summarizes the duration of faunal and floral accumulation represented by each of the assemblages discussed in this report.

Mid-Wisconsinan interstadial

Jones Spring (= early mid-Wisconsinan). Radiocarbon age determination of the lower peat unit in Jones Spring indicates it to be >40,000 years old (Haynes 1980). A small *Juniperus* log collected from the basal contact of this unit with underlying gray clay has been dated at 48,900±900 BP (QL-962, Haynes 1980). These dates place the Jones Spring faunal and floral records in the early mid-Wisconsinan interstadial interval.

Only the upper part of the lower peat deposit (i.e., dark brown sandy peat) in Jones Spring contained preserved pollen, the lower portion of this unit (i.e., light brown gravelly peat) did not. Plant macrofossils occurred throughout the fossiliferous deposits, however, and, coupled with the pollen data, permit punctuated paleoecological interpretations.

Seeds from the basal portion of the peat dated at 48,900±900 BP include maple (*Acer*), dogwood (*Cornus* cf. *alternifolia* and *C. florida*), wild plum (*Prunus americana*), wild cherry (*P.* cf. *serotina*), hazel (*Corylus americana*), hawthorne (*Craetaegus* sp.) and hornbeam (*Carpinus carolina*). They indicate a definite temperate deciduous tree component around the spring. Wood macrofossils from this horizon include juniper (*Juniperus* cf. *virginiana*), oak (*Quercus* sp.), maple (*Acer*), honey locust (*Gleditsia* sp.), ash (*Fraxinus* sp.), hickory (*Carya* sp.) and osage orange (*Machura pomifera*).

Pollen recovered from the upper portion of the lower peat unit include 20-30% pine, 10% oak, high percentages of sedge (Cyperaceae), and approximately 5% each of ragweed (*Ambrosia*), grass (Graminae) as well as other composites (King 1973). Relative to the macrofossils from the lower portion of the

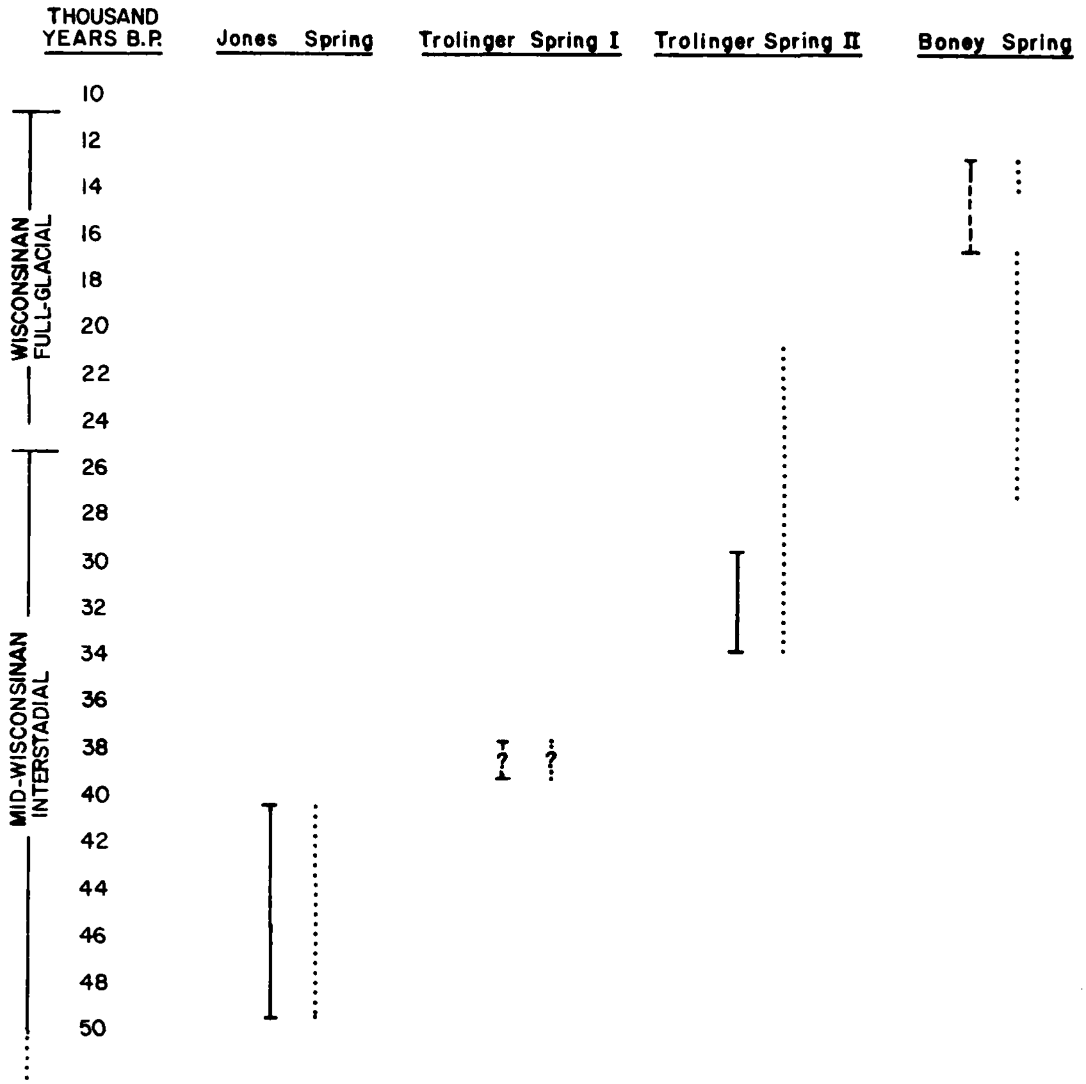

Figure 37. The duration of biological events recorded in reported spring site fossil assemblages from western Missouri. (Solid line = faunal record; dotted line = floral record.)

lower peat unit, these data indicate a cooler climate supporting both deciduous species and pine.

The Jones Spring fauna has already been summarized (Table 28). Though there is some indication of earlier and later periods of fossil accumulation in Jones Spring, distinct, temporally separate faunas can not be demonstrated with certainty based on stratigraphic separation. It is probable that Jones Spring faunal accumulation was punctuated over probably an appreciable interval of time. At the beginning of this interval, at least by 48,900 years ago, deciduous species appear to have dominated the immediate site area, which was succeeded before 40,000 years ago by open pine-parkland. This floral readjustment is interpreted as a response to shifting climatic phases whereby a dryer, warmer climate gave way to a moister, probably appreciably cooler, climate after 48,900 years ago but before 40,000 years ago. Associated with this climatic shift was the disappearance of alligator from western Missouri, the evolutionary transition from *Bison latifrons* to *Bison antiquus* as well as a probable, though undemonstrable, increase in the number of mastodons relative to mammoths in the fauna.

Trolinger Spring I (undated). Trolinger Spring I sediments and fossils are as yet undated. It is inferred from stratigraphy and from finite radiocarbon age determinations relating to Trolinger Spring II sediments and fossils that this earlier fauna and flora dates from prior to 35,000 years ago but subsequent to >40,000 years ago (i.e., post Jones Spring fauna and flora).

Though the Trolinger Spring I fauna lacks mastodon, it does include bear, mammoth, horses, deer and bison (Table 26), all animals representative of savanna-steppe conditions. Fossil wood specimens of deciduous species recovered from these sediments indicate that the spring was surrounded by open woodland or savanna. The known or inferred affinities of the fauna members indicate that savanna-steppe probably dominated the landscape during this interval of time. This fauna may be contemporaneous, in part, with the pollen from adjacent Kirby Spring that indicates deciduous savanna and that is dated at >38,000 years ago (King 1973). In any event, the Trolinger Spring I fauna and flora are younger than the pine-parkland recorded at Jones Spring from shortly after 48,900 years ago to greater than 40,000 years ago but are older than the open pine-parkland recorded by Trolinger Spring II fauna and flora.

Trolinger Spring II (=late mid-Wisconsinan). The late phase of the mid-Wisconsinan interstadial, recorded in sediments containing the Trolinger Spring II fauna and flora, is associated with abundant mastodon remains (Table 27). Pollen and plant macrofossils from these sediments indicate that an open pine-dominated parkland had again developed in western Missouri during this period (King 1973). Radiocarbon age determinations for these sediments and fossils are between 34,300±1200 BP and 29,340±900 BP (Haynes 1980), but the actual accumulation of fossils may have been restricted to a relatively brief period during this interval. The Trolinger Spring II assemblage appears to represent the terminal phase of the cool mid-Wisconsinan interstadial. The Trolinger Spring II fauna represents a browsing assemblage containing mastodon, stilt-legged deer and woodland muskox, all animals presumably occupying an open pine-parkland.

Wisconsinan full-glacial

There are no spring deposit faunas known from the maximum Wisconsinan full-glacial interval (= 25,000 - 16,000 years ago) in western Missouri. For whatever reasons, the faunal record during this interval (and presumably earlier glacial episodes as well) is commonly recovered from sinkholes, fissures and caves, or from other non-spring depositional environments (e.g., colluvial and alluvial valley fill).

The pollen record from western Missouri indicates a dramatic change in vegetation and climate between 25,000 and 20,000 years ago. In pollen records spanning this period from both Trolinger and Boney springs there is an abrupt shift from pine and herbaceous pollen to spruce pollen dominance. Spruce had been essentially absent prior to this time but by about 23,000 years ago it first appears and within a few centimeters of vertical sampling percentages as high as 60 to 90% occur in the sediments of the two springs. This shift from pine and herbs to spruce reflects the climatic shift from cool interstadial to cold full-glacial conditions (King 1973).

The pollen data from both Trolinger and Boney springs indicates that this interval must have been the coldest period during the last 50,000 years in western Missouri. The pollen during this period is dominated almost exclusively by spruce (70-90%) with few other species represented. In the project area, this spruce dominated flora occurred 400 km south of the maximum extent of the Wisconsinan glacial front.

Late full-glacial

Boney Spring. The final accumulation of Pleistocene fauna and associated flora in western Missouri is represented by the Boney Spring fossil assemblage (King 1973; Saunders 1977a). At Boney Spring an extensive bone bed was contained in gray alluvial clay. Immediately below the bones at the base of this unit were wood fragments of spruce and larch, and clumps of moss, the latter probably representing the remnants of an earlier extensive moss mat. In addition to dispersed vertebrate remains, the granular tufa filling the spring feeder, representing primarily calcareous overgrowth on moss (moss in a decayed condition), contained seeds, wood, ostracod tests and insect fragments.

Radiocarbon dates from the Boney Spring bone bed fall into two groups. Four age determinations on spruce wood recovered from immediately below the bone bed are: 16,450±200 BP, 16,580±200 BP, 16,490±290 BP and 16,540±170 BP. Two age determinations on organic debris filling the pulp cavities of two mastodon tusks from the uppermost portion of the bone bed are similarly consistent: 13,700±600 BP and 13,550±400 BP. In addition, a radiocarbon date on moss filling the spring feeder near but below the level of the bone bed is 16,190±400 BP, which establishes moss decay by that time. Taphonomic analysis strongly suggested that faunal accumulation occurred during the latest portion of this interval, i.e., approximately 13,500 years ago during a period of severe drought.

Pollen recovered from dated mastodon tusk pulp cavity fillings is dominated by spruce but include larger amounts of deciduous tree pollen (oak, willow, alder, poplar, elm and ironwood) and lower spruce values (26 to 36%) than occur in the earlier full-glacial pollen section at Trolinger Spring. The Boney Spring fauna is listed in Table 29. The ostracod fauna has a modern aspect and is comparable to present-day faunas of Ozark springs. The insects, with the exception of the possible occurrence of *Olophrum* which is a staphylinid beetle with a present-day boreal distribution, are common to Missouri today. The herpetofauna of 9 genera and 11 species is also modern Missouri in aspect. The mammalian fauna includes 21 genera and 22 species. Three genera (*Glossotherium*, *Castoroides*, and *Mammut*) and five species (*Glossotherium harlani*, *Castoroides ohioensis*, *Mammut americanum*, *Equus* sp.

TABLE 29

The late Pleistocene fauna from Boney Spring, Benton County, Missouri.[1]

Taxon	No. of Specimens	MNI
Class Ostracoda		
Potamocypris smaragdina	200	- -
cf. *Potamocypris illinoisensis*	4	- -
Cypridopsis sp.	50	- -
Candona crogmaniana	35	- -
Candona sigmoides	1	- -
Candona cf. *fluviatillis*	10	- -
Limnocythere reticulata	2	- -
Class Pterygota		
cf. *Pterostichus*	2	- -
indeterminate Dytiscidae	- -	- -
cf. *Helophorous*	- -	- -
cf. *Olophrum*	1	- -
indeterminate Scarabaeidae	- -	- -
indeterminate Curculionidae	2	- -
indeterminate Chrysomelidae	- -	- -
Class Osteichthyes		
indeterminate fish	11	2
Class Amphibia		
Order Anura		
Bufo sp.	10	4
Rana catesbeiana	1	1
Rana sp.	8	2
Order Urodela		
Ambystoma opacum	1	1
Class Reptilia		
Order Squamata		
Eumeces cf. *fasciatus*	1	1
Carphophis amoenus	4	1
Diadophis punctatus	1	1
Lampropeltis triangulum	1	1
Storeria sp.	2	1
Thamnophis proximus or *Thamnophis sauritus*	1	1
Thamnophis sp.	6	1
Class Mammalia		
Order Insectivora		
Blarina brevicauda	28	4
Cryptotis parva	2	2
Scalopus aquaticus	30	2
Order Edentata		

Table 29 (concluded).

Taxon	No. of Specimens	MNI
Glossotherium harlani	87	4
Order Lagomorpha		
Sylvilagus floridanus	1	1
Order Rodentia		
Sciurus cf. *niger*	1	1
Marmota monax	4	1
Tamias striatus	7	2
Glaucomys volans	4	1
Geomys bursarius	4	1
Castoroides ohioensis	3	2
Peromyscus cf. *leucopus*	21	6
Neotoma floridana	3	2
Synaptomys cooperi	5	2
Microtus pennsylvanicus	3	1
Microtus ochrogaster and/or *Microtus pinetorum*	16	4
Microtus sp.	13	- -
Napaeozapus insignis	1	1
Order Carnivora		
Procyon lotor	1	1
Order Proboscidea		
Mammut americanum	717	31
Order Perissodactyla		
Equus sp.	1	1
Tapirus veroensis	5	2
Order Artiodactyla		
Odocoileus sp.	8	1

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[1] data are from Saunders 1977a, and from taxonomic reassessment.

and *Tapirus veroensis*) are extinct. *Napaeozapus insignis* is extant but does not presently occur in Missouri. *Microtus pennsylvanicus* occurs in Missouri today but does not inhabit the Pomme de Terre River valley. In the Pomme de Terre River valley *Synaptomys cooperi* is near the southern limit of its distribution.

In sum, the late Pleistocene fauna of western Missouri 13,500 years ago, as reflected at Boney Spring, had a strong modern aspect. The Boney Spring fauna was associated with the terminal phase of the full-glacial vegetation in Missouri. The complete disappearance of spruce, including refugia, probably occurred within the following 1,000 years. Spruce was gone from central Tennessee by 12,500 years ago (Delcourt 1979) and from northeastern Kansas by 11,300 years ago (Grüger 1973). In its place deciduous forest developed, indicating the development of warm conditions.

Morphological Response to Environment in Wisconsinan Mastodons

Pine versus spruce adapted mastodons

Based upon a study of dentitions from Trolinger Spring compared with those from Boney Spring, I suggested (Saunders 1977a:112-113) that mastodons, although probably preferring a spruce-dominated forest or woodland landscape, nevertheless adapted to a pine-dominated vegetation through selection for a rugged cheek tooth morphology. As noted by Leidy (1869:242) during the last century, two distinct varieties occur as morphological extremes among large series of *Mammut americanum* cheek teeth. A "smooth variety" is distinguished by possessing transverse valleys that are uninterrupted by only weak or moderate cristae or ridges descending from the anterior and posterior faces of the pretrite cusp. The enamel is relatively smooth and the cingula are only weakly to moderately developed. In the "rugged variety" the transverse valleys are interrupted in their bottoms by the juncture of moderately to strongly developed cristae descending from the pretrite cusp. In the extreme condition these cristae descend from the posttrite cusp as well. The walls of the valleys, and the labial and lingual surfaces of the crown as well, bear strong plications producing numerous vertical corrugations of the enamel surface. In addition the enamel is choerodont and the cingula are well developed.

Cheek teeth of *Mammut americanum* from Trolinger Spring are of the "rugged variety," with rugose enamel and generally interrupted valleys (Saunders 1977a:32, 34-35). Additional data obtained during the 1978 and 1979 excavations at Trolinger Spring also support this conclusion. Mastodon cheek teeth from Jones Spring recovered during the excavation program reported here are similar, in general, to those from Trolinger Spring in this regard. They contrast with the "smooth variety" of *M. americanum* cheek teeth from Boney Spring that are characterized by smooth enamel and uninterrupted valleys (Saunders 1977a:54-61). *Mammut americanum* from Trolinger Spring as well as those from the upper portion of the lower peat lens at Jones Spring occupied an open pine-parkland during the late mid-Wisconsinan interstadial. At Boney Spring this taxon occupied a forest of spruce mixed with deciduous species during the Wisconsinan late full-glacial. Mastodon cheek teeth from Trolinger Spring also show greater wear, relative to their progression through the jaws, than do those from the Boney Spring mastodons. Jones Spring specimens have not yet been assessed in this regard. This accelerated wear is apparently due to the more rapid wear of teeth in the mastication of pine or pine-associated plants. This suggests that *Mammut americanum* fared less favorably in an open pine-parkland and that optimum conditions for *M. americanum* in the late Pleistocene were spruce forests or woodlands. This agrees with the assessment of Kurtén and Anderson (1980), although the western Missouri data do not support their view that *Mammut americanum* was morphologically homogeneous in space and time. Rather, the data from western Missouri indicate that *Mammut americanum* adapted to less favorable high pine habitat by natural selection for a more rugged cheek tooth morphology in partial compensation for accelerated wear of teeth in this environment.

Size trends: mid-Wisconsinan versus late-Wisconsinan mastodons

In addition to cheek teeth character, absolute size of teeth also appears to correlate with environment. I have suggested (Saunders 1977a:113) that *Mammut americanum* from deposits correlated with late Wisconsinan stadial conditions in western Missouri were on the average larger than *M. americanum* from deposits correlated with mid-Wisconsinan interstadial conditions. This was concluded on the basis of length and width measurements of cheek teeth in Trolinger Spring and Boney Spring samples, the former having smaller cheek teeth. Measurements of the Jones Spring cheek teeth (M1-M3) indicate they are either smaller than, as small as, or only slightly larger than those from Trolinger Spring. They are definitely smaller than the large molars from Boney Spring. Table 30 presents the size relationships of $M^2/_2$ of *Mammut americanum* from Jones, Trolinger and Boney springs, Missouri. Length and width measurements of $M^2/_2$ are plotted in Figures 38 and 39 and include measurements of mastodon teeth from an additional locality in Missouri (Kimmswick, Jefferson County, eastern Missouri) as well as from a site in the Mississippi River valley of western Tennesee (Nonconnah Creek, Shelby County). Kimmswick is a Clovis culture-mastodon association in eastern Missouri (Graham et al., in press). The artifacts associated with the remains of at least two individual mastodons include several diagnostic fluted projectile points. No organic samples suitable either for radiocarbon dating or paleoenvironmental reconstruction have so far been recovered from the Kimmswick excavations. Elsewhere in North America, Clovis assemblages date to the interval between 11,300 and 11,000 years ago (Saunders 1980) and presumably the mastodons from the Clovis levels at Kimmswick date to this interval as welll. In Shelby County, western Tennessee, along Nonconnah Creek, a tributary to the Mississippi River, pollen and plant macrofossils associated with a mastodon have been dated at 17,195±505 BP (Lackey 1977; Delcourt et al. 1980). I have examined this mastodon and have recorded measurements of the cheek teeth, including the $M^2/$'s. The associated pollen, 75% spruce, 4% pine, 1-2% fir and larch, and 7-16% oak, are interpreted as representing a spruce forest containing deciduous species. This mixed spruce and deciduous forest had occurred there since at least 23,000 years ago and represents a mid-continent full-glacial vegetation considerably south of Wisconsinan glacier ice.

The teeth represented in Table 30 and in Figures 38 and 39 from Jones, Trolinger, and Boney springs were analyzed using t-tests to determine any differences in mean length and width of M2/2. Comparing the size of M2/ in Jones Spring and Boney Spring, the specimens from Jones were an average of 10.7 mm shorter ($t= 5.60$, $P<.001$) and 5.3 mm narrower ($t=3.03$, $P<.01$). The Trolinger sample was also shorter, on the average by 8.2 mm, than the Boney specimens ($t=2.90$, $p<.01$); there was, however, no significant difference in the width of Trolinger and Boney M2/. The mean length and width of M2/ did not differ in the Jones and Trolinger samples.

In general, the M/2 demonstrate a pattern similar to the upper teeth. Jones Spring specimens were shorter by an average of 6.8 mm ($t= 2.95$, $P<.01$) and narrower by an average of 4.1 mm ($t= 2.90$, $p<.01$) than those from Boney Spring. The Trolinger sample was also smaller than the Boney sample by 6.2 mm in length and 3.7 mm in width; these differences are, however, less significant ($t= 2.37$ and 2.38, respectively; both $p<.05$). As with the upper teeth, the M/2 from Jones and Trolinger springs did not differ in either length or width.

The trends in the data, Table 30 and Figures 38 and 39, can be summarised as follows: 1) differences in means of length and width of M2/2 between mid-Wisconsinan *Mammut americanum* samples (Jones Spring and Trolinger Spring II) are not significant, and 2) mastodons from the mid-Wisconsinan interval were significantly smaller, based on means of M2/2 lengths and M/2 width, than those from the full-glacial (Boney Spring). Furthermore, although sample sizes do not compare and are inadequate, there is some

TABLE 30

Comparison of metrical data[1] on mid-Wisconsinan and late Wisconsinan *Mammut americanum* from western Missouri. Measurements are in millimeters.

	mid-Wisconsinan		late Wisconsinan
	early	late	
	Jones Spring	Trolinger Spring	Boney Spring
M2/ length			
n	28	8	34
OR	102-132	106-124	110-137
$\bar{x}$	112.5	115.0	123.2
s	8.1	6.3	7.4
CV	7.2	5.5	1.3
M2/ width			
n	28	8	34
OR	79-105	84- 96	83-104
$\bar{x}$	88.0	90.8	93.3
s	7.7	3.9	6.1
CV	8.8	4.3	6.5
M/2 length			
n	16	13	37
OR	105-127	101-124	101-135
$\bar{x}$	113.3	113.9	120.1
s	6.8	8.2	8.0
CV	6.0	7.2	6.7
M/2 width			
n	16	13	37
OR	78- 94	79- 95	81- 99
$\bar{x}$	85.1	85.5	89.2
s	5.3	5.7	4.4
CV	6.2	6.6	5.0

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[1] Measurements and statistics:
n, number of specimens
OR, observed range
$\bar{x}$, mean
s, standard deviation
CV, coefficient of variation

indication that 1) mastodons of the Wisconsinan maximum full-glacial (Nonconnah Creek, Tennessee) were larger than mid-Wisconsinan mastodons and fit well within the size limits of the Boney Spring mastodons; and 2) mastodons from the late-glacial (Kimmswick Clovis levels, Missouri) were as small as mid-Wisconsinan mastodons. These data suggest that mid-continent mastodons were of a relatively constant size during the mid-Wisconsinan interstadial, and that they increased in size during the full-glacial and that they may have begun decreasing in size in the late-glacial. It was during this latter trend that the mastodons became extinct. A similar trend, based on forelimb stature, has been suggested by Heintz and Garutt (1965), on the basis of

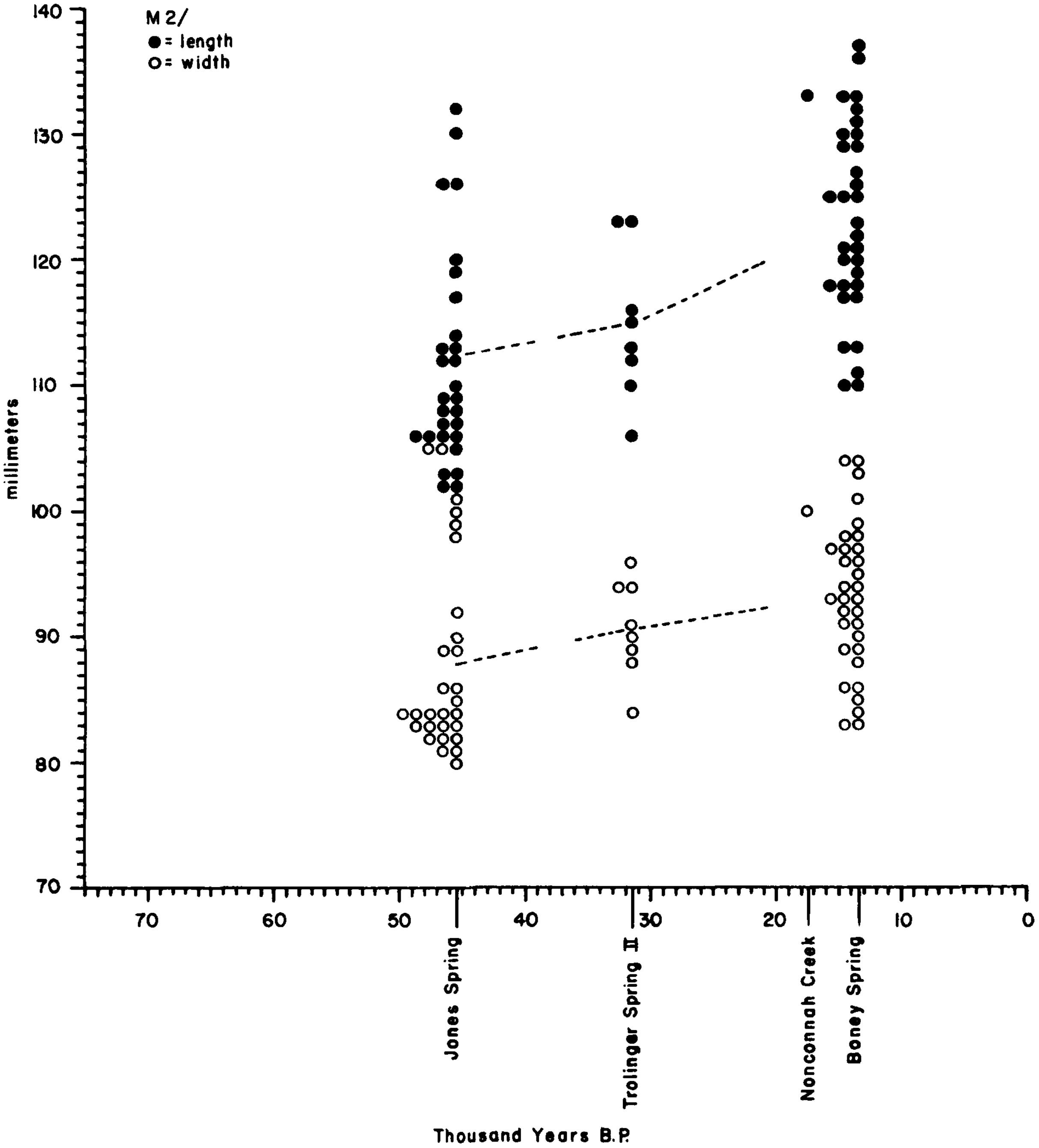

Figure 38. Length and width measurements of M2/'s of *Mammut americanum* from western Missouri and western Tennessee. The dashed line shows the direction of overall trends in average size of teeth.

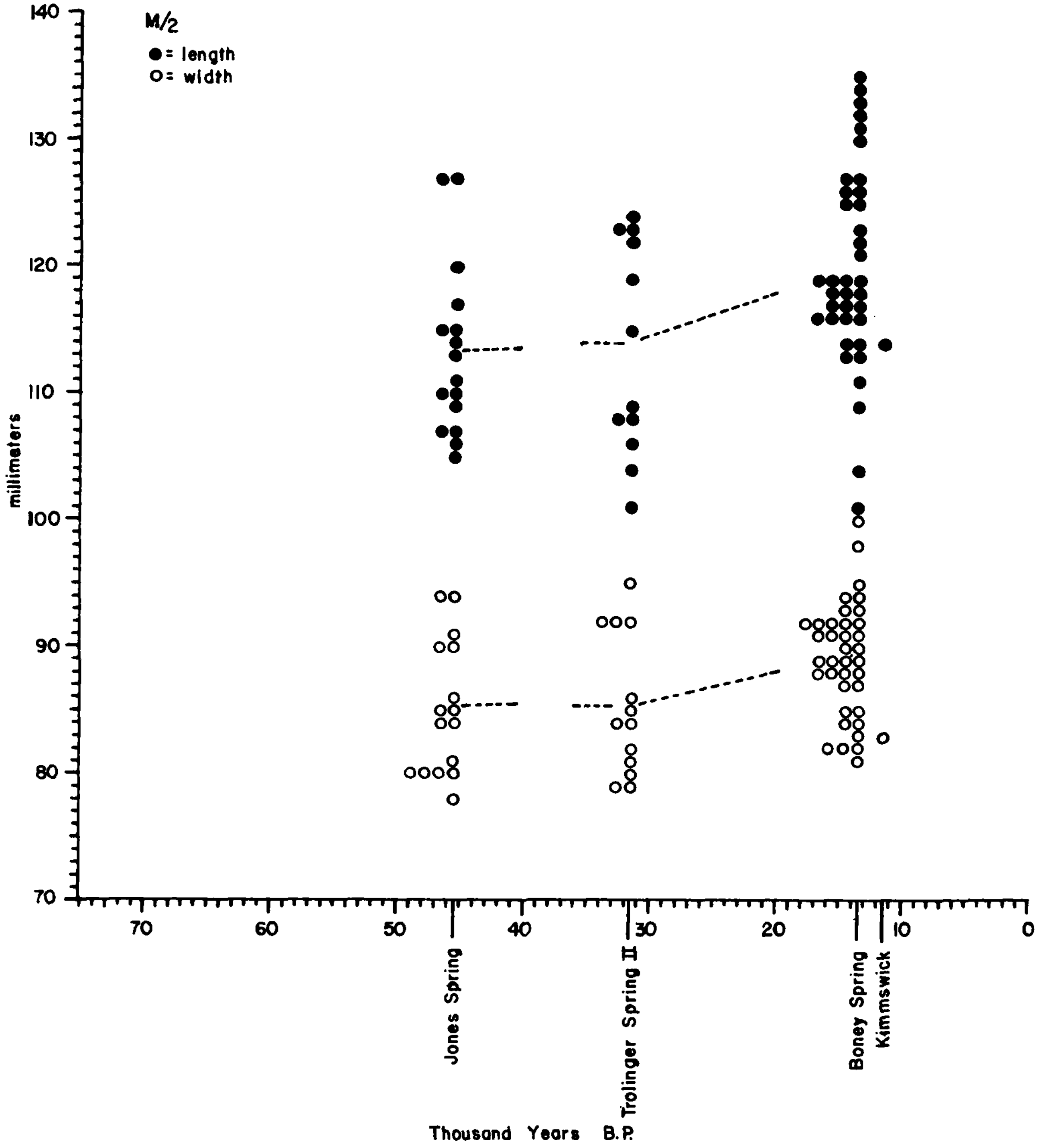

Figure 39. Length and width measurements of M/2's of *Mammut americanum* from western and eastern Missouri. The dashed line shows the direction of overall trends in average size of teeth.

small sample size (n=6), for Siberian mammoths (*Mammuthus primigenius*) during this same dated interval: 47,500 - 11,200 years ago. They interpret this trend as a morphological response of mammoths to favorable (large size) and less favorable (small size) environments. The same relationship exists in the data on mid-continent mastodons. Mid-Wisconsinan mastodons associated with pine-parkland possessed rugged cheek teeth and were small whereas later mastodons associated with Wisconsinan full-glacial spruce forest had smooth cheek teeth and were large. In addition, there is the suggestion that mastodons during the terminal late-glacial to early post-glacial interval were again trending toward smaller size.

Sample Trends: Mid-Wisconsinan versus Late-Wisconsinan Mastodons

Mid-Wisconsinan

Data pertaining to mid-Wisconsinan mastodon sample trends from western Missouri are primarily age structures inferred for mastodons in Jones and Trolinger springs. I have (Saunders 1977a), following the method of Laws (1966) for African elephants, assigned discrete ages to individual mastodons in the western Missouri record based on the eruption and progression of cheek teeth through the lower jaw (Saunders 1977a:Table 16 and Figure 31 for Boney Spring; this report, Figs. 12 and 30 for Trolinger Spring and Jones Spring). These ages, in African-equivalent years (AEY), are summarized as histograms in Figure 40.

Regarding the mid-Wisconsinan record, there was close agreement in mean inferred age of the Jones and Trolinger springs samples (25.4 and 24.8 AEY, respectively). Recruitment, or the percentage of suckling individuals inferred in the sample (= those through 3 AEY, Sikes 1971:169-170) was 12% in the Jones Spring sample and 13% in the Trolinger Spring sample. The percentage of immature individuals in the samples (= those less than 15 AEY) was 36% for Jones Spring but fell to 23% for Trolinger Spring. Finally, prime individuals (= those 25 through 39 AEY, a period during the life span marked by the first appearance of wear on the erupting M/3 and continuing until M/2 is eliminated) comprised 44% of the Jones Spring sample and 47% of the Trolinger Spring sample.

Late-Wisconsinan

The Boney Spring fossil assemblage contains the only large sample of late-Wisconsinan *Mammut americanum* known from western Missouri. The mean inferred age calculated for this sample was 25.7 AEY. Recruitment was 3%. Immature individuals comprised 27% of the sample while those individuals in their prime comprised 53% of the sample.

Table 31 summarizes individual inferred age data for mid-Wisconsinan and late-Wisconsinan *Mammut americanum* from western Missouri. Unexpectedly, the mean inferred age indicated for each sample was very similar. Recruitment indicated for mid-Wisconsinan samples was constant but fell appreciably in the late-Wisconsinan sample. The percentage of immature individuals was high in the earlier mid-Wisconsinan sample, fell appreciably in the later mid-Wisconsinan sample and then rose slightly in the late-Wisconsinan sample. The percentage of prime individuals in the samples from the mid-Wisconsinan showed a slight increase in the later sample, compared to the earlier, and then increased appreciably in the late-Wisconsinan sample. The most interesting trend in the data regards mortality. While

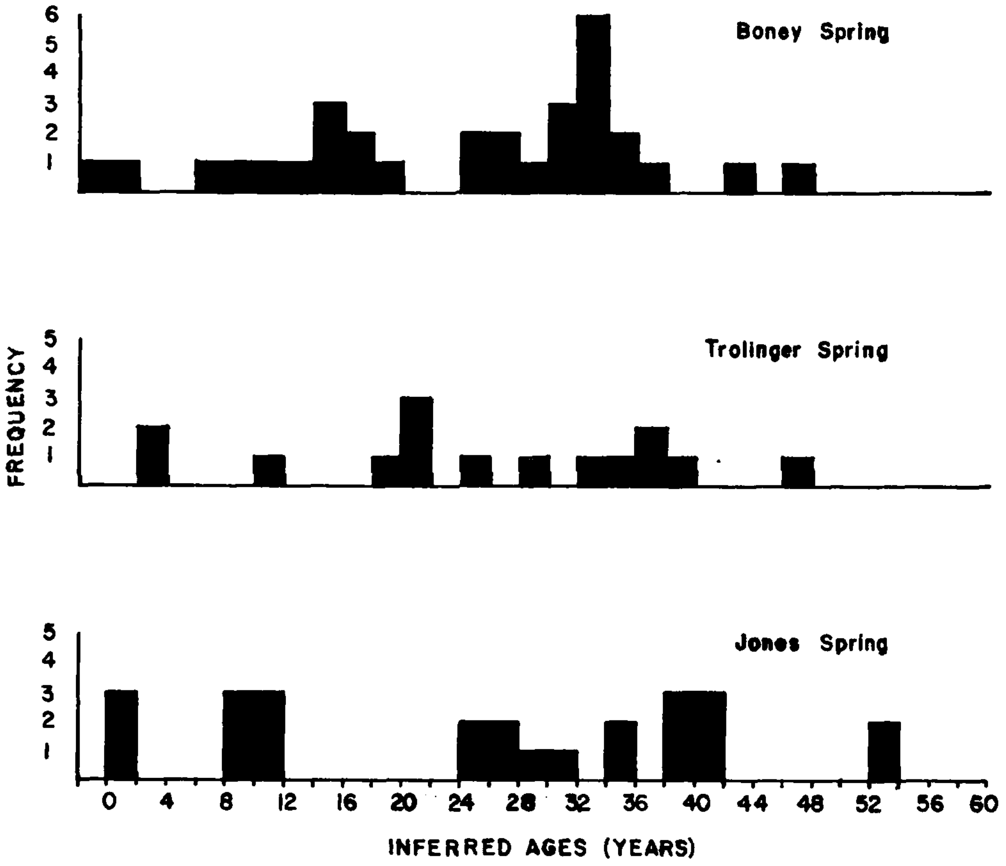

Figure 40. Summary histograms of inferred age structure of *Mammut americanum* from western Missouri spring site fossil assemblages.

the mean inferred age for each sample was similar, there was nevertheless a probably significant increase in the number of prime individuals in the late-Wisconsinan sample relative to their proportions in the mid-Wisconsinan samples. Indication of decreased recruitment during the late-Wisconsinan is also probably significant.

TABLE 31

Comparison of individual age data[1] on mid-Wisconsinan and late-Wisconsinan *Mammut americanum* from western Missouri.

	mid-Wisconsinan		late Wisconsinan
	early	late	
	Jones Spring	Trolinger Spring	Boney Spring
Sample size	25	15	30[2]
Mean age (AEY)	25.4	24.8	25.7
% recruitment	12%	13%	3%
% immatures	36%	23%	27%
% prime	44%	47%	53%

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[1] as explained in the text.

[2] although there are 31 individuals represented in the Boney Spring sample, one is a foetus and is not included in the calculations.

These trends in the western Missouri record are interpreted to be evidence of mastodons in poor condition in the late-Wisconsinan by 13,500 years ago, relative to their good or better condition indicated for the mid-Wisconsinan interval. The increase in the proportion of prime individuals entering the fossil record during the late-Wisconsinan appears to have been a direct consequence of the disruption and disappearance of coniferous habitat. As the coniferous habitat was collapsing, it appears from the Boney Spring data that mastodons were undergoing self-regulation, evidenced by low recruitment and high modal age class analogous to the African evidence (Laws and Parker 1968), during a time of environmental stress (Saunders 1977a). Because a more mastodon-favoring environment failed to return to western Missouri after 13,500 years ago, this self-regulation was in vain, and mastodons became locally extinct.

Man is not associated with mastodons at Boney Spring. Previously suggested evidence for such associations in the project area are, upon close examination, either 1) younger artifacts secondarily intruded into older, mastodon-containing, sedimentary units or 2) geofacts, i.e., angular chert pebbles chipped by natural means during sedimentary transport or subsequent spring activity. Thus, man does not currently enter the discussion of the disappearance of the mastodon, and other animals, from western Missouri. Rather, it is strongly suggested by the foregoing discussion that mastodons disappeared from western Missouri during a period of environmental stress 13,500 years ago, presumably caused by locally severe drought.

CONCLUSIONS

1. The following taxa, reported here for the first time, are new additions to the known Pleistocene fauna of Missouri: *Trionyx* sp., *Alligator mississipiensis*, *Equus* cf. *scotti*, *Equus calobatus* or *E. hemionus*, and *Bison latifrons*. Fossils of *Terrapene carolina putnami* first recovered at Jones Spring in 1975 have been previously published but represent the first record of this extinct variety of large box turtle known from Missouri as well as the northernmost occurrence of this variety known in North America. In addition, samples of *Mammuthus jeffersonii*, which has been provisionally recognized previously in the Pleistocene fauna of Missouri, from both the Trolinger Spring I and Jones Spring fossil assemblages reported here are large and complete and allow for certain identification of this species. An antler fragment from the Trolinger Spring II fossil assemblage is unique and is provisionally referred here to *Sangamona fugitiva*, antlers for which are unknown.

2. Each of the faunas reported here occurred in a sequence of spring-associated deposits consisting of conduit clayey, sandy gravels (Trolinger Spring I), peat and spring feeder sands and fine gravels (Trolinger Spring II) or these in addition to conduit clayey, sandy gravels (Jones Spring) or in alluvial clay filling a spring depression (Boney Spring). In addition, the occurrence of fossils in host alluvium peripheral to major concentrations in spring-laid sediments has been noted for the Trolinger Spring I and Jones Spring fossil assemblages. The Trolinger Spring I and Trolinger Spring II fossil assemblages each occurred in three strata, the former dispersed throughout gray sandy gravel and brown sandy gravel in addition to gray clay and the latter both concentrated in a bone bed in peat as well as dispersed in peat, variegated organic sand and underlying feeder sands and five gravels. The Jones Spring fossil assemblage was dispersed throughout fine strata, including gray clay, conduit clayey, sandy gravels, feeder sands and fine gravels and two peat lenses. The Boney Spring fauna occurred in two strata, including a bone bed in an alluvium filled spring depression that overlaid a feeder filled with granular tufa that contained dispersed wood fragments as well as the remains of both invertebrate and vertebrate animals.

3. Each of the fossil assemblages contained in these spring sites was buried when first encountered. The peat lens that contained the Trolinger Spring II fossil assemblage was encountered 2 m below the present day surface. The sediments that contained the Trolinger Spring I fossil assemblage occurred beneath or lateral to those that contained the Trolinger Spring II fossils. The upper peat lens in Jones Spring occurred approximately 1 m below the present day surface; the lower peat lens, that contained the bulk of the specimens recovered at this locality, was encountered approximately 3.2 m below the present day surface in the same test trench. The top of the Boney Spring bone bed occurred 4 m below the present day surface; it represents the most deeply buried fossil assemblage considered here.

4. The sedimentary body that contained the major portion of each of the fossil accumulations reported here, exclusive of the Trolinger Spring I fossil assemblage, was lenticular in cross section and roughly to nearly circular in plan. The diameter of the fossil accumulations varied from 8.5 m (Trolinger Spring II) to 16 m (Jones Spring). The maximum thickness of each accumulation occurred near its center and varied from approximately 1 m (Boney Spring) to 5 m (Jones Spring).

5. The fossils that comprised the bone beds in Trolinger Spring II and

Boney Spring occurred like "logs in a jam." In both of these accumulations specimens rested directly on one another and the matrix was usually restricted to thin seams between fossil specimens. The specimens in the Jones Spring and Trolinger Spring I fossil assemblages were dispersed throughout the fossiliferous sediments and no bone beds were developed. The specimens usually occurred as isolated elements variably separated from one another like "raisins in a pudding," in contrast with those that comprised the Trolinger Spring II and Boney Spring bone beds.

6. Polar co-ordinate plots of specimen long axes show that specimens in spring site fossil assemblages lacked a preferred orientation. They also show that specimens in the Trolinger Spring II and Boney Spring bone beds had a similar preferred attitude ($\leq 12^{\circ}$) while those dispersed in the Trolinger Spring I and Jones Spring fossil assemblages did not.

7. With the exception of the Trolinger Spring I fossil assemblage mastodons dominated the faunas reported here which also contained fossils of other large vertebrate taxa but generally lacked the remains of small vertebrates. The remains of 71 mastodon individuals have been recovered from the localities reported here, including Boney Spring. The Trolinger Spring I fauna contained no mastodon fossils but mammoth remains were recovered in some abundance. The Jones Spring fauna contained the remains of both mastodons and mammoth but mastodons dominated in terms of the number of individuals represented. Differences in faunal compositions among the spring site fossil assemblages reported here reflect both varying climates and faunal evolution.

8. In general, dissociation of skeletal remains in spring site fossil assemblages was complete. There were no articulated remains recovered in either Trolinger Spring fossil assemblage. An articulated mastodon forefoot was recovered in Jones Spring which contained no other specimens in actual articulation. Three instances of articulated mastodon specimens have previously been noted in the Boney Spring bone bed. The factors causing the dissociation and dispersal of skeletal remains are many and variable and include, for spring site fossil assemblages, the activities of carnivores, scavengers and decomposers among others and perhaps especially the trampling and curiosity of other large animals in addition to natural weathering.

9. Mastodon age frequency distributions in spring site fossil assemblages are quite variable and reflect differences in mortality, population age structures and duration of faunal accumulation. Few generalizations concerning age frequency distributions for mastodons in spring site fossil assemblages are possible and each must be interpreted separately within the constraints imposed by an understanding of the geological framework.

10. The late Pleistocene faunal and floral records from the project area in western Missouri, though punctuated, include much of the last 50,000 years. The early and late portions of the mid-Wisconsinan interstadial and the late (= waning) portion of the late Wisconsinan full-glacial are well represented by fauna and flora. A faunal record from the intervening early (= maximum) late Wisconsinan full-glacial period is not known from the project area but a floral record for this interval is well represented at Trolinger and Boney springs.

11. Mastodons inhabited coniferous forests of spruce as well as pine in the project area in western Missouri but had discrete morphological adaptations to each. Previous adaptation to pine (Jones Spring, Trolinger Spring II) occurred over a long period of time and included general small size and more rugged cheek teeth to compensate for accelerated wear. Sub-

sequent adaptation to spruce (Boney Spring) included increasing size and less rugged teeth.

12. The terminal late-Wisconsinan mastodon sample from Boney Spring (MNI=31) included a higher proportion of prime individuals than did samples from the early and late mid-Wisconsinan at Jones Spring (MNI=25) and Trolinger Spring II (MNI=15), respectively. This suggests that self-regulation was occurring through time in western Missouri mastodon populations.

13. From point of view of mastodon habitats, adaptive morphologies and strategies, and sample trends in the project area in western Missouri, an environmental insularity hypothesis explains the extinction of *Mammut americanum*. The samples from the Jones Spring, Trolinger Spring II and Boney Spring fossil assemblages were temporally discrete microcosms of western Missouri mastodon populations generally. The extinction of *Mammut americanum* in western Missouri, and probably geographically more broadly as well, was the consequence of unsuccessful self-regulation within the rapidly changing climate and vegetation that occurred during the terminal late-Wisconsinan.

14. Man was not associated with mastodons in the project area in western Missouri. Previously suggested evidences for this association in the project area are, upon close examination, either 1) younger artifacts secondarily intruded into older, mastodon-containing sediments or 2) geofacts, i.e., angular chert pebbles chipped by natural means during sedimentary transport or subsequent spring activity.

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APPENDIX A

Scope of Work

Contract No. DACW41-77-C-0096

APPENDIX A

This Appendix A supplements ARTICLE 1 of the contract and delineates the services to be performed by the Contractor under this contract.

1. Introduction

a. The Government currently is engaged in construction of the Harry S. Truman Dam and Reservoir project. The reservoir will have a surface area of 55,600 acres at multipurpose pool elevation. The project area contains significant paleontological resources. To date there have been two surveys for spring sites containing such resources. These surveys have revealed a total of six sites containing significant deposits. The work defined herein to be performed by the Contractor will involve excavation at three spring sites and analysis of the materials recovered.

b. The work defined herein is authorized for funding under Public Law 86-523 as amended by Public Law 93-291.

2. Scope

a. This study encompasses the scientific excavation of three Pleistocene spring bog sites within the Pomme de Terre arm of the project. These sites are Boney Spring, Jones Spring, and Trolinger Spring. Selection of sites was made following an analysis of the materials recovered from surveys to date. This study also encompasses the scientific analysis and data presentation of the recovered materials.

b. The Contractor shall conduct this study in a professional manner and shall utilize those avenues prescribed to conduct the excavation and analysis. The area of concern shall be the Pomme de Terre arm of the project. The Contractor shall prepare a report of findings as described in paragraph 6.

3. Coordination

a. The Contractor shall attend meetings of the Western Ozarks Research Consortium (WORC) to insure coordination with the cultural resources work being conducted by others in the same area.

b. Prior to initiation of actual field work the Contractor shall coordinate all field schedules and activities with the appropriate project cultural resources coordinator.

4. Study Approach: The work to be performed by the Contractor shall be closely coordinated with the Contracting Officer or his representative. The Contractor shall perform the following activities as requirements of the study.

a. Problem orientation: The Pomme de Terre River valley in southern Benton and northern Hickory counties, Missouri, remains the most paleontologically significant region in the project area. Concentrated multidisciplinary endeavors since 1967 have revealed that four bone beds developed within late Pleistocene spring deposits containing macrofloral, pollen-floral and provisionally artifactual materials, in addition to abundant diverse magafaunal remains. Hypotheses and conclusions currently being generated have, as an initial approximation, geologically and biologically characterized these as low energy, intermittent spring environments (Haynes, 1976; King, 1973; Saunders, 1975). Springs as sedimentary environments have not received prior attention and those on the lower Pomme de Terre River can provide the basis for initial understanding. Further refinement of initial approximation requires complete recovery and analysis of the late Pleistocene records from already well sampled spring sites. Therefore, further work at the below mentioned springs is required.

(1) Boney Spring—Recovery of materials from this spring shall be directed toward (a) comparison of full-glacial Wisconsinan fauna and flora with those more numerous fauna and flora from earlier, or later nonglacial, Wisconsinan context; (b) resolution of the man/mastodon association in the project area and; (c) further resolution and refinement of the stratigraphic framework in this part of the project area.

(2) Jones Spring—All work will be directed toward a better understanding of the ecological flexibility of each fossil taxon, particularly the mammoth and mastodon. In addition, work shall provide the populational variation for taxonomic determination of Mammuthus in Missouri.

(3) Trolinger Spring—All work shall be directed toward a complete recovery of the late Pleistocene record and provide for comparison with spatially adjacent but temporally removed Jones Spring.

With these questions/problems in mind, the Contractor shall, in consultation with the Government, prepare a written research design outlining the methods to be used to test the hypotheses generated by the problems stated.

b. Methodology: In general, the Contractor shall employ methods that insure full, clear, and accurate descriptions of all field operations and observations, including excavation and recording techniques, stratigraphic and/or associational relationships where appropriate, and significant environmental relationships, etc. Specifically, the Contractor shall perform the following activities and those outlined in the prepared resea[illegible] design:

(1) Photograph all phases of excavation.

(2) Prepare maps showing stratigraphic and provenience relationships.

(3) Perform all measurements using the metric system.

(4) Process, catalog, and curate all materials.

(5) Collect and analyze sufficient material to provide supportive data for discussion of the problems presented in paragraph 4.a, above.

(6) Compare all data with that being presented by the Western Ozarks Research Consortium (WORC) to insure proper coordination of information within the Osage River basin.

c. Ancillary studies: The Contractor shall provide for the following related disciplines at a level consistent with those studies currently underway:

(1) Palynology/Paleobotany

(2) Geomorphology

(3) Alluvial Geology

(4) Paleoecology

d. References cited:

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1975 "Late Pleistocene Mammals of the Western Missouri Ozark Highlands." Ph. D. Dissertation, University of Arizona, Tucson. 245 pp.

e. Staff and facility requirements

(1) Project Director. The person in charge of this project must have a doctorate degree in paleontology and a publication record that demonstrates experience in field project formulation, execution, and technical monograph reporting.

(2) Paleontologist (Vertebrate). The minimum formal qualifications for individuals practicing paleontology as a profession are a B.A. or B.Sc. degree from an accredited college or university, followed by two years of graduate study with concentration in vertebrate paleontology and at least two summer field schools or equivalent under the supervision of paleontologists of recognized competence. A master's thesis or its equivalent in research and publications is highly recommended, as is the Ph. D. degree.

(3) Standards for Consultants. Personnel hired or subcontracted for their special knowledge and expertise must carry academic and experiential qualifications in their own fields of competence.

(4) Institutional or Corporation Qualification. The Contractor must provide. or demonstrate access to the following capabilities:

(a) Adequate permanent field and laboratory equipment necessary to conduct operations defined in the scope of work. However, this qualification may be waived under circumstances of extreme need through negotiation.

(b) Adequate laboratory and office space and facilities for proper treatment, analysis, and storage of specimens likely to be obtained from the project. This does not necessarily include such specialized facilities as pollen, geochemical, or radiological laboratories, but does include facilities sufficient to properly preserve or stabilize specimens for any subsequent specialized analysis.

f. Collections: The collections shall be stored in containers clearly marked "Property of the U.S. Government, Corps of Engineers, Kansas City District." These materials may be stored at the contracting firm's laboratories for use in future studies or at a repository agreed upon by the Corps, the Contractor, and the Missouri State Historic Preservation Officer. Retrieval of these materials by the U.S. Army Corps of Engineers for use by them is reserved. If materials are to be removed from the agreed upon facilities, this action must be previously approved by the Contracting Officer or his representative.

g. Court Action: In the event of controversy or court challenge, the principal investigator(s) (that person(s) responsible for the validity of the material presented in the report) shall testify on behalf of the Government in support of the report findings.

h. Modifications: Because of the complex nature of the resources being excavated, it is recognized that situations may arise or data may be encountered that was not anticipated in the design of this study. If such a situation should develop, and as a result it appears that additional scientific excavation should be performed in order to complete the work within the scope of this contract, the Contracting Officer shall be notified. If the Contracting Officer concurs, he will initiate negotiations with the Contractor concerning the work to be added to the contract and the cost thereof; and if negotiations are successful, the contract will be modified pursuant to the provisions of Article 2, CHANGES, of the contract. Any modification of this nature must be justified and should be clearly within the purview of the legislation under which this study is authorized and funded.

i. The Contractor shall provide a safe working environment for all persons in his employ as prescribed by EM 385-1-1, "General Safety Requirements."

5. Availability of Data:

a. It is intended that the Contractor shall conduct all necessary review of literature, Governmental reports, and other sources of information in the depth required for a comprehensive coverage of the study. The Contractor is expected to accumulate, develop and interpret all needed scientific and technological information and data.

b. The Government will provide the Contractor with available background maps, remotely sensed data, files, reports, and correspondence as needed. In addition, the Government will provide support to the Contractor regarding suggestions on data sources, format of study outline and report, and review of study progress.

c. The Government will furnish the right-of-entry to all Government owned property associated with the Harry S. Truman project.

d. The Government will provide surplus equipment from surplus depots in Missouri that might otherwise have to be rented or contracted for a short period of time. This equipment shall be picked up and returned to the Government after the completion of the study by the Contractor. The Contractor shall be responsible for the maintenance needs of any Government-owned equipment.

6. Schedule of Work:

a. The Contractor shall pursue the study in a professional manner to meet the schedule specified. During the course of the study, the Contractor shall submit a monthly progress report. In addition, the Contractor shall review the progress of the work performed for both the Corps of Engineers and the profession at meetings scheduled as follows:

(1) Periodic WORC meetings;

(2) Monthly coordination meetings with the Corps during the field season at the field headquarters;

(3) Bi-monthly coordination meetings with the Corps during the laboratory and analysis period at the Contractor's facilities; and,

(4) One professional meeting a year. The purpose of attending these meetings shall be for presentation of methods and results to the profession for their critical review and evaluation. Prior to presentation of any paper concerning the work described herein during the term of the contract, the Corps shall be afforded the opportunity to review an outline of the anticipated presentation.

b. Thirteen (13) copies of the draft of a report of findings, together with five (5) copies of background data, shall be submitted to the Government for the purpose of peer and Governmental review within 36 months after receipt of the notice to proceed. (If excessive inclement weather or other delays are incurred, this date may be extended to one mutually agreed upon between the Contracting Officer and the Contractor).

c. Sixty (60) calendar days after the return of the draft report by th[illegible] Government, the Contractor shall submit one set of originals of the final report of findings and the background materials. The Government will reproduce the report of findings and provide the Contractor ten (10) copies plus one copy for each individual associated with the project for their personal use. The report shall be in a format suitable for publication. In addition, the report shall conform to the following standards:

(1) Typed on paper measuring 8 x 10-½ inches, except for foldout maps, charts, or other illustrative material.

(2) Text and line drawings shall be clean, clear, and easily reproducible.

(3) Photographs shall be original black and white positive prints, or high-quality reproductions.

(4) Typescript shall be single spaced.

(5) All pages shall be numbered in sequence.

(6) Form NTIS-35, available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22161 shall be inclosed with each volume of the report.

d. The report shall contain the following:

(1) Discussion of the collection, to include the following:

(a) Description of taxa.

(b) Abundance.

(c) Description of habitat.

(d) Discussion/comparison with other collections.

(2) Maps as previously described.

(3) A discussion of each site inspected.

(4) A discussion of each of the problems stated in paragraph 4.a., above.

(5) Copies of all correspondence pertaining to the review of the draft report. These are to include the comments of the Missouri State Historic Preservation Officer, National Park Service, and at least 3 reviews by professional paleontologists not associated with a Governmental agency together with responses to each of the comments given.

(6) Recommendations for material preservation and interpretation.

(7) An abstract not exceeding 250 words authored by the project director/principal investigator. (If the project director is not the principal investigator, then the abstract and a review of the report shall be authored by the project director and included as a preface to the report).

(8) A glossary of technical terms.

(9) A review of references utilized in the background research.

(10) A statement of the problem orientation and the research design used in directing the work.

(11) A discussion of the field methods.

(12) A discussion of the laboratory methods.

(13) A description of the results of the analysis.

(14) An evaluation of the resources examined.

(15) A Certificate of Authenticity from a recognized expert not employed by the Contractor, attesting to the validity of the materials recovered, shall be attached to the letter of transmittal for the final report.

(16) A lengthy summary written in a style suitable for reading by persons not professionally trained as paleontolcgists shall be included as a separate report.