34359

National Library of Canada | Bibliothèque nationale du Canada

CANADIAN THESES ON MICROFICHE | ***THÈSES CANADIENNES SUR MICROFICHE***

NAME OF AUTHOR/*NOM DE L'AUTEUR* CHARLES RICHARD HARINGTON

TITLE OF THESIS/*TITRE DE LA THÈSE* "PLEISTOCENE MAMMALS OF THE YUKON TERRITORY"

UNIVERSITY/*UNIVERSITÉ* UNIVERSITY OF ALBERTA

DEGREE FOR WHICH THESIS WAS PRESENTED/*GRADE POUR LEQUEL CETTE THÈSE FUT PRÉSENTÉE* Ph. D. (ZOOLOGY)

YEAR THIS DEGREE CONFERRED/*ANNÉE D'OBTENTION DE CE GRADE* 1977

NAME OF SUPERVISOR/*NOM DU DIRECTEUR DE THÈSE* DR. RICHARD C. FOX

Permission is hereby granted to the NATIONAL LIBRARY OF CANADA to microfilm this thesis and to lend or sell copies of the film.

The author reserves other publication rights, and neither the thesis nor extensive extracts from it may be printed or otherwise reproduced without the author's written permission.

L'autorisation est, par la présente, accordée à la BIBLIOTHÈQUE NATIONALE DU CANADA de microfilmer cette thèse et de prêter ou de vendre des exemplaires du film.

L'auteur se réserve les autres droits de publication; ni la thèse ni de longs extraits de celle-ci ne doivent être imprimés ou autrement reproduits sans l'autorisation écrite de l'auteur.

DATED/*DATÉ* AUGUST 25, 1977 SIGNED/*SIGNÉ* C.R. Harington

PERMANENT ADDRESS/*RÉSIDENCE FIXÉ*
PALEOBIOLOGY DIVISION
NATIONAL MUSEUMS OF CANADA
OTTAWA, ONTARIO, K1A 0M8

National Library of Canada

Cataloguing Branch
Canadian Theses Division

Ottawa, Canada
K1A 0N4

Bibliothèque nationale du Canada

Direction du catalogage
Division des thèses canadiennes

NOTICE

The quality of this microfiche is heavily dependent upon the quality of the original thesis submitted for microfilming. Every effort has been made to ensure the highest quality of reproduction possible.

If pages are missing, contact the university which granted the degree.

Some pages may have indistinct print especially if the original pages were typed with a poor typewriter ribbon or if the university sent us a poor photocopy.

Previously copyrighted materials (journal articles, published tests, etc.) are not filmed.

Reproduction in full or in part of this film is governed by the Canadian Copyright Act, R.S.C. 1970, c. C-30. Please read the authorization forms which accompany this thesis.

THIS DISSERTATION
HAS BEEN MICROFILMED
EXACTLY AS RECEIVED

AVIS

La qualité de cette microfiche dépend grandement de la qualité de la thèse soumise au microfilmage. Nous avons tout fait pour assurer une qualité supérieure de reproduction.

S'il manque des pages, veuillez communiquer avec l'université qui a conféré le grade.

La qualité d'impression de certaines pages peut laisser à désirer, surtout si les pages originales ont été dactylographiées à l'aide d'un ruban usé ou si l'université nous a fait parvenir une photocopie de mauvaise qualité.

Les documents qui font déjà l'objet d'un droit d'auteur (articles de revue, examens publiés, etc.) ne sont pas microfilmés.

La reproduction, même partielle, de ce microfilm est soumise à la Loi canadienne sur le droit d'auteur, SRC 1970, c. C-30. Veuillez prendre connaissance des formules d'autorisation qui accompagnent cette thèse.

LA THÈSE A ÉTÉ
MICROFILMÉE TELLE QUE
NOUS L'AVONS REÇUE

NL-339 (3/77)

THE UNIVERSITY OF ALBERTA

PLEISTOCENE MAMMALS OF THE YUKON TERRITORY

BY

© CHARLES RICHARD HARINGTON

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF ZOOLOGY

EDMONTON, ALBERTA
FALL 1977

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled PLEISTOCENE MAMMALS OF THE YUKON TERRITORY .... submitted by ....CHARLES RICHARD HARINGTON .... in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Zoology.

Richard C. Fox
Supervisor

William A. Fuller

Mark V.H. Wilson

R. Dale Guthrie
External Examiner

Date May 12, 1977

TABLE OF CONTENTS

DESCRIPTION OF STUDY AREA:

PREVIOUS WORK:

PRESENT WORK - 1966 to 1975:

METHODS:

ABSTRACT

This study is based on a selection of specimens from a collection of approximately 14,000 Pleistocene vertebrate fossils made from 1966 to 1975. Most of the ice age mammal material described has come from the Dawson and Old Crow areas in the Yukon Territory. The latter area appears to be the most productive for Pleistocene vertebrate remains in Canada.

Ten orders, 19 families, 44 genera and 64 species of mammals have been identified from Yukon Pleistocene deposits. Among the families, Cricetidae, Mustelidae, Equidae and Bovidae are most strongly represented. Horse, mammoth, bison, caribou, muskrat, ground squirrel, brown lemming and pika remains are the commonest in the collection. Approximately 40% of the species which occupied the Yukon during the ice age are extinct, and about 60% no longer occur in the region.

Early Pleistocene (e.g. plains shrew *(?Planisorex* cf. *dixonensis)*, giant pika *(Ochotona* cf. *whartoni)* and southern mammoth *(Mammuthus* cf. *meridionalis)*); middle Pleistocene (e.g. Soergel's muskox *(Soergelia* cf. *elisabethae)*, Staudinger's muskox *(Praeovibos priscus)*,

giant moose (*Alces latifrons*), steppe mammoth (*Mammuthus* cf. *armeniacus*), and large horses (*Equus* cf. (*Plesippus*) *verae*)); and late Pleistocene (e.g. Yukon wild ass (*Equus* (*Asinus*) *lambei*), moose (*Alces alces*), tundra muskox (*Ovibos moschatus*), arctic fox (*Alopex lagopus*), Dall sheep (*Ovis ?dalli*), and western bison (*Bison bison occidentalis*)) mammal remains are recognized in the Yukon Pleistocene fauna.

A large number of direct radiocarbon dates indicate that the following species occupied the Eastern Beringian refugium from approximately 30,000 to 10,000 years ago: ground squirrel (*Spermophilus parryi*), American lion (*Panthera leo atrox*), woolly mammoth (*Mammuthus primigenius*), Yukon wild ass (*Equus* (*Asinus*) *lambei*), western camel (*Camelops* sp.), caribou (*Rangifer tarandus*), large-horned bison (*Bison crassicornis*), Sargent's muskox (*Bootherium sargenti*), helmeted muskox (*Symbos cavifrons*) and Dall sheep (*Ovis ?dalli*). A caribou tibia fleshing tool made by man yielded a radiocarbon date of $27,000 \pm^{3000}_{2000}$ years B.P.

Two basic components comprise the Yukon ice age mammal fauna. An estimated 75% of the species (mainly cold-adapted) were derived from Eurasia or Beringia, while 25% (mainly dry, scrub grassland species) seem to have been derived from southern North America. The first group reached the Yukon chiefly by the Bering Isthmus during glacial maxima; the second group entered mainly by the "western corridor" along the eastern margin of the Cordillera.

Analysis of habitat information on 52 of the mammal species represented in the Yukon collection suggest the following preferences: grassland (33%), tundra (20%), forest (17%), parkland (16%), water (11%), alpine (3%).

Detailed studies based largely on fossil pollen, plant macrofossils, molluscs, ostracodes, and vertebrates at sites of ?Sangamon (> 54,000 years B.P.), and mid-Wisconsin (32,400 ± 770 years B.P.) age have provided interesting glimpses into Pleistocene paleoenvironments in the Yukon Territory.

ACKNOWLEDGEMENTS

This study began in 1966 and has been supported since that time by the National Museum of Natural Sciences of the National Museums of Canada. I am grateful to Drs. A.W.F. Banfield and L. Lemieux, successive directors of the National Museum of Natural Sciences, and to Dr. D.A. Russell, Chief of the Paleobiology Division, for continuing support of this long-range project. The Canadian Wildlife Service and the National Museums of Canada provided important aid by allowing me to take academic leave at the University of Alberta in 1963-64 and 1969-70 respectively.

Drs. O.L. Hughes and L.H. Green of the Geological Survey of Canada stimulated my interest in the Yukon as a potential site for collecting ice age vertebrates. Dr. Hughes showed me a number of important sites in the Dawson Area in 1966, and gave me a map showing a few Pleistocene vertebrate localities near Old Crow that he had recorded during "Operation Porcupine". He has made valuable collections of Pleistocene mammals from various parts of the Yukon and has provided stratigraphic information on the most important sites. Dr. A. Lissey of Brock University, then of the Geological Survey of Canada, kindly collected fossils for me in the Dawson Area during the 1969 field season. Dr. J.V. Matthews, Jr., Geological Survey of Canada, studied samples of organic sediments from a few sites in the Old Crow Area and has greatly added to my appreciation of Pleistocene environments there. Dr. A.H. Clarke and Mrs. M.F.I. Smith, National Museums of Canada, have identified most of the Pleistocene mollusc remains collected during the project. Dr. L.D. Delorme of the Canada Centre for Inland Waters identified many ostracode samples.

Dr. W.N. Irving, University of Toronto, found two significant fossil localities on the Old Crow River, and has donated valuable specimens from them to the National Museums of Canada. He, Dr. R.E. Morlan, Archaeological Survey of Canada, and Dr. R. Bonnichsen, of the University of Maine, have been helpful in their analyses of and advice on a number of artifacts attributed to early man.

Mr. P.M. Youngman gave useful advice regarding field travel and contacts at the beginning of the project. As successive curators of mammals in the National Museum of Natural Sciences, he and Dr. C.G. van Zyll de Jong freely allowed me to use Recent material in their care for comparative purposes.

Dr. Richard C. Fox, chairman of my supervisory committee, and Drs. J. Westgate and W.A. Fuller, members of the committee, have greatly encouraged and helped me in carrying out this study. Dr. Fox offered many valuable comments on a draft of the manuscript.

I am especially grateful to Mr. G.R. Fitzgerald, Curatorial Assistant in Quaternary Zoology, for his outstanding help in the laboratory, during field work at Old Crow since 1970, and for aid in preparing the maps and figures. Mr. Peter Lord and Mr. Charlie Thomas of Old Crow contributed greatly to the establishment of substantial Quaternary vertebrate fossil collections from their region. Their great knowledge of the area, keen powers of observation and very hard work were invaluable. The following R.C.M. Police officers were helpful in many ways during my work at Old Crow: Corporals J. Strain, D. Wheeler, T.N. Baldwin, C. Legassicke, and D. James.

The following placer miners in the Dawson Area donated valuable Pleistocene mammal fossils to the National Museums of Canada, and provided unfailing hospitality and assistance to me since 1966: the late

Mr. Harold Schmidt, and Mrs. Marion Schmidt and family; Mr. and Mrs. Art Sailer and family; Mr. Ernie Schink; Mr. Gus Heitman; Mr. and Mrs. Ole Lunde; Mr. Tony Kosuta, Mr. and Mrs. Lorne Ross, Mr. and Mrs. Bert Bratsberg, Mr. and Mrs. A. Burgelman, Mr. Max Kinakin and family; Mr. Walter Yaremcio; Mr. Adrien Brisebois; Mr. Walter Rasmussen; Mr. Jack Lacross; Mr. Klaus Djukastein; Messrs. E. Faucher and Lorenzo Grimard; and Messrs. J. and R. Archibald. Mr. and Mrs. Axel Nordling and Mr. and Mrs. Fred Berger of Dawson were most hospitable during my time there and gave me valuable leads on new fossil sites. Les Butterworth, Kelly and Evelyn Connolly, and Al Cusick took extra pains in storing and shipping the fossils, for which I am most grateful. Surely the greatest resource of the Yukon is its people!

I acknowledge the help of Mirielle Rochon and Marla Weston, summer student assistants, in cleaning, numbering and cataloging many of the Yukon specimens. Mr. Derek Munroe and Mrs. Laura Lu Mathews, as voluntary assistants in the laboratory, also helped to preserve and catalog many of the Yukon fossils.

I thank Mr. G.N. Anderson, National Museums of Canada, and his staff for photographic work. I am particularly grateful to Mr. Ralph Mouland for technical advice and printing, and to Mr. Harry Foster for much of the photography. Bonnie Dalzell provided most of the restorations of Yukon ice age mammals, while Mr. Charles Douglas drafted the final copies of the maps, charts and graphs. He also supplied several restorations. Mrs. Claudette Ozoux and Mrs. Phyllis Wiaz helped greatly with typing the manuscript. Above all, I wish to thank Mrs. Gail Rice for typing the draft and most of the final copy of the manuscript. Her extra effort and attention to detail are gratefully acknowledged.

LIST OF TABLES

Page

Page

Page

Page

Page

Page

Page

Page

LIST OF FIGURES

Page

Page

Page

Page

Page

Page

LIST OF ABBREVIATIONS

a	Approximate measurement.
ANSP	Academy of Natural Sciences of Philadelphia.
BCPM	British Columbia Provincial Museum, Victoria.
BM(NH)	British Museum (Natural History), London.
B.P.	Before present (i.e. before 1950).
C	Canine or caniniform tooth, with superscript (upper) and subscript (lower).
CM	Carnegie Museum, Pittsburgh.
cm	Centimeter (used with measurements).
CNHM	Chicago Museum of Natural History, Chicago.
CV	Coefficient of variation.
d	Milk (or deciduous) tooth.
DCMP	Dawson City Museum, Dawson.
e	Estimated measurement.
F:AM	Frick Collection, American Museum of Natural History, New York.
GRPM	Grand Rapids Public Museum, Grand Rapids, Michigan.
GSC	Geological Survey of Canada Radiocarbon Dating Laboratory, Ottawa.
GIN	Geological Institute, USSR Academy of Sciences, Moscow.
GX	Geochron Inc., Boston.
I	Incisor tooth; with subscript (lower) and superscript (upper).

I	Teledyne Isotopes, Westwood, New Jersey.
K	University of Copenhagen radiocarbon dating laboratory, Copenhagen.
km	Kilometer.
L	Lamont Geological Observatory, radiocarbon dating laboratory, New York.
LACM	Los Angeles County Museum, Los Angeles.
LAM	See LACM.
LUM	Laurentian University Museum, Sudbury, Ontario.
M	Mean of a series of measurements.
m	Meter (used with measurements).
M	Molar or molariform tooth; with superscript (upper) and subscript (lower).
M	University of Michigan radiocarbon dating laboratory, Ann Arbor.
mm	Millimeter.
MO	University of Moscow radiocarbon dating laboratory, Moscow.
N	Number of specimens in sample.
NMC	National Museums of Canada, Ottawa.
OCR	Old Crow River - specimen collected by party under the direction of W.N. Irving, Department of Anthropology, University of Toronto.
OR	Observed range of measurements of specimens.
P	Premolar tooth; with subscript (lower) and superscript (upper).

PIN	Paleontological Institute, USSR Academy of Sciences, Moscow.
Plus (+)	Measurement smaller than what the original would have been because of wear or damage.
PU	Princeton University, Department of Geological and Geophysical Sciences, New Jersey.
S or SD	Standard deviation.
SE	Standard error.
SEM	Scanning electron microscope.
SI	Smithsonian Institution radiocarbon laboratory, Washington, D.C.
SM	University of Saskatchewan Department of Anthropology, Saskatoon.
ST	Geological Survey of Sweden radiocarbon laboratory, Stockholm.
T	Geochemical and Analytical-Chemical Institute, USSR Academy of Sciences, Moscow.
TSM	Tennessee State Museum.
UA	University of Alaska, College.
UA*	University of Alberta, Edmonton.
UCMP	University of California Museum of Paleontology, Berkeley.
UMMP	University of Michigan Museum of Paleontology, Ann Arbor.
UMMZ	University of Michigan Museum of Zoology, Ann Arbor.
USNM	United States National Museum, Washington, D.C.

W	U.S. Geological Survey radiocarbon laboratory, Washington, D.C
PM	Yale Univer[illegible] Peabody Museum of Vertebrate Paleontology, New Haven.
ZIN	Zoological Institute, USSR Academy of Sciences, Leningrad.

Terminology

For purposes of this discussion, where areas are specifically defined in the text and used in a special sense, capitals are applied (e.g. Dawson Area, Old Crow Area, Eastern Beringia). Capital letters are also applied to proper names of birds (e.g. Snowy Owl) and breeds of dogs (e.g. Chow Chow), practises adhered to by the American Ornithologists' Union and the American Kennel Club respectively. For the sake of variety, the term ice age is used here as an alternative to Pleistocene.

INTRODUCTION

During Pleistocene continental glaciations, as ice from the central areas spread over Canada, mammals were forced to shift their ranges until, at the peaks of glaciations, they occupied three or four main survival areas or refugia: (a) the southern refugium in unglaciated parts of the northern United States; (b) the Beringian refugium, in unglaciated areas of the Yukon and Alaska and extending across the Bering Isthmus into eastern Siberia; (c) the Banks Island refugium, which existed at least during the late Pleistocene in the western Canadian Arctic Islands; and (d) the Pearyland refugium in northern Greenland. Of these refugia, the Beringian is one of the most interesting because of its importance as a periodic connecting link between the mammalian faunas of Eurasia and America. Basic information on the history of Beringia, its past environment and the faunal interchange which occurred there is included in "The Bering Land Bridge" (1967).

Throughout the Pleistocene, large, contiguous, unglaciated areas of the Yukon and Alaska (Eastern Beringia) were occupied by relatively rich, homogeneous mammalian faunas, and it is difficult to obtain a satisfactory perspective on Yukon Pleistocene mammals without considering Alaska. As I (Harington 1970, pp. 35-51; Harington 1976 MS.) have attempted to provide reviews of that nature, this study is confined mainly to the results of my field work in the Dawson and Old Crow areas of the Yukon during the 1966-75 period. Because these two areas contain some of the richest Pleistocene mammal sites in Canada and Beringia, they provide a significant insight into the mammalian history of this interesting part of the world. Studying these faunas is like putting a finger on the Eurasian-American faunal pulse.

No detailed study of Yukon Pleistocene mammals has been undertaken before, and no comparable study on a state-wide basis is available from adjacent Alaska. Because the Yukon is situated on a route of mammal migration between Eurasia and the central regions of North America, it is important from paleontological and zoogeographical view-points to examine the Pleistocene faunal evidence there. Only by studying this kind of evidence can we hope to gain a sound idea of the origins of the present North American mammalian fauna. The object of this study is to answer the following questions: (a) What mammals occupied the Yukon during the ice age? (b) When did they live there? (c) Where did they come from? (d) How did they get there?, and

(e) Under what environmental conditions did they live?

The main part of this report consists of identifying, describing, measuring and comparing ice age mammal remains collected from the Dawson and Old Crow areas. In some cases pertinent specimens in other museums are mentioned, and these data are augmented with information derived from literature research.

Obtaining a satisfactory idea of the geological age of Yukon Pleistocene mammals is a great challenge. Because localities where most of the specimens have been collected were unglaciated, stratigraphic dating of faunal remains is difficult. No thick tills are present to indicate periods of glaciation. But, occasionally, other stratigraphic clues are present that seem to mark peaks of glaciation or glacial periods. In an effort to clarify this problem, I have taken samples of bone from various species, and of associated organic material (wood, mollusc shells, peat), for radiocarbon dating in order to supplement stratigraphic information derived mainly from the work of O.L. Hughes and from personal observation. Of course, radiocarbon dates can only provide an idea of the age of organisms during the last 50,000 years - merely 2.5% of the entire length of the Pleistocene, which is currently estimated to have covered the last 2 million years (Berggren and Van Couvering 1974, p. 164).

An attempt to explain the origins of Yukon ice age mammals hinges on a consideration of their known fossil distribution and their probable dispersal centres, which in turn is based on our present knowledge of their ancestry. Where mammals represented in Yukon Pleistocene deposits are still living, their present distribution and degree of endemism can also yield suggestive evidence of their past distribution. Available migration routes to and from the Yukon during the Pleistocene are limited. Consideration is given to the "western corridor" along the eastern margin of the Rocky Mountains, and the Bering Isthmus, which connected Eurasia and America during periods of world wide sea-level depression at times of glacial maxima. A link between Eastern Beringia and southern North America through the interior of British Columbia is also worth considering (Harington *et al.* 1974, p. 302).

It is important to try to fit ice age mammals into their natural surroundings. This helps to make the study of fossils a lively and interesting subject. Fossils of species with particular adaptations and habitat requirements often suggest the nature of past environments of a locality or region. My basic assumption here, which is open to challenge, is that species represented by fossils had ecological requirements similar to those of the same or closely allied living species. In some cases, other fossils directly associated with mammal remains have provided clues to habitats of extinct mammalian species. Studies of fossil pollen, plant macrofossils, insect remains, and Pleistocene mollusc shells have shed new light on environments occupied by Yukon ice age mammals.

Brief consideration is given to the presence of man in the Yukon during the late Pleistocene.

From a zoologist's view, many of the following descriptions will be merely tantalizing, for one of the common strictures in working with fossils is their incompleteness. A tooth critical to the identification of a species may be missing from a jaw; or unique characteristics of an articula surface of a humerus may be eroded.

Another common problem is locating adequate Recent mammal specimens with which to compare the fossils. There is no quicker way to discover the weaknesses of zoological collections! The problem is accentuated where relatively rare, extinct genera or species are discovered; in some cases only a few skeletal elements of extinct Pleistocene mammals are known. On the other hand, specimens of some Yukon ice age mammals are remarkably abundant and well preserved (e.g. almost perfect hornsheaths of *Bison crassicornis* from frozen muck deposits near Dawson). Such limitations should be borne in mind when reading this report.

I feel that the fossil collections made since 1966 are sufficient to ensure that most of the large mammals living in unglaciated parts of the Yukon during the late Pleistocene have been sampled. Still, it would be valuable to have better specimens of some species, and enough specimens of certain kinds to permit statistical treatment. These deficiencies are an incentive for carrying o further field work. Probably some surprises still remain with regard to the microvertebrates. Matrix has been screened at a few suitable localities in the Old Crow Area during the field seasons of 1971 and 1973, but this method has yet to be applied at sites in the Dawson Area. I hope to do this soon. It will take a few years to satisfactorily describe the thousands of microvertebrate remains (including fish and bird fossils) screened from sediment at Old Crow localities 27W and 44.

Another problem that strictly limits knowledge about the geological age and environments of Yukon ice age animals is the fact that relatively complete specimens, in their original position at death, are seldom found. Indeed, most bones from Old Crow and Dawson localities show signs of having been reworked at least once or twice. This recycling of fossil deposits can result in mixing, so it is often difficult to tell whether all species identified from a single stratigraphic unit lived in the same area at the same time. It is best to retain a healthy skepticism in this regard. Careful taphonomic studies may help to overcome such problems in the future.

DESCRIPTION OF THE STUDY AREAS

Yukon Territory

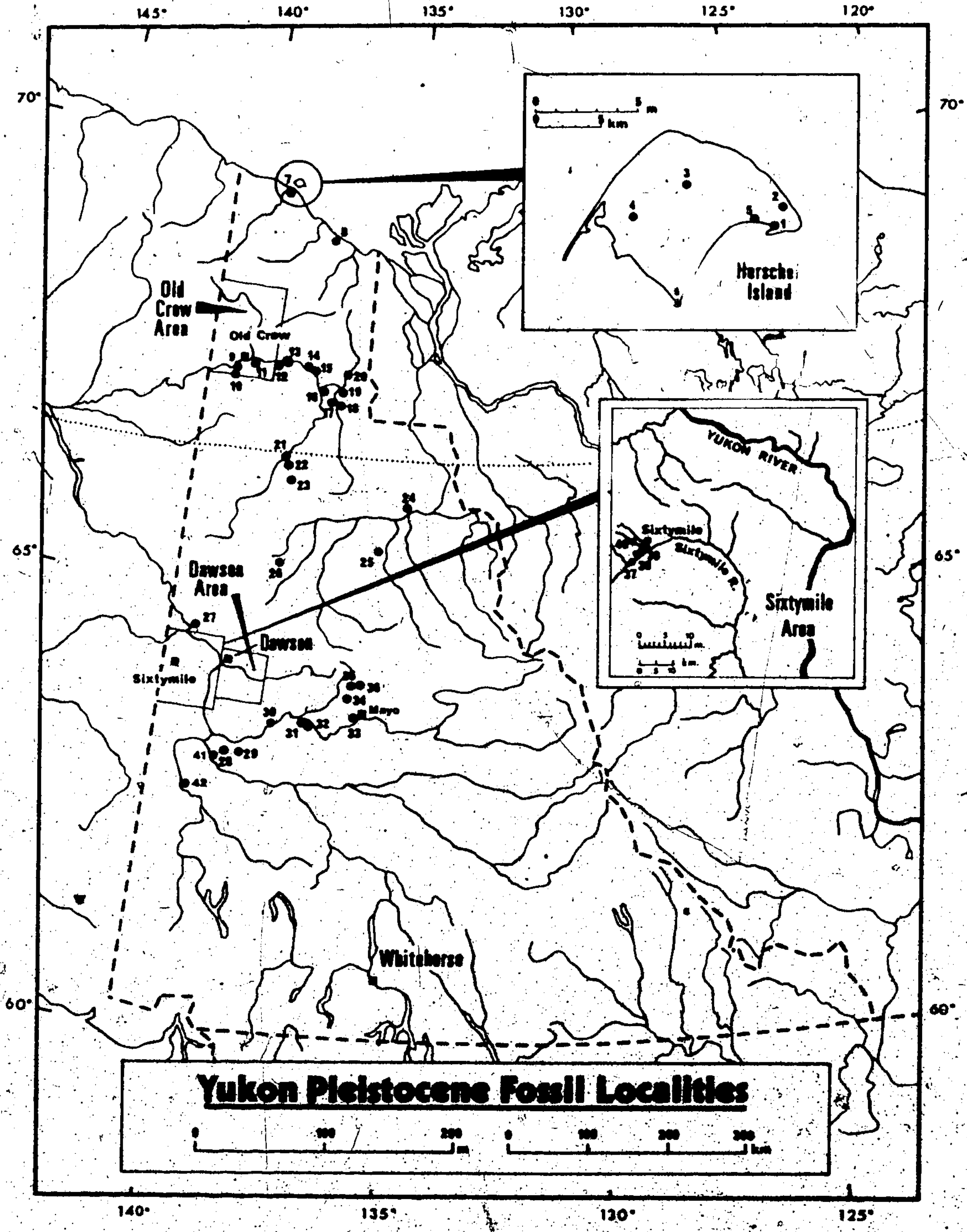
Situated in a right-angled triangular area forming the northwest corner of Canada, the Yukon lies north of 60° and extends westward from near the eastern margin of the Canadian Cordillera to the 141st meridian, where it borders on Alaska. The Yukon covers 536,327 km^2 - larger than all the New England states and more than twice the size of Great Britain. The physical features of the landscape have been described by Bostock (1948).

The area has a colorful history. Twice it has exceeded its present population of just under 20,000: in 1898 during the Klondike gold rush the population of Dawson City reached nearly 30,000; and again 46 years later Whitehorse reached nearly 40,000 during the Second World War

FIGURE 1. PLEISTOCENE VERTEBRATE LOCALITIES IN THE YUKON TERRITORY.

LEGEND:

MAP NUMBER	LOCALITY NUMBER	MAP NUMBER	LOCALITY NUMBER
1	Herschel Island Loc. 1	22	Whitestone River Loc. 43
2	Herschel Island Loc. 2	23	Whitestone River Loc. 1
3	Herschel Island Loc. 3	24	Peel Plateau Loc. 1
4	Herschel Island Loc. 4	25	Hungry Creek Loc. 1
5	Herschel Island Loc. 5	26	Ogilvie River Loc. 1
6	Herschel Island Loc. 6	27	Cliff Creek Loc. 1
7	Arctic coast Loc. 1	28	Brewer Creek Loc. 1
8	Arctic coast Loc. 2	29	Scroggie Creek Loc. 1
9	Porcupine River Loc. 100	30	Stewart River Loc. 1
10	Bluefish River Loc. 1	31	Stewart River Loc. 2
11	Porcupine River Loc. 1	32	Stewart River Loc. 3
12	Porcupine River Loc. 34	33	Stewart River Loc. 4
13	Porcupine River Loc. 2	34	Highet Creek Loc. 1
14	Porcupine River Loc. 3	35	Haggart Creek Loc. 1
15	Porcupine River Loc. 40	36	Dublin Gulch Loc. 1
16	Porcupine River Loc. 35	37	Sixtymile Area Loc. 1
17	Eagle River Loc. 37	38	Sixtymile Area Loc. 2
18	Eagle River Loc. 38	39	Sixtymile Area Loc. 3
19	Rock River Loc. 1	40	Sixtymile Area Loc. 4
20	Bell River Loc. 1	41	Thistle Creek Loc. 1
21	Porcupine River Loc. 4	42	White River Loc. 1



Yukon Pleistocene Fossil Localities

when the Alaska Highway was constructed. In 1953 the territorial capital was moved from Dawson to Whitehorse, which has become a major transportation centre in the northwest part of the continent.

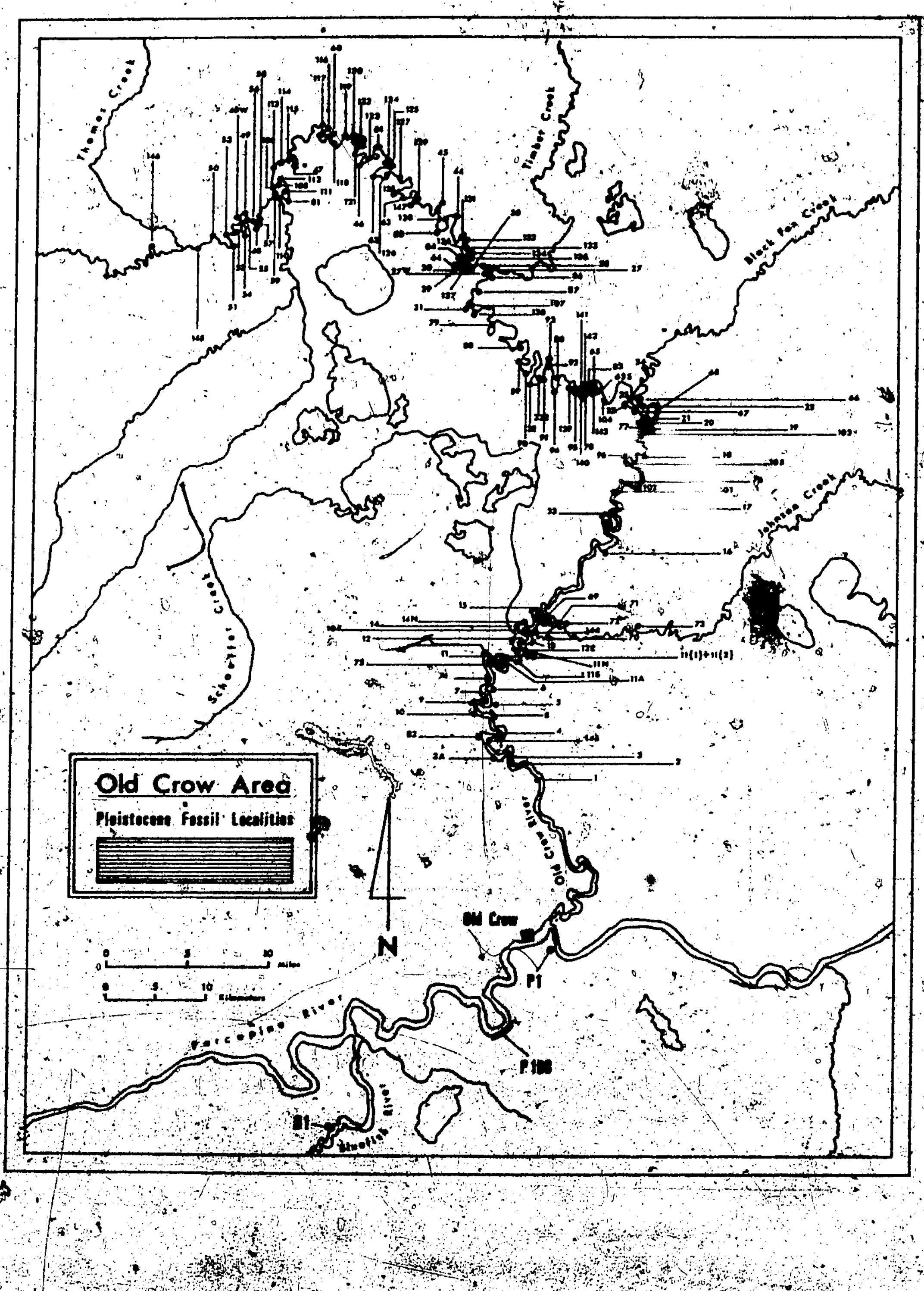
This study concentrates on two districts in the unglaciated western part of the Yukon, the Old Crow and Dawson areas, both of which are highly productive of ice age mammal remains. Fossil deposits at Old Crow are exposed by stream erosion, which is most effective during the spring melt period. In contrast, Dawson fossil beds are generally exposed by artificial means (e.g. monitoring with high pressure jets of water, washing with dammed up water behind automatic gates, and dredging) in the course of man's search for gold. Occasionally specimens from other localities will be mentioned in this study (Figure 1).

Old Crow Area

The Old Crow Basin ("Old Crow Plain" of Bostock (1948, p. 76)) covers an area of approximately 6,216 km^2 centred on about 68^oN, 140^oW (Figure 2) (Lawrence 1973, p. 307). During Devonian time the area was part of an orogenic belt extending into the northern Brooks Range of Alaska. Conglomerates such as those exposed on Dave Lord

FIGURE 2. PLEISTOCENE VERTEBRATE LOCALITIES IN THE OLD CROW AREA.

Numbers on the map are those of the actual fossil localities.


Old Crow Area
Pleistocene Fossil Localities
Thomas Creek
Timber Creek
Black Fox Creek
Johnson Creek
Schaeffer Creek
Old Crow River
Porcupine River
Bluefish River
Old Crow
P1
P100
B1
N
0 5 10 Miles
0 5 10 Kilometers

Ridge were then deposited on the east side of the basin. Quieter conditions prevailed during the Mississippian when the Kayak Shale and open marine crinoidal limestone of the Lisbourne Group were deposited. Apparently pre-Permian uplift and erosion removed the Mississippian rock from much of the southern part of the area. Permian conglomerate rests with angular conformity on Silurian graptolitic shale on the eastern margin of the Old Crow Basin (Norford 1964). Little or no sediment seems to have been deposited in the area during the Triassic, but a major marine transgression, starting in Middle Jurassic time, deposited Jurassic and Cretaceous sediment over the whole area (Jeletzky 1975).

The Old Crow Basin as it exists now was formed by downwarping and/or faulting during the Laramide orogeny in Tertiary time with subsequent infilling of late Tertiary to Recent clastics. The latter nonmarine sediments blanket the basin to a depth of from 460 to 610 m (Lawrence 1973, p. 311). The depth of the Pleistocene deposits is unknown. Probably it would be necessary to take a core from the central part of the basin in order to answer this question. Stratigraphic sections measured at some of the highest bluffs along the Old Crow River indicate that ice age sediments reach depths of over 37 m.

Commonly exposed at the bottom of the thickest Pleistocene sections is a basal clay unit ("Older deltaic, lacustrine and fluvial sediments" of Hughes (Lichti-Federovich 1973, Figure 2)) characterized by a rolling, evidently heavily eroded surface with peaty mats in some of the depressions. At some places this irregular surface may be attributed to thawing of permafrost, and thus may be an expression of Pleistocene thermokarst (see Brown and Kupsch 1974, p. 41). At many exposures the basal clay is overlain by a gray sandy silt to fine gravel containing abundant fossils. A very thick layer of deltaic and lacustrine silts (= "Deltaic and lacustrine sediments (silt with minor fluvial sand and gravel)" of Hughes (Lichti-Federovich 1973, Figure 2)) cover the fossil-bearing unit which is in turn overlain by an upper glaciolacustrine unit and silt and peat of postglacial age. Although Hughes (Lichti-Federovich 1973, p. 563) suggested that this section ranges in age from early Wisconsin to postglacial, more recent evidence, which I will mention later, indicates that the basal clay unit is older - perhaps of Illinoian age.

The Old Crow Area lies within the continuous permafrost zone (Brown, 1970), and occasionally in summer the contents of large basins of melted muck from the upper glaciolacustrine unit surge down into the Old Crow River.

In a few cases these solifluction lobes, carrying trees and shrubs from the surface, partially block the river.

Ancient beaches preserved in places along the margins of the basin demonstrate the area and depth of a late Wisconsin lake which occupied it (Hughes 1969, p. 211). About 11,000 years ago a bedrock threshold was breached and the lake began to drain via the Yukon system to Bering Strait. As the Old Crow River cut through the lake bottom sediments, the basin took on its present appearance. Hughes (1969, p. 211) summarized the Pleistocene geological history of the region with particular relation to the movements of Laurentide ice to and from the flanks of the Richardson Mountains to the east. There is no evidence that the Old Crow Basin was ever glaciated. Lichti-Federovich (1973) has reconstructed the late Pleistocene botanical history of the area from samples of fossil pollen taken at six sites within the basin, and has given a tentative interpretation of climate during that period.

Pleistocene mammal fossils are found in various situations: (a) on the surface of river banks, where they have been deposited after high water of the spring melt has subsided. In this case they may have slid down the bank with sediment from fossil-bearing units above, or they may have been washed downstream from other fossil localities; (b) on modern point bars; (c) in sands and gravels of terraces which have been laid down during the last few thousand years. Generally the ice age mammal fossils have been reworked and are much older than the terrace deposits; (d) in buried point bars, which may vary in age from about 10,000 to a few thousand years ago. Again, the fossils are usually older than the deposits in which they are found; and (e) in place at various levels in the high bluffs cut by the river. Fossils from organic sediments in place near the surface of, and directly overlying the basal clay were deposited over 54,000 years ago, while the youngest Pleistocene mammal fossils found in place near the upper surface of the bluffs are about 12,000 years old. Fossils of the extinct muskoxen *Soergelia* and *Praeovibos* and the giant moose *Alces latifrons* suggest that deposits as old as middle Pleistocene age may be exposed within the basin - perhaps where tributaries of the Old Crow River such as Johnson and Black Fox creeks cut down to Tertiary rock near the eastern margin of the basin. Traces of early Pleistocene mammals are present also.

At present, the Old Crow Basin is circled by hills and low mountains: the British Mountains to the north; the Richardson Mountains to the east; and the Porcupine Plateau and Old Crow Range to the south. Much of the basin lies at an elevation of 380 m above sea-level. It is dominated by a few bedrock outcrops such as Schaeffer Mountain and Timber Hill, the former rising to over 610 m above sea-level. Nearly half of the basin is covered by shallow lakes, ponds and sluggish streams. Patches of tundra occur on the floor of the basin, whereas spruce, willow and alder dominate the lower levels along the banks and meander scars of the Old Crow River and its tributaries. Lichti-Federovich (1973, pp. 554-557) gives more details on the vegetation. A description of the terrain in the southern part of the basin has been compiled by Monroe (1974).

Total annual precipitation in the Old Crow Basin is 25 cm, of which half falls as snow. The growing season is about 80 days, with 1000 degree-days above 42°F (6.7°C). The mean daily July temperature is 50°F (10°C) (Lichti-Federovich 1973, p. 554).

Dawson Area

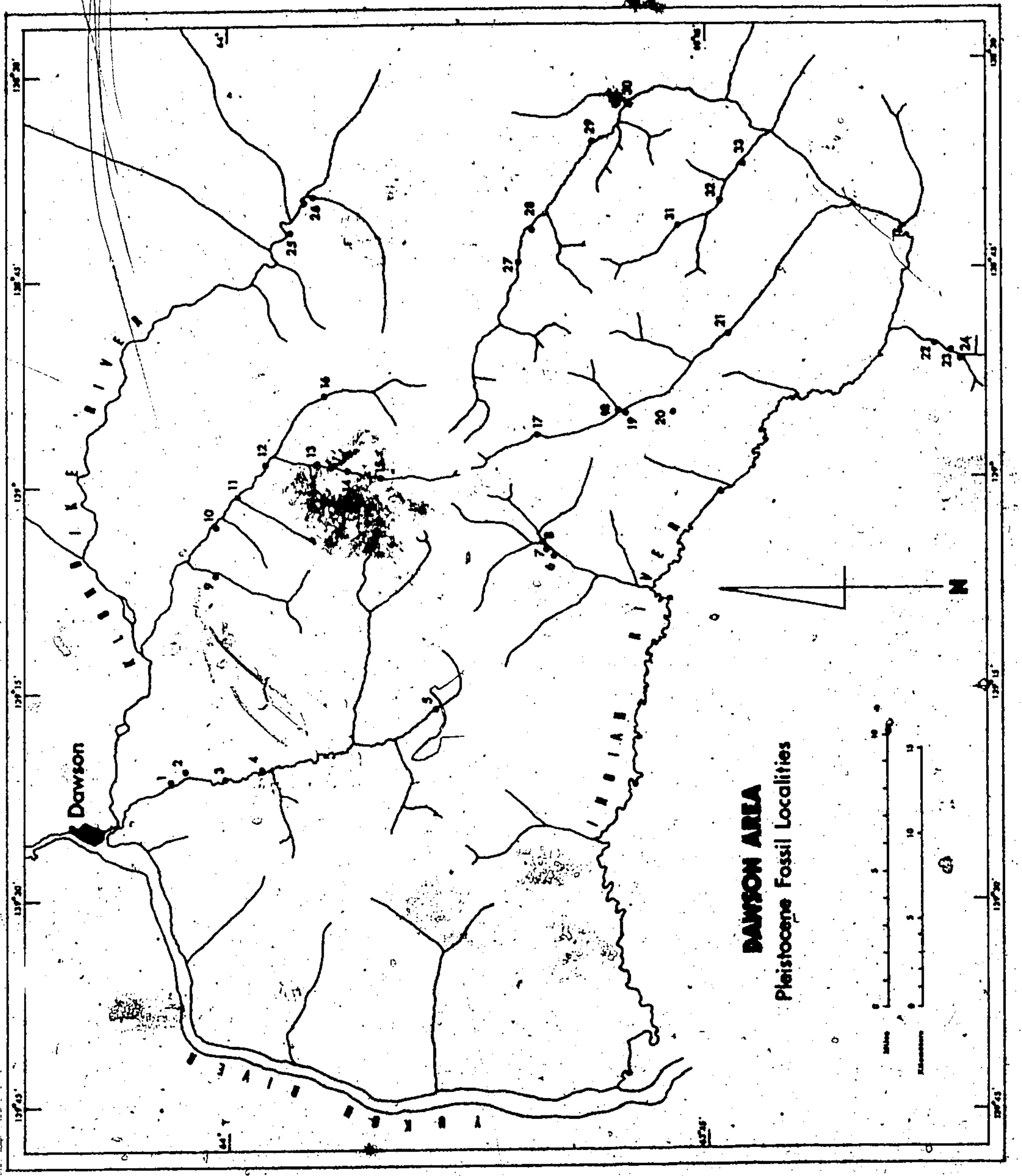
This area consists of approximately 2,590 km^2 centred on about $63^{\circ}50'$ N, $139^{\circ}00'$ W (Figure 3). It includes the principle gold-bearing creeks and is equivalent to the "Klondike Region" or "Klondike Gold District"

FIGURE 3. PLEISTOCENE VERTEBRATE LOCALITIES IN THE DAWSON AREA.

LEGEND:

Numbers on the map are those of the actual fossil localities. Names in brackets are of placer miners who hold, or who have held, claims on which vertebrate fossils have been discovered.

1 - Bonanza Creek, Trail Hill (Nicolson).
2 - Bonanza Creek, Cripple Hill (Heitman).
3 - Bonanza Creek, claim 52 below discovery.
4 - Bonanza Creek, claim 37.
5 - Eldorado Creek (Franklin, Caley).
[illegible] Quartz Creek (Schmidt).
[illegible] Quartz Creek (Sailer).
[illegible] - Quartz Creek (Rasmussen, Lacross).
9 - Last Chance Creek, Discovery Pup.
10 - Hunker Creek, 80 Pup (Kosuta).
11 - Hunker and Independence Creeks - juncture.
12 - Hunker Creek (Fa[illegible]t, Norback).
13 - Gold Bottom Creek (Lunde).
14 - Gold Bottom Creek.
15 - Gold Bottom Creek (Bratsberg).
16 - Hunker Creek (Erickson, Leidtke).
17 - Sulphur Creek (Djukastein).
18 - Sulphur Creek, Friday Gulch (Gibson).
19 - Sulphur Creek.
20 - Sulphur Creek area.
21 - Sulphur Creek, claim 50 below discovery.
22 - Eureka Creek (Haakonson).
23 - Eureka Creek (Ross).
24 - Eureka Creek (Cole Brothers).
25 - Flat Creek, bench (Strachan).
26 - All Gold Creek (Kinakin).
27 - Dominion Creek, just below lower discovery.
28 - Dominion Creek (Schmidt).
29 - Dominion Creek (Sailer).
30 - Dominion Creek (Burgelman).
31 - Gold Run Creek, claim 57a.
32 - Gold Run Creek (Schink, Lamontagne).
33 - Gold Run Creek (Ross, Matson).


DAWSON AREA
Pleistocene Fossil Localities

as defined by McConnell and Tyrrell (1898). It is situated between the Klondike and Indian rivers and is east of the Yukon River. McConnell (1903 [illegible] 1905) and Bostock (1943) have reported on the geology of the area.

The region is underlaid by a complex of rock formations that range in age through the greater part of the geological scale and that are highly varied in structure and composition. The area has been repeatedly broken through by igneous intrusions and has been subjected to great pressure resulting from earth movements. For example, massive igneous rocks have been sheared, granulated and crushed into finely plicated schists, and in many cases the clastic rocks have been recrystallized to resemble igneous rocks.

The oldest rocks are thick schists of Precambrian age, which Bostock calls the Yukon Group. They form the foundation of the Dawson Area and are exposed along Hunker and Dominion creeks. Apparently they have been downwarped to form a major north-northwest trending syncline that crosses the Indian River just above its mouth. The Yukon Group is intruded by Paleozoic? Klondike Schist, which consists of mica, chlorite, and amphibolite schists, and which underlies most of the area (Geol. Surv. Can. Map

1048A, 1957). Although gold-bearing quartz veins penetrating the Klondike Schist are generally of low value, McConnell (1905) and Tyrrell (1912) indicate that they are rich enough to account for the placer deposits in the Klondike creeks. Basic and ultrabasic intrusive rocks, mainly of Mesozoic age, are exposed northwest of Allgold Creek and near the juncture of Montana Creek with Indian River. Acidic intrusives (Coast Intrusions) of similar age occur north of the mouth of Indian River.

At present, the Dawson area is a maturely dissected plateau. King Solomon Dome (1230 m above sea-level) dominates the area. Its summit appears to be the remnant of an early stage of erosion (Campbell 1952, p. 51). It is the principal drainage centre of the district: from it Allgold and Dominion creeks flow eastward, Quartz and Sulphur creeks flow southward, and Gold Bottom and Hunker creeks flow northward.

A remarkable feature of the area is that the topographic surface below the level of King Solomon Dome has been deeply eroded to form broad, high level valleys, which in turn are cut by younger, steeper valleys 60 to 90 m deep. Before these inner valleys were cut, stream gravels were deposited in the broad, high valleys over a long period of time. These gravels (White Channel gravels) are over 107 m thick near Dawson. They consist of white quartz and pale, leached quartz-muscovite-chlorite schist and are strikingly exposed along Bonanza and Hunker creeks.

Dominion and Sulphur creeks, which flow southward into Indian River, unlike Bonanza and Hunker creeks on the opposite slope, lack high-level terraces. However, Dominion Creek has low terraces along its upper valley. The lower parts of the valleys contain thick gravels of White Channel type overlain by stream gravel of quartzite schist and quartz - resembling those in the beds and low terraces of all streams in the area. At the mouths of Hunker and Bonanza creeks, the White Channel gravels are overlain by Klondike gravels (McConnell 1905) to a depth of about 30 [illegible]. The Klondike gravels consist of quartzite, slate, chert, granite and diabase pebbles, largely derived from the western slopes of the Ogilvie Mountains.

Narrow rock terraces, which have a significant bearing on the history of the landscape, occur at various points on the flanks of the steep slopes of the present valleys. They occur at all elevations up to the bottoms of the old valleys, and carry gravel beds from 2 to 5 m thick, which are very similar to those in the creek bottoms.

The terrace gravels, like the creek gravels, are usually overlaid by muck (frozen silt generally consisting of loess or reworked loess with some organic matter). At one point on Hunker Creek, terrace gravels were buried beneath 30 m of muck.

McConnell (1907, p. 6) thought the terrace systems in the Dawson Area were caused by an episode of depression followed by one of uplift. Hughes and Rampton (1972, pp. 33-34) offer an interesting alternative explanation that involves uplift and drainage changes related to glaciation. I will try to summarize their views in the following paragraph.

A broad upwarping on a west-southwest axis crossing the Yukon River between Fortymile River and the Alaskan border was followed by aggradation of the Yukon River as a result of its reduced gradient. Other tributaries including Hunker and Bonanza creeks responded similarly, but south-flowing creeks, such as Dominion and Sulphur, increased in gradient, initiating some cutting near their heads and forming low bedrock terraces. Deposition occurred in the lower parts of these creeks because the Indian River into which they flowed was aggrading. Near the end of the aggradation cycle during the first glaciation in the region, mountain glaciers advancing down the North Klondike, South Klondike and lesser valleys diverted the Klondike River from the Tintina Trench to its present course, causing deposition there of Klondike gravels and Flat Creek beds. In the Dawson Area, deposition of the White Channel gravels, considered by McConnell to have been laid down in a climate warmer than the present, gave way to gravel evidently produced by weathering in a periglacial environment. Thus, although McConnell thought the White Channel gravels were at least as old as Pliocene, the uppermost part is considered to be earliest Pleistocene. Following this glacial episode, the Yukon River cut nearly to its present grade; the Klondike River was entrenched through the thick fill of Klondike gravels into bedrock and the glacial fill of the Tintina Trench. The lower part of the Indian River cut to the present grade of the Yukon River, but cutting has not extended to Sulphur and Dominion creeks, hence high level terraces are lacking on those streams. Although ice approached within about 32 km of the Dawson Area, like the Old Crow Area, it was never glaciated.

The gravels flooring the creeks and the gullies or "pups" that feed them are generally less than 3 m thick. They are of local origin and are composed of schists with quartz pebbles and boulders, and occasionally with regional volcanics. The pebbles are commonly embedded in an oxidized sand matrix and alternate locally with thin beds of sand and muck (McConnell 1905).

Muck was the last sediment of any importance to be deposited in the Dawson Area. Although McConnell (1905) records plant remains and Pleistocene mammal fossils enclosed in the creek gravels, I find that they are usually located near the surface of creek, pup or terrace gravels and at the base of the overlying muck. Obalski (1904, p. 216) supports this view: "C'est, en général, à l'intersection mal définie, que j'ai constaté les gisements de fossiles." Occasionally, I have seen Pleistocene mammal bones a few metres up from the base of the muck (e.g. bison bone at Heitman's former claim on Cripple Hill (Dawson Locality 2), and mammoth bone at Kosuta's claim on lower Hunker Creek (Dawson Locality 10)).

Pending further evidence, I suggest that muck deposition resulted from rapid erosion of steppe-like grasslands which evidently existed in the uplands of the region during the late Pleistocene. Perhaps most of the Pleistocene mammal remains were partly washed down and partly moved downslope by mass wastage with abundant loess and vegetation from the former grassland. This phase of exceedingly heavy, rapid erosion may have taken place about 11,000 years ago. Perhaps most bones were deposited near the surface of local creek gravels and the base of the overlying muck because of their relative density (Harington and Clulow 1973, p. 743). Evidently the transported organic loess was refrozen after this depositional phase, which may be significant as an indicator of rapid climatic change about this time. A publication by Péwé (1975 b, p. 15) tends to support these conclusions. He states that the Goldstream Formation in the Fairbanks region, which I consider to be the equivalent of most of the muck deposits producing mammal remains of late Wisconsin age near Dawson, is a valley-bottom deposit into which vertebrate bones were gradually transported downslope. He then remarks that the Goldstream Formation froze ~~soon~~ after deposition. In addition, it is worth noting that McCulloch and Hopkins (1966, p. 1089) have detected in northwestern Alaska a warm interval approximately spanning the 10,000 - 8,300 years B.P. period, followed by a cold period marked by the Anivik Lake glacial readvance. Therefore, the period during which the muck was refrozen may have been between 8,300 and the hypsithermal, which lasted from about 6,000 to 3,000 years ago in central Alaska. Evidently ice wedges began to grow again in northwestern Alaska about this time (McCulloch and Hopkins 1966, p. 1105).

Since most Pleistocene vertebrate fossils found in the Dawson Area have been exposed and collected as a result of placer mining, a brief description of a common method using a bulldozer and monitor seems pertinent. Usually land is stripped of vegetation by a bulldozer a year or more ahead of time to allow deep melting of the surface muck. Then the partly frozen muck face is washed back by a high pressure jet of water from a large hose or monitor, which is usually fed from a dammed up head of water nearby. Thus, the gold-bearing gravels beneath the muck are exposed and can be pushed by a bulldozer into a sluice box (which lies on a slope below the cut and collects the heaviest minerals, including gold, in the bottom), allowing water to wash the gravel through. Gold is then collected from the matting in the bottom of the sluice box and concentrated. Bulldozing is carried down to a few feet below the weathered bedrock surface, which underlies the gravels, in order to pick up gold that may have sunk into cracks. McConnell (1905) and Campbell (1952, pp. 6-8) give more details on methods of placer mining.

It is during the monitoring phase of the operation that ice age mammal bones are most often exposed at the base of the muck. Many good specimens break up under the impact of water from the monitor, but, fortunately for vertebrate paleontologists and paleobotanists, some miners pick up and preserve interesting looking specimens.

Paleobotany of the Dawson Area was first studied by Campbell (1952, pp. 106; 108-110), who noted that a Pliocene flora found there indicated a distinctly warmer climate than did a pollen diagram of the Independence Peat Bed, a deposit which evidently developed during hypsithermal time. In 1961, Terasmae (1967, p. 4) examined plant-bearing deposits in the Dawson Area.

At present, trees in the area consist of white and black spruce, aspen and balsam poplar, and white birch. The lower ridges and slopes of the higher ones are generally wooded. Stunted spruce occurs sparingly on the highest points. The flat valleys have patches of spruce and poplar that alternate with bare swamps and marshes. Vegetation on well-drained, south-facing slopes having a deep active layer contrasts greatly with that on lower north-facing slopes (Hughes and Rampton 1972, pp. 34, 36).

Total annual precipitation in the Dawson Area is about 33 cm of which about half falls as snow. The growing season is about 150 days, with 1500 degree-days above 42°F (6.7°C). The mean daily July temperature is 56°F (14°C) (Atlas of Canada 1974, p. 58).

PREVIOUS WORK

Old Crow Area

The first recorded ice age mammal remains from this part of the Yukon were collected along the Porcupine River prior to 1873 by the Anglican missionary Rev. Robert McDonald (Table 1). Exact localities were not specified for these fossils, only "Upper Porcupine River", so it is conceivable that some or all could have come from the Old Crow River, a tributary of the Porcupine (Maddren 1907, p. 17). Lydekker (1885, pp. 25-27; 1886, pp. 39, 203) mentioned McDonald's specimens in his "Catalogue of the Fossil Mammalia in the British Museum (National History)". Unfortunately, a clue to the relatively early age of some Pleistocene deposits in this area was lost because a muskox cranial fragment belonging to *Praeovibos*, which had not previously been reported from North America, was identified as belonging to the living muskox *Ovibos*. Adams (1881, p. 117) mentioned three mammoth molars from this collection in his work on British fossil elephants.

Four Americans collected fossils along the Old Crow River. A.G. Maddren (1907, p. 9), working for the Smithsonian Institution, in June 1904 heard from Indians of a promising fossil locality on Old Crow River. Maddren decided to explore

Table 1. Pleistocene mammal specimens from the "Upper Porcupine River", Y.T. presented to the British Museum (Natural History) by Rev. Robert McDonald in 1873 (Lydekker 1885, 1886).

SPECIES	SPECIMEN
Bison sp. - bison	Cranial fragment with right horncore (BM(NH) 44063). Two mandible fragments (BM(NH) 44064-5). Left matacarpal (BM(NH) 44069). Damaged dorsal vertebra (BM(NH) 44068). Three parts of the vertebral column (BM(NH) 44068-8a).
Mammuthus primigenius (= "*Elephas primigenius*") - woolly mammoth	Left Molar (LM_3) (BM(NH) 44060. Heavily worn right molar (RM_3) with a very narrow crown (BM(NH) 44061).
Praeovibos priscus - (incorrectly identified as "*Ovibos moschatus*") - Staudinger's muskox	Posterior part of cranium with partial horncores (BM(NH) 44070.

the river, having received assurances that fossil bones there far exceeded those at any other locality known to Indians of the region. He started up the Porcupine River from Fort Yukon on June 23, and explored the lower part of the Old Crow River by following its winding route for some 270 km. Ice age mammal bones were found on the river bars toward the central part of the basin, and Maddren assumed that they were deposited during spring floods by floating ice from the headwaters of the river. About a mile above the first tributary entering the river from the left, a badly damaged mammoth skull was found. A short food supply caused Maddren to turn back on July 23. He (1907, p. 6) stated: "It was with much reluctance we did so for nearly every mile of the last hundred travelled on the Old Crow River had yielded increasing evidence, in the shape of a tooth, a horn core, or a bone lying on the banks below highwater mark, of the existence of deposits containing considerable remains of the skeleton of large Pleistocene mammals". He concluded that extensive Pleistocene mammal remains, representing principally mammoth, bison and horse, existed on the headwaters of the Old Crow River.

While collecting Recent mammals for the Smithsonian Institution during the summer of 1912, Copely Amory, Jr. obtained a small collection of Pleistocene mammal bones from a locality about 80 km from the mouth of the Old Crow River. Of greatest significance was the presence of a camel toe bone, which Gidley (1913, p. 2) thought was similar in size, but flatter than toe bones of *Camelops*. He considered that the specimen supported the supposition that "milder climatic conditions prevailed in Alaska during probably the greater part of the Pleistocene period", which was rather a broad assumption on the basis of the facts available. Other specimens in the collection were isolated foot bones and teeth of the woolly mammoth, horse, and bison. Gidley remarked on the color and degree of fossilization of the bones, which he thought pretty definitely determined their age as Pleistocene. They were transferred as a gift to the Smithsonian Institution (Gilmore 1941).

O.J. Murie (Geist 1956, pp. 12-13), a United States Biological Survey biologist, made an interesting collection of Pleistocene mammal bones while banding birds in the Old Crow Area in 1926. Most represented horse, mammoth and bison, but a fragment of incisor enamel was identified as belonging to the giant beaver *(Castoroides)*. It was the latter specimen that Murie sent to Otto Geist, which stimulated Geist's interest in the Old Crow Basin as a potential Pleistocene mammal collecting site.

Geist's (1956, p. 13) previous collecting in Alaska for the American Museum of Natural History and the University of Alaska sponsored by Childs Frick had not permitted extensive work elsewhere. However, sponsored by the University of Alaska and financed by the Explorers Club Exploration Fund, he began his boat trip up the Old Crow River on August 3, 1952 (Dodge and Korff 1953, p. 11; Geist 1955, p. 1702). Peter Lord and Charlie Linklater from the settlement of Old Crow acted as his guides.

By August 5, after passing Schaeffer and Johnson creeks, Geist had begun to collect a few fossils on some of the exposed gravel bars. On August 8, beyond Timber Creek, fossils were found on many sand and gravel bars, and some fossils (mainly mammoth) were found "in place in the hard bases of some of the high cliffs." Geist (1956, p. 16) observed what I have called the basal clay unit: "These lower 8 to 10 feet of the river bank consist of hard, tough, gumbolike material which becomes somewhat brittle when exposed to and baked by the sun." Horse and mammoth specimens were most common along this stretch of the river, but some beaver fossils were collected. Above "Last Cutbank" (Locality 51), the water became clearer and Geist stated: "We could see the fossils on the river bottom as we travelled along. We collected only the valuable ones, mostly mammoth teeth." Fossils were evidently scarce or lacking beyond this point.

On August 21 the party climbed Ammerman Mountain, which is just west of the Yukon-Alaska border. After they started downstream, the Old Crow River began to drop noticeably and the weather became colder. They usually found fossils when they stopped to rest. Geist walked up Thomas Creek for a few miles and collected some fossils.

Above Timber Creek fossils were collected on bars and at the foot of bluffs. Geist (1956, p. 27) states. "We also dug out a cottonwood (poplar) stump which evidently had been cut down by beavers; and from the width of the tooth marks, it could have been cut down by a giant beaver. This stump we found still buried very near the line which separated the harder lowerpart (basal clay unit) of the high bluff from the soft overlaying mass". The stump measured 28 cm high by 30 cm in diameter. I think this stump is from the gray organic silty sand (Unit 2) at Locality 44, which may be of Sangamon interglacial age, because Geist (1956, pp. 53-54) mentions collecting samples of fossil wood from "silt banks near Jack Frost's trapping camp [=Locality 44]". Charlie Linklater (personal communication 1975) confirms this notion. Fossils were collected near the mouth of Black Fox Creek on August 28, and many specimens, mainly mammoth, were found on rocky bars farther south. They returned to the settlement of Old Crow on August 30, where the fossils were cleaned, shellacked and packed for shipment.

Although Geist was not an expert in scientific identification of Pleistocene mammals, he was familiar with the more common species that occurred in ice age deposits of Eastern Beringia. Of 380 specimens collected by Geist during his trip up the Old Crow River during 1952, mammoth, horse and bison were most common (Table 2). Evidently at least nine species were represented in his collection, five of which no longer occur naturally in the Yukon Territory.

Brief archeological surveys of the area were conducted in the late 1940s and early 1950s by Douglas Leechman, R.S. MacNeish and Gordon Lowther for the National Museum of Canada.

Vern Rampton, a field assistant of O.L. Hughes of the Geological Survey of Canada, made a geological reconnaissance of the Old Crow River in 1962 during which he collected some fossils. A specimen that particularly attracted my attention was a long, robust antler beam which corresponds most closely to specimens from Alaska referred to "*Cervalces alaskensis*." I believe that these, and other comparable specimens which have been collected since, represent the giant moose, *Alces latifrons*, which had been reported previously only from Eurasian ice-age deposits. Three years later, Corporal L.N. Bates of the R.C.M. Police made another small collection of bones from deposits along the Old Crow River. Both collections were given to the National Museums of Canada.

Table 2. List of Pleistocene mammal specimens from Old Crow River, Y.T. collected during 1952 and identified by O.W. Geist (1956).

SPECIES	NUMBER OF SPECIMENS COLLECTED	% OF TOTAL COLLECTION
Mammoth	126	33.2
Unidentified	86	22.6
Horse	74	19.4
Bison or Muskox *	53	14.0
Bison	18	4.7
Caribou	8	2.1
Muskox	6	1.6
Giant beaver	3	0.8
Moose	3	0.8
Beaver	2	0.5
Wolf	1	0.3
TOTALS	380	100.0

* Probably mainly bison (C.R.H.).

Dawson Area

G.M. Dawson was the first of a series of Canadian geologists, mainly working for the Geological Survey of Canada, to mention Pleistocene mammal remains from the Yukon Territory. He (Dawson 1894, pp. 1-2) credited Robert Campbell of the Hudson Bay Company with originally discovering mammoth fossils there, and gave the following quotation from a brief account by Campbell of his exploration of the Yukon River between 1840 and 1852: "I saw the bones, heads and horns of Buffaloes; but this animal had become extinct before our visit, as had also some species of Elephant, whose remains were found in various swamps. I forwarded an Elephant's thigh-bone to the British Museum, where it may still be seen." Sir John Richardson identified the bone as a tibia rather than a thigh-bone, and referred it to *"Elephas primigenius"* (=*Mammuthus primigenius*, the woolly mammoth). The skeleton from which this bone came was said to be complete when found, but most of the bones were lost. Campbell later remarked that the bones were found near the former site of Fort Selkirk, at the juncture of the Lewes and Pelly rivers (probably the junction of the Pelly and Yukon rivers about 130 km southeast of the Dawson Area). Dawson (1894, p. 3) also noted that gold miners had frequently seen mammoth bones farther down the Yukon River, particularly in the vicinity of Fortymile River, which lies about 60 km northwest of the Dawson Area.

Dawson (1901, p. 185A) also recorded a fragmentary bison skull from Gold Run Creek. Presumably this is the specimen (NMC 7392; Harington and Clulow 1973, pp. 735-736) that was collected by R.G. McConnell in 1900. Whiteaves (1903, p. 241) discussed it and three other *Bison crassicornis* cranial fragments from Dominion Creek, Bear Creek and Bonanza Creek - all in the Dawson Area.

In the course of investigations on behalf of the Muséum d'histoire naturelle de Paris, Obalski (1904, p. 216) visited the Dawson Area, and was able to identify remains of the following Pleistocene mammals: mammoth, mastodon, muskox, bison or buffalo, moose, caribou, wapiti, mountain sheep and horse. Lambe (1905), the newly appointed Verbebrate Paleontologist with the Geological Survey of Canada, listed only nine Pleistocene and postglacial mammal species (only a few of which were from the Yukon) for Canada to 1904. Evidently he had not seen Obalski's report.

In a discussion of the low level creek gravels of the Dawson Area, McConnell (1905) stated: "The creek gravels frequently inclose leaves, roots and other vegetable remains and also bones of various extinct and still existing northern animals, such as mammoth, the buffalo, the bear, the musk-ox and the mountain sheep and goat." Possibly McConnell confused an adult female thin-horn sheep *(Ovis ?dalli;* cranial fragment NMC 17411) that he collected at Thistle Creek in 1901 with that of a mountain goat *(Oreamnos)*. This fossil, with its relatively small, straight horncores, could easily be mistaken for a mountain goat (Harington 1971b, p. 1093). In addition to NMC 17411 and the *Bison crassicornis* specimen mentioned previously, McConnell also collected a cranial fragment of an adult male *Ovis ?dalli* (NMC 17387) from Thistle Creek.

While working for the United States Biological Survey in the summer of 1904, W.H. Osgood (1905a, p. 173; 1905b, pp. 254-255) visited the Dawson Area. He met J.B. Tyrrell of the Geological Survey of Canada, who presented him with two cranial fragments of the extinct muskox *"Scaphocera tyrrelli"* (= *Symbos cavifrons*) and a well preserved American mastodon *(Mammut americanum)* tooth, which are now preserved in the Smithsonian Institution collections. The more complete of the two *Symbos* specimens (USNM 2555) came from Lovett Gulch on Bonanza Creek. The mastodon tooth was collected on Gold Run Creek. These reports extended the known range of both Pleistocene species much farther north. Subsequent papers (Anonymous 1906; Osgood 1907) dealt with two bison specimens from the area.

An interesting coincidence of efforts to collect important ice age mammal specimens in the Yukon and Alaska occurred in 1907, when field parties of the Smithsonian Institution, led by C.W. Gilmore, and of the American Museum of Natural History, led by L.S. Quackenbush, converged on Dawson. Obviously both groups were after "big game" like the remarkably well preserved Berezovka mammoth from the Siberian tundra that had been excavated in 1901.

Gilmore arrived first on June 14 and departed for Alaska on June 22. His goals were to secure remains of large extinct vertebrates and to investigate the causes that led to their extinction. Gilmore (1908, pp. 5-6) assessed fossil collecting in Dawson as follows: "Scattered remains of Pleistocene mammals are commonly found in the diggings of this region, but the result of diligent inquiry regarding the finding of complete or partial skeletons in the mining operations conducted here were not encouraging. In only one instance were we told of the finding of an accumulation of bones such as would lead one to believe that an entire skeleton or any considerable part of the skeleton of a single individual had ever been found.

The single case mentioned was that of the remains of a mammoth (*Elephas primigenius*) disinterred while sinking a shaft on Quartz Creek in March 1904. The skull and tusks were recovered intact, but, according to our informant, although surrounded by a mass of other bones, no attempt had been made to preserve them." Gilmore (1908, p. 15) picked up parts of mammoth, bison, horse and moose in the talus from Magnet Gulch. At Fox Gulch, about 2 km downstream from Magnet Gulch on the left limit of Bonanza Creek, he was shown many fine skulls and other skeletal parts of the same species. A complete mammoth skull and three bison skulls were seen at Fox Gulch.

After arriving in Dawson on July 19, 1907, Quackenbush (1909, pp. 88, 89) spent three days examining several collections of ice age mammal fossils that had been found in the vicinity, his object being to collect specimens for the American Museum of Natural History. He described a section from Fox Gulch on Bonanza Creek as consisting of bedrock overlain by from 10 cm to 1.2 m of gravel, which was covered by 6 m or more of muck. Quackenbush (1909, p. 91) noticed a small mammoth tusk projecting from just above the gravel unit, and the radius of a large bear within about a metre of it on the same level. G.T. Coffey, who was in charge of the operations, said that all fossils came from a small area near the head of the gulch, where they lay in the muck on top of the gravel or partly embedded in the gravel. Quackenbush recorded the following additional specimens from the site: bison (33 "bones", seven skulls, two mandibles); mammoth (one skull, two molars, several damaged tusks); horse (one fragmentary pelvis). A list of 14 species of Pleistocene mammals from the Dawson Area recorded by Quackenbush (1909, pp. 126-127) is given in Table 3.

Lambe (1911a, b) reported an interesting find of an extinct short-faced bear cranium from Gold Run Creek. It was collected in 1909 and is the largest known cranium of *Arctodus simus yukonensis* (Harington and Clulow 1973, pp. 699-700). In the following year (1912), Lambe reported five species of Pleistocene mammals from the vicinity of Dawson that had been collected by D.D. Cairnes of the Geological Survey of Canada, and listed Canadian ice age mammals known to him. He recorded 18 species for Canada of which 14 had been reported from the Yukon Territory (10 of which had only been found in the Yukon). At that time, Yukon Pleistocene mammals were better known than those from any other province or territory in Canada because of the abundance of well preserved remains in that part of the unglaciated region, and because they were being uncovered rapidly by booming placer operations.

Table 3. List of Pleistocene mammal species of the Dawson Area, Y.T. recorded by L.S. Quackenbush (1909).

SPECIES	REMARKS
Mammut americanum (="*Mastodon americanus*") - American mastodon	- Obalski (1904, p. 216) saw mastodon remains in the area. Maddren (1907, p. 7) considered this an error, but there are two definite records from branches of the Indian River (Gilmore 1908, p. 30). Other specimens have been found since.
Mammuthus primigenius (="*Elephas primigenius*") - woolly mammoth	
Equus sp. - horse	
Bison crassicornis - large-horned bison	
Bison bison occidentalis (="*Bison occidentalis*") - western bison	
?*Bootherium* sp. (="*Bootherium bombifrons*") - extinct muskox	- This identification, made from a photograph taken by T. Obalski on Gold Run Creek in July 1903, is questionable (Harington and Clulow 1973, p. 734).
Symbos cavifrons (="*Symbos tyrrelli*") - extinct muskox	- Quackenbush saw an incomplete skull from Magnet Gulch, Bonanza Creek in 1907.
Ovibos moschatus - muskox	
Ovis sp. - *mountain sheep*	- Quackenbush examined an incomplete skull from near Hunker Creek in 1907.
Alces sp. - moose	
Rangifer sp. - caribou	
Cervus elaphus (="*Cervus canadensis*") - wapiti	- An 18-inch tine from near Hunker Creek was seen by Quackenbush in 1907.
?*Ursus* sp. - bear	- Perhaps this specimen represents *Arctodus*, the extinct short-faced bear, rather than the brown bear.
Canis sp. - wolf	- A fairly complete wolf skull from Pleistocene deposits near Hunker Creek was examined by Quackenbush in 1907.

J.B. Tyrrell (1912, p. 35) listed 15 species of ice age mammals that he considered to be represented by fossils in Pleistocene gravels of the Dawson Area. As with most lists of this nature it is difficult to say what fossils it is based on and who identified them. The list is probably derived from Quackenbush's (Table 3). I question particularly the identification of *Bootherium bombifrons* and *Ursus*.

In a review of extinct North American bison, Hay (1913, pp. 167-168, 180-181) commented on and figured two Pleistocene bison cranial fragments from near Dawson. A fairly complete cranium (AMNH 13721) collected by Quackenbush at Fox Gulch he perhaps incorrectly refers to *Bison occidentalis*: it is probably *Bison crassicornis*. Another cranium with complete hornsheaths from Bonanza Creek displayed in the Golden Gate Park Memorial Museum, San Francisco, is referred to *Bison crassicornis*. Mastodon and additional mammoth remains, mainly molar teeth, were reported from the area by Lambe (1914); and Holland (1915) recorded a *Bison crassicornis* skull from the Dawson Area deposits.

In 1917 Hay described one of the most important members of the Pleistocene fauna from the region, as a new species of small, broad-skulled horse, *Equus lambei*. The type specimen (USNM 8426) is a complete skull that was unearthed on Gold Run Creek in 1903. It was purchased by the Geological Survey of Canada and was loaned to O.P. Hay of the Smithsonian Institution for examination (Harington and Clulow 1973, p. 708). Six years later Hay (1923) described two additional specimens of this kind.

Clark (1927) described another *Bison crassicornis* skull from the area. H.S. Bostock of the Geological Survey of Canada made an interesting collection of ice age mammal fossils from Miller Creek near Dawson in 1932. Four species are represented in this collection, which is in the National Museums of Canada: *Mammuthus* cf. *primigenius*, *Equus (Asinus) lambei*, *Rangifer tarandus* and *Bison crassicornis* (Porsild *et al.* 1967, p. 113). The most recent contribution on Yukon fossil mammals by a geologist was published by the late M.Y. Williams (1937). Three *Bison crassicornis* crania from the Dawson Area are described in the publication. Two skulls were found on Bonanza Creek, and the locality of the third is unknown.

[illegible] thesis on the paleobotany of the Pleistocene muck deposits [illegible] the Dawson Area, Campbell (1952, pp. 58, 101) remarks [illegible] at Hunker Creek "Remains of certain moose-like animals [illegible] found in the lowermost silt beds a little above 'grade' [illegible] Pleistocene horse and some forms of giant bison and musk-ox appear in the region of interspersed coarse beds. At grade level a few remains of mammoth are found, and in the levels dug by the dredge below grade, considerable amounts of ivory are recovered, often in good condition. Mastodon remains are very rare in the Klondike, having been recovered only once or twice and then from mucks of doubtful position." To his knowledge no remains of flesh and hide were reported from the Dawson Area, although bones were plentiful. He found, or was present when others found, remains of the following Pleistocene mammals at Hunker Creek: "Grizzly bear {possibly *Arctodus* rather than *Ursus*, the grizzly or brown bear, C.R.H.}, Horse, Wapiti, Moose, various extinct Moose-like cervids, Bison of several kinds, various Musk-ox-like Bovids, and Mammoth." Campbell's was the first attempt at a detailed paleoenvironmental study of the area based on paleobotanical evidence.

Further data on fossil mammals as related to Pleistocene stratigraphy in the area were provided incidentally with a description of a pathological mammoth tooth from Hunker Creek by Hunter and Langston (1955, p. 675). This information was derived from the field records of O.L. Hughes, who made valuable collections of Yukon Pleistocene vertebrates for the National Museum of Canada during the 1960-1965 period.

In a study of Pleistocene wapiti of Alaska and the Yukon Territory, Guthrie (1966, pp. 50-51) illustrated a large antler of *Cervus elaphus* from Sulphur Creek in the Dawson Area.

It is easy to see a few general trends affecting the study of Pleistocene mammals in the Old Crow and Dawson areas of the Yukon during this period. Specimens were first collected by explorers, traders and missionaries and donated to the British Museum (Natural History). The next stage, beginning about 1900 was characterized by reconnaissance and collecting trips of Americans, mostly representing large museums in the eastern United States. The last of any note was Geist's collecting trip up the Old Crow River in 1952. Obviously, Canadians generally lacked expertise in the study of Pleistocene vertebrates and were not very concerned with preserving them as part of the nation's heritage during this period. The fact is clearly demonstrated in cases where valuable specimens collected by Canadians were donated by them to foreign museums. Certain parallels may be seen in the Canadian dinosaur rush (Colbert 1968, pp. 175-200). Many of the most remarkable dinosaur specimens from southern Alberta and Saskatchewan are found in museums abroad.

PRESENT WORK - 1966 to 1975

Old Crow Area

In addition to discussions with O.L. Hughes and L.H. Green of the Geological Survey of Canada, the following comments by H.S. Bostock (1961, p. 118) stimulated my interest in the Old Crow Basin as a study area: "The explorers in the northern Yukon from the early days have remarked on the tusks seen there, and the Indians are reported as saying that the course of the Old Crow River was the best locality in Alaska and the Yukon to find them. Certainly the geological setting of the Old Crow Plain with its recent subsidence and unglaciated character suggests that it should be." Field work began in 1966 and has continued each year until the present, except for 1969, 1970, 1972 and 1974.

1966 - Collecting took place between July 2 and August 17. My field assistant was Peter Lord. The first three weeks were spent on a reconnaissance of the Old Crow River. Specimens were collected at 34 localities between the mouth of the river and Timber Creek. My goal was to find the most productive fossil localities and the most complete and clearly exposed stratigraphic sections for detailed examination in the future. Horse, mammoth and bison specimens were most common. Moose, giant moose *(Alces latifrons)*, caribou, muskox *(Boötherium)*, mastodon, fox, ground squirrel, fish and bird remains were rarer.

At Locality 14N a fleshing tool made from a caribou tibia was found with mammoth and other Pleistocene mammal remains. Realizing the significance of the artifact, I showed it to W.N. Irving, then an archeologist with the National Museum of Canada, who was excavating a Kutchin site on the Porcupine River near the settlement of Old Crow. Another week-long trip was made up the Old Crow River in order to show Irving Locality 14N.

A reconnaissance trip was made up the Porcupine River, the lower Bell River, and the lower third of the Eagle River from August 6-13. A few promising localities were noted on the Porcupine River, but fossil collecting on the lower Eagle River was much poorer than on the Old Crow River.

1967 - Field work lasted from June 30 to August 22. My field assistant was Peter Lord. During the first week of July we travelled down the Porcupine River from Old Crow, in order to examine three of the most complete stratigraphic sections in the region. Mollusc shells for radiocarbon dating, and rodent, fish, beetle and plant remains were collected from Wisconsin age deposits at Porcupine Locality 100 about 10 km south-southwest of Old Crow (McAllister and Harington 1969). A significant discovery at this site was a highly oxidized, compacted basal unit containing large tree trunks, beaver-cut sticks and many large spruce cones. I tentatively interpreted it as having been deposited in an interglacial period. This unit had been covered by slumped material when Hughes had visited the site earlier.

Fossils were excavated *in situ* (but not in primary position) at localities along the lower part of Old Crow River, south of Johnson Creek, from July 7-22. Excavated material consisted mainly of mammoth, horse, moose, caribou and rodent specimens. Since these fossil-bearing deposits were relatively high on the stream banks, the unusually high waters of the Old Crow River prevalent during the summer had little effect on our work.

A late Wisconsin fossil deposit was discovered near the top of a bluff at Locality 11(1) by a field party under W.N. Irving. Two well-preserved large-horned bison crania and associated material were collected there. This find was important in establishing the type of variation between males and females of *Bison crassicornis*, and, so far, provides the last evidence of the species in that region. Further excavation at Locality 14N yielded remains of beaver, giant beaver, mammoth, horse, muskrat, ground squirrel, fish and bird.

On July 23, Irving and I made an aerial reconnaissance of the Eagle River in an attempt to locate promising archeological and fossil sites. Irving, T. Hamilton, a Pleistocene geologist from the University of Alaska, and I examined in detail the stratigraphy at Localities 10, 11, 12, 14, 14N and 15. Fossils were excavated at various levels on the steep bluffs at Localities 12 and 15.

Many bones, including the skull and teeth, of an individual mammoth were collected during a reconnaissance trip up the Whitestone River between July 27 and August 9. This was the first time I had encountered a partly-articulated Pleistocene mammal skeleton. The discovery was exciting because I was led to it by following up an old story, which had been handed down to some of the natives of Old Crow, of "monsters" in that area.

During August 14 to 19, many fossils were excavated along the Old Crow River, and a few new and promising localities such as Locality 44 were found upstream from the mouth of Timber Creek.

1968 - Field work took place between June 9 and August 7. My field assistant was Peter Lord. O.L. Hughes and I carried out co-operative stratigraphic - paleontological studies during the first two weeks of this period. We spent June 12-14 at Locality 100 on the Porcupine River, prior to examining Pleistocene sections on the lower Old Crow River. A well-preserved giant beaver *(Castoroides)* mandible with teeth was collected at Locality 100, and Hughes confirmed my earlier report of a basal organic unit there suggesting a relatively warm climate. We collected paleobotanical specimens from the basal unit for study by L.V. Hills of the University of Calgary.

We surveyed fossil localities on the lower half of the Old Crow River as far upstream as Locality 32 from June 15-19. Hughes noted signs of cryoturbation in the lower levels at a number of localities, providing a further criterion for their separation from the higher sedimentary beds. Pollen and radiocarbon samples taken by Hughes were used later by Lichti-Federovich (1973) in her reconstruction of the late Pleistocene botanical history of the Old Crow Basin. Hughes departed on June 21.

From June 23 to July 13, emphasis was placed on discovering new localities in the upper part of the Old Crow

River, which I had not surveyed previously. Specimens were found as far upstream as Thomas Creek. Some of the more promising localities upstream from Black Fox Creek were excavated.

A reconnaissance of the lower part of the Bluefish River was attempted from July 17-19, but had to be abandoned because of low water.

Excavations were carried out on the lower Old Crow River between Black Fox and Schaeffer creeks. New Pleistocene vertebrate sites were discovered, bringing the total in the Old Crow Area to 73. Interesting specimens represented: lemming, hare, black-footed ferret (Anderson 1973), a camelid, muskox *(Ovibos)*, wolf and waterfowl. Some bones, apparently modified by early man, were collected. Perhaps the most unexpected find was a scimitar cat *(Homotherium)* mandible - a northward Pleistocene range extension of about 3200 km.

<u>1971</u> - Pleistocene vertebrate fossils were collected during the period July 1 - August 12. My field assistants were G.R. Fitzgerald and Charlie Thomas. July 3-4 was spent at Locality 100 on the Porcupine River. The basal unit was checked carefully again and further organic samples were

collected, but no trace of vertebrate remains was found.

The first trip up the Old Crow River took place from July 4 to 23. We camped at Locality 11A, a point bar consisting of layers of pea-sized gravel, sand and vegetation. The site, discovered in 1970 by a field party under W.N. Irving, is one of the richest concentrations of ice age vertebrate remains in the Old Crow Basin. The most remarkable specimen collected from the site is a cranial fragment with horncores of *Soergelia* cf. *elisabethae*, a primitive muskox, which until then was only known from early middle Pleistocene deposits in Germany. Seven test trenches were cut into the bar and many specimens were collected. A new site (Locality 74) produced many fossils, the highlight of which was the discovery of the first specimen of the extinct muskox *Praeovibos* from the Old Crow Basin. This partial skull with horncore confirmed Robert McDonald's earlier find on the "Upper Porcupine River."

Locality 11(1) yielded more *Bison crassicornis* material, including a cranium with horncores. Sediment and peat samples were taken from the fossil zone for paleoenvironmental studies by J.V. Matthews. On July 12, Charlie Thomas excavated an interesting black obsidian biface at Locality 20 -- the first finely-flaked stone artifact we had seen in the deposits carrying remains of ice age mammals in the Old Crow Basin. Many fossils were collected at this site including pika, wolverine, ground squirrel and vole. At one point our excavation near the base of the bluff at Locality 20 was stopped by permafrost. The farthest point upstream that we reached was Locality 65.

The goal of the next trip up the Old Crow River (July 27 to August 9) was to find new localities and excavate old ones upstream from Timber Creek. A few days (August 1-4) were spent excavating with trowels and sluicing the gravels at Locality 29 in order to pick out smaller specimens, such as rodent, bird and fish. During this period, I collected a gray chert flake, which had evidently been struck from a core, and the proximal part of a caribou antler showing four polished facets on the base. I speculated that it could have been used as a pestle.

Most of the site which Peter Lord and I had excavated at Locality 44 in 1968 had been eroded away, so efforts were directed to obtaining samples of small vertebrates, beetles, mollusc shells, seeds, and wood for radiocarbon dating from finer sediments of the same unit a few metres downstream from the original site. Matthews was able to provide a great deal of information on the paleoenvironment that existed there during the deposition ~~of the fossil~~ de-posits by studying our samples from this locality.

1973 - On July 2, with O.L. Hughes and N. Rutter of the Geological Survey of Canada, a helicopter survey was made of the southern Old Crow Basin, and the upper parts of the Driftwood and Berry river valleys. We later visited a site on the lower Rock River, where Hughes had found fossil elephant remains during the previous year. Evidently the material had come from a unit near the base of a high bluff. Much slumping had occurred since, and the fossil-bearing unit was masked. We proceeded to the lower Eagle River, where a caribou toe bone and part of a large cervid (?) metacarpal were collected along the shore.

Hughes had visited Locality 12 and gave me part of a caribou mandible and the metatarsal of a small horse from that site. Other fossils, including bison and wolverine specimens, from Locality 81 near the mouth of Surprise Creek were donated by D. Showalter and D. Reid who were working for the Canadian Wildlife Service. On July 4, I accompanied them on an aerial biological survey to Herschel Island, where a number of Pleistocene vertebrate fossils had been found previously. A small seal scapula fragment was collected half way up an 18 m coastal bluff on the west side of Pauline Cove.

Bob Mackenzie, who was living there, had collected part of a hornsheath that had characteristics of *Bison crassicornis* hornsheaths.

My intention this year was to spend long periods excavating at some of the most productive sites, such as Localities 11A, 20, 22, 27W and 44, in order to get a better idea of the variety of Pleistocene vertebrate species in the Old Crow Basin, and in the hope of finding further critical evidence of early man. With Charlie Thomas and G.R. Fitzgerald as assistants, I started up Old Crow River on July 5. The next day we camped at Locality 11A, where the bar was so densely covered with fossils that it was difficult not to step on them when landing from the boat. It was more efficient to excavate trenches into the bar than to try to wash away the finer sediments with a hose (water was absorbed too rapidly by the sand and gravel). Among the bones collected were those belonging to: fish, bird, muskrat, beaver, giant beaver, bison, mammoth, large and small horse, ground sloth, caribou, muskox, camel, moose, wolf. I collected a fine gray chert flake that had been struck from a core. Charlie Thomas found the left part of a *Bison crassicornis* cranium with horncore partly buried in surface sand at the upstream end of the bar. From its relatively fresh appearance, which contrasted with the almost blackish staining of most of the other fossils, I thought it had been washed down from the mouth of the gully at Locality 11(1), which was a few kilometres upstream. A radiocarbon date on bone from the skull that I received later suggested that this was so. More late Wisconsin bison material was collected at Locality 11(1). Locality 14N was virtually destroyed as a collecting site by a combination of clay slumping down from the bank above, and by a thick cover of stream silts that masked the lower bank and the fossil-bearing unit.

A number of interesting specimens were collected at Locality 66: ground sloth, scimitar cat, and wolverine. A large sample of shells was collected from the fossiliferous gray silt overlying the basal clay unit at Locality 64, in an effort to obtain further specimens of *Fluminicola*. A single specimen of this coiled shell from Locality 64 had been identified by A.H. Clarke (personal communication 1970), who stated that it was a significant northerly range extension and indicated that warmer climatic conditions once prevailed in the area. A black-footed ferret mandible was the highlight of a collection from a new site, Locality 83.

On July 19 I collected a mammoth tooth that was definitely in place near the upper surface of the basal clay unit at Locality 12. Few Pleistocene vertebrate specimens have been found in this unit, which is presumably beyond dating by the radiocarbon technique. A few days were spent at Locality 11A, and 10 trenches 1 m wide x 1 m deep and up to 12 m long were excavated from the shore back into the bar deposits. Careful excavation with trowels yielded many fish, bird and rodent fossils. Outstanding specimens were: a maxilla fragment with teeth of the short-faced bear *Arctodus*; a mandible with teeth of a large, extinct marten *(Martes nobilis)*; and, on July 25, Charlie Thomas excavated a large gray chert biface that may have been used as a knife. We returned to Old Crow on July 26.

A second trip up the Old Crow River lasted from July 30 to August 8. Between August 2 and 3 enough matrix was excavated at Locality 44 to fill two large boxes in order to facilitate further paleoenvironmental work by Matthews on the fossiliferous layer (Unit 2). Three pails of matrix from that unit were screened, dried and bagged. Many specimens were collected at Locality 27W near the mouth of Timber Creek from August 4 to 6. The fossil-bearing sediment was well suited for wet-screening, and many bags of concentrate were collected for study in the laboratory. A grayish chert blade was excavated from the oxidized fossiliferous gravels overlying the basal clay unit at this site on

August 5. Nine new localities were discovered between the mouths of Timber and Black Fox creeks. More *Bison crassicornis* material was collected from Locality 11(1).

1975 - Field work took place from July 1 - August 21. The first week of July was spent in co-operative studies with members of the Yukon Refugium Project (O.L. Hughes (geologist), R.E. Morlan (archeologist), C. Schweger (paleobotanist) and an associate, R. Bonnichsen (archeologist). During the rest of the field season in the Old Crow Area, I was assisted by G.R. Fitzgerald and C. Thomas. Old Crow River Localities 11, 11A, 12 and 44 and Porcupine River Locality 100 were visited from July 1-7. At Locality 44 a pika mandible was collected *in situ* from sediments containing wood, conifer cones and mollusc shells approximately 30 feet (9.1 m) above river level. Few fossils were found along the base of the bend at Porcupine River Locality 100, largely because of the degree of slumping that had occurred after the high water of the spring melt. At Locality 11, O.L. Hughes found a horse lower cheek tooth *in situ* approximately 3 feet (0.9 m) above stream level in the upper organic part of the basal clay unit. Ironstone appeared to be characteristic of that particular stratigraphic level. Part of a mammoth limb was found in a similar stratigraphic position about 5 feet (1.5 m) above stream level farther downstream at Locality 12. The period July 7-12 was spent on a reconnaissance of Johnson Creek. Although a good collection of fossils was obtained at Locality 71 and a few bones were collected on the surface near the base of a number of the bluffs on the lower part of the creek, no important fossil vertebrate localities were discovered. At the farthest locality upstream on Johnson Creek, samples of wood were taken for radiocarbon dating from tree stumps that appeared to be rooted in organic silt at least 5 feet (1.5 m) from the surface. Tundra now occupies the surface in this region.

From July 12 - July 22 four new localities were found between Locality 14N and the mouth of Black Fox Creek. Most of the time was spent excavating at Localities 20 and 22. At the former, a mammoth molar was found *in situ* in the basal clay unit. At the latter site a black chert "knife" was found on the surface by G.R. Fitzgerald. Among the specimens collected on the bar at Locality 66 were: wolf, wolverine, giant beaver, muskrat, mammoth, horse, moose, caribou. A camel toe bone (first phalanx) was collected on the bar at Locality 23. The only other find of note during this trip was a beaver-cut stick collected *in situ* in the basal clay unit approximately 15 feet (4.6 m) above stream level at Locality 96. It indicates that beavers (Castoridae) occurred in the region during ?Illinoian time with mammoth, horse, and caribou. This site has one of the longest continual exposures of the basal clay unit I have seen on the Old Crow River, and would be a good place to study it.

The second trip up Old Crow River took place between July 27 and August 16. At Locality 11(1) the tibiofibula of a small rodent was found in place in an oxidized sandy layer in gray and orange banded silts about 15 feet (4.6 m) above creek level and well above the upper surface of the basal clay unit. The specimen may be of early Wisconsin age. On July 28, I found a new locality (106). Overlying the basal clay unit at this site was more than 18 feet (5.5 m) of organic matter with a rooted stump, small logs, layers of woody detritus, lenses of whitish mollusc shells, and beetle remains. It was overlain by approximately 33 feet (10.1 m) of buff and gray banded silts with thin organic layers, at least 2 feet (0.6 m) of late Wisconsin glacial lake clay and 15 feet (4.6 m) of indeterminate postglacial surface deposits. No bones were found *in situ* in the thick organic unit, which I correlate with the fossiliferous zone of ?Sangamon age at Locality 44, but a beaver cut stick was collected *in situ* 1 foot (0.3 m) below the stump. This locality when studied in detail promises to produce a great deal of information about the late Pleistocene environment of the Old Crow Basin.

On July 29, a grayish black, veined chert flake made by man was collected from the surface of a gravelly bar at Locality 32E. At Locality 60 a lower horse cheek tooth, and a caribou antler base with part of the braincase attached were excavated from gravels that appeared to be in the upper part of the basal clay unit. I later cleaned a large section of the basal clay unit, exposing what seemed to be a section of a stream channel cut into the lower inorganic part of the basal clay. The channel was at least 11.5 feet (3.5 m) across and 4.1 feet (1.3 m) deep and lined from outside to inside by successive layers of: (1) oxidized gravel containing part of a horse metapodial, part of an elephant (probably mammoth) tusk and a fragment of the root of an unidentified tooth; (2) sand; (3) organic detritus and twigs; (4) a fill of relatively flat lying oxidized sandy silt with some thin bands of organic material. I consider that this channel represents the sequence of deposition expected in a cut-off meander, with a steadily decreasing rate of stream flow. If the relatively sterile basal clay unit surrounding the channel represents an Illinoian Glacial Lake Old Crow deposit, then probably the downcutting phase of the channel would have occurred at the close of Illinoian time and most of the channel fill would be attributable to the early Sangamon phase. In turn, this would suggest that the fossiliferous sediments at Locality

44 would be of middle to late Sangamon age.

On August 3, a caribou naviculocuboid that had been faceted on the proximal surface was collected from the head of the bar at Locality 108, with goose, giant beaver, mammoth, horse, caribou and bison fossils. The next day we explored the banks near the mouth of Surprise Creek and then began the return journey to Old Crow. Charlie Thomas collected a well-preserved red fox cranium from the surface at Locality 115. Locality 127 seemed to be a promising site, because 15 minutes of excavation yielded 10 valuable specimens both large and small.

At Locality 45, a tusk and fragments of an elephant limb bone were found *in situ* in banded silts approximately 10 to 15 feet (3.0 to 4.6 m) above the upper surface of the basal clay unit and 40 feet (12.2 m) below the surface of the section, suggesting an early to middle Wisconsin age. The specimens were collected with woody material from the same lens in order to obtain radiocarbon dates. Gravel patches along the river downstream from Locality 132 were definitely more productive of fossils than those upstream from that site. A lower cheek tooth of a horse, faceted by man on the labial surface, was collected on August 7 at Locality 134. An interesting artifact was collected at

Locality 29. It consists of the proximal part of a caribou antler from which the brow tine had been removed and the base bevelled in. Cut marks can be seen on the bez tine "handle". Presumably this artifact was used like a hammer for removing flakes from a stone core. Two other artifacts had been found at this locality previously, making it of great interest to archeologists. Another camel phalanx was collected here. On August 10 at Locality 138 I found a complete black chert projectile point on the surface of the basal clay. *Anodonta beringiana* shells and Pleistocene mammal bones were found with it.

Locality 143, a large area of exposed river bottom, yielded two pails of good specimens. Among them was the distal end of a horse humerus with facets on either side of the olecranon fossa that obviously had been made by man. On August 14 the organic horizon at Locality 106 was sampled. A cranial fragment of the extinct muskox *Symbos* was found later at Locality 21. We arrived at Old Crow on August 16. Approximately 50 new localities had been discovered during the summer.

A substantial collection of well preserved *Bison crassicornis* bones from Locality 11(1) was transferred to the Quaternary Zoology section by R.E. Morlan. They add to the abundant collection of large-horned bison specimens from that late Wisconsin site.

Dawson Area

1966 - Field work took place during two periods from June 12 - July 1 and from August 17-28. On June 14, O.L. Hughes and I visited the recently abandoned Fant and Norback site on Hunker Creek, where hundreds of Pleistocene mammal fossils were found during the previous few years. We then proceeded to Harold Schmidt's operation on Dominion Creek and I visited several other sites on Gold Bottom, Bonanza and Eldorado creeks.

On June 18, Hughes showed me other localities on Dominion and Sulphur creeks. Most of the active placer miners in the area were visited and proved willing to keep vertebrate remains for the National Museums of Canada. The commonest remains collected were of horse, mammoth and bison. Caribou and mountain sheep specimens were less common, and American mastodon, giant moose *(Alces latifrons)* and muskox *(Symbos cavifrons)* were rare. Samples of what appeared to be organic clay in the White Channel gravels were taken for paleobotanical analysis.

On June 21, Hughes and I examined sites at Stirling Bend and "Ash Bend" (the next bend upstream from Stirling Bend) on the Stewart River. No vertebrate fossils were found beneath sediments of the Reid advance, which is older than late Wisconsin. At "Ash Bend", bison and mammoth specimens were collected below a layer of volcanic ash that has been radiocarbon dated at over 42,900 years old. On June 22 we visited various sites farther down Stewart River by boat. I received a few *Bison crassicornis* cranial fragments from K. Djukastein on Brewer Creek.

Articulating humerus and ulna fragments of the extinct American lion *(Panthera leo atrox)* found on Harold Schmidt's ground on Dominion Creek proved to be the first record of the species for Canada (Harington 1969). Another interesting find consisted of viable arctic lupine seeds, which Schmidt had collected earlier with a collared lemming skull from Pleistocene deposits at Miller Creek. Before leaving for Old Crow, I visited O. Medby and J. Lynch at Glacier Creek and Miller Creek. Although no fossils were collected, Lynch told me that J.F.V. Millar, an archeologist, had taken a large pile of ice age mammal bones that had been amassed by J.P. Miller near the dredge on Glacier Creek. This collection is apparently at the University of Calgary. However, it could not be located there in 1976.

From August 17 to 28, I revisited the placer operations seen earlier and obtained fossils collected by some of the miners. Many specimens were obtained from G. Heitman on Cripple Hill (Dawson Locality 2), Harold Schmidt on Dominion Creek (Dawson Locality 28), and Ernie Schink on Gold Run Creek (Dawson Locality 32). A few days were spent in reorganizing, labelling and cataloging the Pleistocene mammal specimens on exhibit in the Dawson City Museum.

1967 - Field work was undertaken from June 5 to 28 and August 22 to September 8. A fine horse skull was received from Harold Schmidt on Dominion Creek on June 8. He was using a monitor to wash away frozen muck and said that it broke up the fossils more readily than when his large sprinkler system was used to gradually "melt down" the muck layer. He noticed that about two-thirds of the fossils he had collected the previous year had come from the point where a "pup" (creek tributary) entered Dominion Creek. These are often areas where great thicknesses of muck and vegetation are concentrated.

This observation enabled me to form a hypothesis that most Pleistocene mammal fossils would be found at points on the major creeks which were fed by pups, and that if pups entered from both sides of the valley near the same point, the fossil concentration would be greater. The reasoning behind the hypothesis is: (a) the pups were the main channels down which the reworked upland loess, with vegetation mats and bones of mammals that had died on the higher steppe grasslands, was washed or moved by mass wastage into the creek bottoms; (b) as these organic loads reached the level of the creek bottoms, they would lose velocity and tend to build up in thickly concentrated masses; (c) the bones, because of their greater density, would become concentrated at the base of the muck near the upper surface of the gold-bearing creek gravels.

The Fant and Norback pit on Hunker Creek, formerly so rich in fossils, had suffered heavy slumping and the surface was nearly covered by vegetation. Promising exposures can be lost rapidly in this country, if the faces of cuts are not kept fresh each year. No specimens were collected at Glacier and Miller creeks, as most of the miners were still stripping vegetation from the surface.

From June 16 to 21, I examined sites in the glaciated Mayo region and had another look at the "Ash Bend" fossil locality on the Stewart River. A few years earlier Pleistocene mammal fossils had been collected by Ed Bleiler on Highet Creek, near Mayo, but when I examined the area, none was found. Stratigraphic sections were made on the clearest exposures seen on Highet Creek and near Hans Barchan's claim on Johnson Creek. No fossils were seen at Haggart Creek near Acheson's placer operation, but Fred Taylor on Dublin Gulch gave me an astragalus that had evidently been washed down to the floor of Dublin Gulch from organic deposits on its left limit. A large sample, including ostracodes and molluscs, was taken from a marl deposit near the landing strip at Mayo for study by L.D. Delorme. Several bison bones were collected at "Ash Bend" on the Stewart River: one bone was found in place about 4 feet (1.2 m) below an ash layer.

On June 26 excavations at Cripple Hill yielded horse, bison, caribou and mountain sheep fossils. Most of the bones were stained reddish-brown from the iron in the gravel at the base of the muck, from which the fossils came.

On August 24, Ernie Schink donated a good immature Yukon wild ass *(Equus (Asinus) lambei)* cranium, a badger humerus, and part of a caribou skull from Gold Run Creek. Two days later I found an almost complete badger cranium and a Yukon wild ass skull on the right limit of Schmidt's claim on Dominion Creek. A nest containing bones of an individual ground squirrel *(Spermophilus parryi)*, droppings, seeds from a cache, beetle remains, etc. was recovered from this site.

Half of a wolf cranium and a posterior fragment of an American lion cranium were the most important fossils from Quartz Creek donated by Art Sailer. A highlight of field work in 1967 was the identification of a postglacial muskox of the living variety *(Ovibos moschatus)* from deposits near the surface at Brewer Creek on Stewart River.

1968 - Field work was carried out from August 7 to 21. A bison cranial fragment with an unusually long horncore was donated by Lorne Ross from his placer operation on Gold Run Creek (Dawson Locality 33). It is larger than any *Bison crassicornis* horncores I have seen and is referred to the Alaskan bison *(Bison alaskensis)*. Bone from this specimen yielded a radiocarbon date of <39,000 years B.P. Ernie Schink donated horse, bison, caribou and moose fossils. He said that Lamontagne had sold a nearly perfect Pleistocene horse skull, with other bones and tusks from their site, to Alex Seeley from Whitehorse, who was buying fossils at $1 per pound for any kind of bone. Seeley was selling them to tourists. Later, with the help of F.V. Clulow, I was able to trace the horse skull and other bones to a collection at Laurentian University and, ultimately, to publish descriptions of them (Harington and Clulow 1973, Figure 22).

On August 19, I collected a Yukon wild ass cranium from the right limit of Dominion Creek on Schmidt's ground. Heavy wear on the teeth indicated that this specimen was from a very old horse. Fossils were also collected from Sailer's ground at Quartz Creek and Lunde's claims on Gold Bottom Creek.

1969 - I did not carry out field work during this period, but, at my request, A. Lissey, then of the Geological Survey of Canada, and his assistants kindly visited the placer operations of E. Schink and J. Lamontagne on Gold Run Creek, M. Kinakin on Allgold Creek, and A. Sailer and H. Schmidt on Quartz Creek. The most interesting specimens from Quartz Creek were a nearly complete humerus of a large turkey (*Meleagris* sp.) and the right horncore of a wood bison (*Bison bison athabascae*). The former was collected by Art Sailer and the latter by Harold Schmidt. Wood bison had never been recorded from the Dawson Area before. Arrangements have been made since then to obtain a relative age on the turkey specimen using the amino acid racemization technique developed by Bada (Anonymous 1975, p. 349).

1970 - Field work took place from August 9 to 18. Yukon wild ass, bison and moose were received from O. Lunde on Gold Bottom Creek. I was able to examine the stratigraphy at Art Sailer's placer operation on Quartz Creek. Most likely the turkey specimen collected the previous year came from the interface between the gold-bearing gravels and the overlying muck unit. Contact was made with Walter Rasmussen, who was preparing ground upstream from Sailer's on Quartz Creek. He said he would be willing to donate fossils to the National Museums of Canada.

Horse, bison, moose and caribou fossils were collected from Schmidt's ground on Dominion Creek. Schink and Lamontagne were closing their operation of Gold Run Creek, which had produced some of the finest and most interesting specimens in the Dawson Area. Horse, caribou, moose and mammoth bones were selected from a number of fossils collected by Ernie Schink. Fossils were also collected at Burgelman's property on the right limit of Dominion Creek.

<u>1971</u> - In July, T. Morgan and P.M. Youngman of the National Museums of Canada collected Pleistocene bison, caribou and mountain sheep bones from near Mile 110 on the Dempster Highway, while gathering material for displays. The fossils came from an area of melting permafrost on the roadside.

Pleistocene remains had not previously been reported from this area.

Field work took place from August 12-23. I collected a nearly complete horse cranium on Gold Run Creek on August 14. It had evidently been washed into the main creek bed from one of the gullies during the peak of the melt period. A few specimens, mainly mammoth, horse, bison and moose were collected at placer operations on Dominion, Gold Bottom, Quartz, Eureka, and Flat creeks. Sites on Bonanza, and Eldorado creeks were examined with no results. The lack of success in collecting this year was attributed to the fact that many placer miners had moved to new areas, so that older sites productive of bones were abandoned. Other miners were in preliminary stages of preparing ground or had experienced serious equipment breakdowns.

1972 - Much of the time in Dawson (August 11-24) was spent in establishing and monitoring a display of the best Pleistocene mammal specimens collected from the area. Most of the fossils had been shipped from Ottawa, and a few were borrowed from the Dawson City Museum. I gave a talk on Yukon Pleistocene mammals to some 40 geologists who were taking part in an International Geological Congress field trip to the southern Yukon. A few bison specimens were collected on a bench near Flat Creek, at Ole Lunde's placer operation on Gold Bottom Creek, and on Cripple Hill.

On August 18, some *Bison crassicornis* and mammoth fossils were found in place on the right limit of Gold Run Creek, about 40 feet (12.2 m) from the mouth of a small tributary or "pup". They were exposed on the surface of the gold-bearing gravel, and were covered by at least 13 feet (4.0 m) of muck (the surface had been stripped by bulldozer).

I travelled the length of the Dempster Highway on August 20 in order to see if other exposures of Pleistocene mammals had been found. Neither the Chief Surveyor, Bob Davies, nor any of the construction workers I talked to had observed any. On August 22, Lorne Ross donate [illegible] nall collection of bison and mammoth bones collected a [illegible] years earlier at his old placer site on Gold Run Creek.

A few bison and mammoth specimens were received from Faucher's ground on Glacier Creek. At that site, a specimen was collected for analysis by J. Westgate from a thin layer of volcanic ash about 4.6 m above the base of the muck unit, that was overlain by at least 1 foot (0.3 m) of muck (evidently the upper part of this section had been stripped off). I examined and measured the posterior of a

Bison crassicornis cranium with horncores, and a mammoth tusk found by Walter Yaremcio in 1971 on slumped material on the bank of the Sixtymile River.

1973 - Field work took place from August 13 to 23. On August 13 Fred Berger gave me a small collection of Pleistocene mammal bones (mammoth, wolf, Yukon wild ass, bison, caribou) from Tony Kosuta's property on lower Hunker Creek. He reported that Kosuta's site produced many fossils. On August 15 I examined hundreds of fossils that had been collected at John Erickson's and Herman Leidtke's placer operation on upper Hunker Creek. Most of the bones had been gathered by Leidtke. Specimens representing large-horned bison, woolly mammoth, Yukon wild ass and caribou were most common. A partial mandible with teeth of the extinct muskox *Symbos cavifrons*, most of the ulna of an American lion, and part of a wolf mandible were also collected from this locality (Dawson Locality 16).

While sorting out the fossils from Erickson's and Leidtke's site, I noticed a large, bullet-shaped piece of caribou antler that appeared to have been purposefully shaped for use as a punch. This is the first evidence suggesting the presence of early man in this higher region of the Yukon near the margin of the Wisconsin ice (Harington 1975, p. 5).

I obtained a few fossils from Ole Lunde on Gold Bottom Creek and later talked with Tony Kosuta at his site on lower Hunker Creek. He estimated that he had recovered about 500 pounds (227 kg) of fossil bone from a small bedrock channel filled with gravel and overlain by thick muck. He mentioned that he had found many bison bones, some sheep skulls, a large tusk (for which he received $100 from an Alaskan woman), and a large carnivore skull that he thought belonged to the short-faced bear *(Arctodus)* after seeing one on exhibit in Dawson the previous year. He later donated this carnivore skull to the National Museums of Canada. It turned out to be the best specimen of the American lion found in Canada.

Although no bones were collected on Dominion or Eureka creeks, I found wolf, Yukon wild ass, bison and caribou specimens at Gold Run Creek. A few bison and caribou specimens were collected at Cripple Hill, and I received a Pleistocene horse femur from the Archibald Brothers' claim on Bonanza Creek. Walter Yaremcio donated a very large horse metatarsal from the Sixtymile Area. The specimen is closer in size to metatarsals of a large horse common in the Old Crow Basin deposits, rather than those of the Yukon wild ass generally found near Dawson.

On August 21 Bert Bratsberg showed me places on his site on the left limit of lower Hunker Creek where blackish-stained rooted tree stumps were overlying gold-bearing gravel - their tops had evidently rotted, and all were in turn covered by peat mats. Evidently muck had been stripped from the surface. This suggested to me that trees had been growing in the lower part of the Hunker Creek valley after the time the gold-bearing gravels had been deposited and before the muck had been laid down - perhaps during a relatively warm period. A visit to Walter Rasmussen's claim on Quartz Creek yielded Yukon wild ass, moose, caribou, and bison bones. Most were found at the base of tailing piles or on their surface. Others were in water-washed areas on stripped ground.

<u>1974</u> - Field work was undertaken during the period August 15 - September 1. No bones were found in the vicinity of Flat Creek, but Clive Nicholson, mining on a bench claim near Lovett Gulch, said he had exposed "stinking clay" above gold-bearing gravel and that bones were found near the interface of the two layers. Mammoth, bison and mountain sheep fossils were identified in a small collection made by Nicholson and his family.

On August 17 I visited John Erickson's placer operation on upper Hunker Creek. Since 1973, he and H. Leidtke had worked downstream about 180 m and had encountered mining shafts of earlier miners. The wall of frozen muck near the road was about 11 m high. Mammoth, horse and bison bones were identified from the site. The fact that the greatest concentration of bones was found near the upstream end of their cut where May Pup and Mint Gulch joins Hunker Creek, and that the fossils decreased in number downstream from that point, evidently supports the "feeder hypothesis" mentioned earlier. Erickson and Leidtke donated some of the more scientifically important specimens that they had collected to the National Museums of Canada.

Leisure Placers had stripped a lot of ground on lower Dominion Creek, but no bones were noticed there because monitoring had not begun.

On August 18 I travelled to Lost Chicken Creek, Alaska Wapiti, mountain sheep, the extinct muskox *Symbos*, and a kiang-like horse were among the more interesting specimens in a collection of Pleistocene vertebrates donated by Barbara Purdy from that site. The stratigraphic sequence on Lost Chicken Creek was similar to that at Hunker Creek.

A few fossils were collected between Lunde's and Crockett's claims on Gold Bottom Creek. A stratigraphic section was made at Tony Kosuta's operation on lower Hunker Creek, where I sampled a discontinuous volcanic ash band about 5 m above the base of the muck for analysis by J. Westgate. Two ground squirrel crania that had been washed out of the deposits, and bison and caribou bones that were in place in the muck about 2.5 m above the upper surface of the gold-bearing gravel, were collected. Later a mammoth toe bone was found lodged in the muck face about 3 m above the gravel surface. Tony showed me two fine specimens he had collected from his site: a woolly mammoth palate with partial tusk sockets and two upper molars, and a large mountain sheep cranium with perfect horncores and most of the cheek teeth. He donated the latter specimen to the National Museums of Canada.

Ross Sailer donated a few interesting rodent bones from Dominion Creek to the National Museums of Canada. Some of the bones, evidently from an individual ground squirrel, had been found in a pocket of gray silt (muck) about 1 m above the surface of the gold-bearing gravel. A fragment of a hawk also came from Pleistocene deposits at this locality. Wet screening is required here. I partly reorganized and made better labels for the collection of Pleistocene mammal bones on display in the Dawson City Museum.

A few mammoth, horse and bison bones were collected from tailings at the operation run by Djukastein and Gatenby where Green Gulch enters Sulphur Creek. Yukon wild ass and bison fossils were collected from Roy Gibson's claims near the mouth of Friday Gulch. Water was high in Gold Run Creek due to a heavy snowfall on August 23 and no fossils were seen.

Walter Rasmussen donated some fossils (woolly mammoth, Yukon wild ass, moose, bison) from Quartz Creek. While collecting at his site on August 26, bison and caribou specimens were excavated from a black, peaty zone with roots and tree (conifer?) stumps found in a depression on top of the creek gravels. This "forest bed" is similar in appearance to that noted in 1973 at Bratsberg's operation on lower Hunker Creek. The caribou bone yielded a radiocarbon date of approximately 5,000 years B.P., suggesting that forest had occupied the area during the hypsithermal period.

During a trip to Glacier and Miller creeks on September 1, I received a few matatarsals and anterior parts of upper and lower jaws of a large Pleistocene horse from Walter Yaremcio. They were excavated from a bench above

Sixtymile River, and may be older than fossils from lower levels in that area.

1975 - Field work took place from August 21 - September 1. On August 22, I visited John Erickson's placer operation on upper Hunker Creek. He gave me a well preserved mandible with teeth of the American lion *(Panthera leo atrox)*, and also a sample of about two dozen ground squirrel *(Spermophilus parryi)* droppings from a small exposure of organic material in muck approximately 20 feet (6.1 m) above the gold-bearing gravel on the right limit of Hunker Creek. I collected the posterior part of an American lion skull, and parts of a *Bison crassicornis* skull. On the following day, horse, moose and bison fossils were collected at Lunde's operation on Gold Bottom Creek. G. Burgleman told me of finding what was almost certainly the limb bone of a mammoth with some flesh and hair on it near the head of Dominion Creek about 1945.

Walter Rasmussen gave me some specimens of the Yukon wild ass and bison from his placer operation on Quartz Creek on August 25, and his partner Jack Lacross donated a good mammoth jaw containing RM_3. The following day, Ian Hamilton showed me mammoth, Yukon wild ass, moose and bison fossils from his site at the head of Dominion Creek. I collected many good specimens of bear, mammoth, Yukon wild ass, caribou, moose and bison on Klaus Djukastein's property on Sulphur Creek. One of the most interesting of these was a bison basicranial fragment with signs of butchering by man. The cut marks were stained dark brown like the rest of the fossil, indicating that they had been made on fresh bone.

On August 27 I collected a canid cranium, which probably represents a dog rather than a wolf. Evidently it had been washed out of muck overlying ~~gold-~~bearing gravels at Sailer's operation on Dominion Creek. On the following day, I received a good posterior cranium with horncores of the extinct muskox *Symbos* from Clive Nicholson. It came from Trail Gulch. I photographed and measured some woolly mammoth specimens he had collected, one of which (most of a maxilla with teeth) was particularly interesting because, in relation to the massive right tusk, the left tusk was vestigial - apparently a pathological condition. On nearby Cripple Hill I excavated well preserved bison specimens *in situ* 10 inches (25.4 cm) above gold-bearing gravel and 15 inches (38.1 cm) above black schistose bedrock. No good specimens were found on the property of Leisure Placers on lower Dominion Creek, but a sample of volcanic ash was collected in perennially frozen muck 4 to 7 feet (1.2 to 2.1 m) above gold-bearing gravel.

August 29-30 was spent in the Sixtymile Area, where I sorted out a large collection of fossils collected by Adrien Brisebois and Walter Yaremcio from a new excavation made by Brisebois approximately 1 mile downstream from the mouth of Miller Creek on the left limit of Sixtymile River. The collection is the largest recorded from this area. It includes: American lion, woolly mammoth, Yukon wild ass, medium-sized horse, caribou, large-horned bison, tundra muskox and mountain sheep. Traces of dried flesh were found on a woolly mammoth cranial fragment and on the lower part of a Yukon wild ass tibia. I examined the site, made a stratigraphic section, and found bone in place in the muck 2 feet (0.6 m) above the surface of the gold-bearing gravel. Later I measured a well-preserved *Bison crassicornis* skull which Brisebois had collected *in situ* 2.5 feet (0.8 m) above the gold-bearing gravel at this site.

On August 31, many bones (a number of them *in situ*) were collected at Kosuta's operation where 80 Pup enters Hunker Creek. Samples of droppings and grasses were collected from two rodent nests. M. Milner and R.E. Morlan gave me specimens of an arctic fox mandible and tibia, respectively, with a few other fossils they had collected at this site and John Erickson's. These are the first records of *Alopex lagopus* from the Dawson Area.

METHODS

Travel

Although Cessna 180 or De Havilland Beaver aircraft on floats were chartered occasionally from Dawson or Inuvik, I usually reached Old Crow by scheduled Douglas DC-3 or Fairchild F-27 flights from Whitehorse or Dawson. During the early stages of the project the DC-3s generally landed on a flat gravelly island a few miles up the Porcupine River from the settlement. Now there is an extensive landing strip at Old Crow.

From Old Crow, the main method of transport to various fossil localities in the area was river boat. The boats are long (approximately 9 m) and flat-bottomed, with upward-bevelled bows and square sterns made basically of plywood by a few skilled workers at Old Crow. They are capable of moving heavy loads (e.g. three or four people with three weeks of field rations, six 10 gallon (38 liter) kegs of fuel and camping and excavating equipment), and they have the advantage of shallow draft. Although a 12 hp engine was used to power the river boat during the first few field seasons, I found a 9½ hp Johnson outboard engine with short shaft to be more effective. It grounded less often, was lighter and more economical than the 12 hp engine and the slight loss of power was not found to be important. The quietness of the 9½ hp engine was also advantageous when making notes on wildlife along the rivers. Fewer animals were scared away before they could be observed.

The rivers in the area rise and fall rapidly at times. Travel by boat was easier during the high water periods because the boat seldom had to be tracked through shallow patches of fast water. On the other hand, high water is a disadvantage from the paleontological viewpoint because some important, low-lying fossil localities are covered. In addition, bones that would otherwise have been exposed on the river banks or bars would not be observed.

Usually two or three boat trips lasting two or three weeks each were made during a field season at Old Crow. An interesting "balance effect" prevailed. As food and fuel were used, their weight-loss was replaced by fossils or other samples. On longer trips fuel or fossils were cached. Caches are placed high on the banks so that there is little danger of their being swept away by quickly rising water.

Where possible, camp sites are located fairly high on the relatively flat tops of sand or gravel bars. Solid gravel bars are preferable because less sediment is tracked or blown into the tent - particularly if the camp is used for a few days. Gravel and sand had an advantage over clay, in that during heavy rains the sites were not waterlogged: water percolated easily through the gravel or sand. Sometimes it is necessary to camp on higher terraces during very wet weather, or when the river is rising (the two do not always coincide). A continual watch must be kept on stream levels in the Old Crow Area for they can rise rapidly. Usually a peg was placed at the water's edge on arrival at a camp site and carefully monitored in order to predict danger to the camp site or as an indication whether or not low-lying fossil localities at other places on the river would be flooded. It is advisable to camp away from willows, if possible, for biting insects were most common near them. A good supply of insect repellant is necessary during the early part of the field season. After the first few frosts in August mosquitoes and black flies are not a problem.

Basic camping equipment for a party of three consists of: a Stormhaven tent (approximately 3.7 m x 2.1 m with 1 m walls) with floor, mosquito bar and extra stakes; a mountain tent (approximately 2.1 m x 1.5 m x 1 m) used for caches or in emergency, a two-burner Coleman stove with extra generators and fuel funnels, three plastic pails for use in camp and alternating as containers for matrix when screening or for carrying larger fossils; two tarpaulins (2.4 m x 3 m) are useful for spreading bones and matrix on, and for covering material in the boat or caches. In the former case, a "covered wagon" section was arranged amidships using four curved willow saplings fastened into the gunwales on each side of the boat and lashed together by a few cross stringers above. It allowed easy access to the supplies and equipment while protecting them from rain. For shipment of equipment between Ottawa and the Yukon, and as strong containers for equipment, rations and sometimes fossils in the field, four medium-sized (63 cm x 43 cm x 25 cm) and one large (81 cm x 50 cm x 43 cm) expandable fibrecases with straps and handles (NVF Industries, Rexdale, Ontario) were handy.

Field work in the Dawson Area took place under quite different conditions. During the first three years I drove a National Museums of Canada Land Rover station wagon from Ottawa to Dawson. It was valuable because I wished to examine other fossil localities or potential localities on the prairies en route to the Yukon. In Dawson, motels or rented buildings were used for accommodation and storage. Most days would be spent in driving to various placer operations.

Occasionally I camped at some of the more remote localities. Because of the roughness of some of the roads and the unpredictable weather in late August, when most of the field work took place, it is advisable to have a 4-wheel-drive vehicle with two spare 6-ply tires and a heavy jack (e.g. "Jack-all"). An extra jerry can of gas and two tins of motor oil were usually carried on longer trips, such as those up the Dempster Highway.

Collecting

The western unglaciated part of the Yukon Territory, compared to most other parts of Canada that had been heavily glaciated, seemed to have great potential as a region for collecting ice age mammal remains. The literature since the beginning of this century suggested as much, as did reports of geologists who were familiar with the region, and who, in some cases, were able to pinpoint a few localities on the basis of previous field work.

The next step was to establish broad contacts with people living and working in the Old Crow and Dawson areas. Only the former area will be discussed.

In the Old Crow area, I was fortunate to start with the assistance of Peter Lord, who knew many places along the Old Crow River where bones were likely to be found. Not only was he familiar with the river because of repeated journeys on it in the course of hunting and trapping, but he had helped to guide Otto Geist on his 1952 reconnaissance of the river for Pleistocene fossils.

Early trips in the Old Crow Area were aimed at covering as much ground as possible and noting the areas where bones were most abundant along the stream banks. The next step was to try to trace the bones back to their source beds. In some cases it was obvious that bones had slipped down from fossil-bearing sediment above their positions on the banks, and it was a matter of locating the source by climbing the banks until the organic layers were found. It soon became evident that the vertebrate fossils were commonly found in oxidized fine gravels or sands containing plant material such as wood, cones, peaty matter, and mollusc shells. As will be mentioned later, radiocarbon age information and the nature of the stratigraphy and fragmentary nature of the fossils at some localities where they were found "in place", usually indicated that the fossils were not in localities where the mammals they represented had died. It seems that primary sites might be found along the margins of the basin where sediments are being freshly cut by major tributaries of the Old Crow River.

When a fossil locality is found it is plotted on a 1:250,000 scale topographic map (or more detailed maps as they become available) and given a number. The positions of the bones in relation to the level of the stream, the surface, or a stratigraphic marker horizon are indicated, and where poss[illegible]he bones are cursorily identified.

[illegible] criterion used in selecting bones for the Quaternary [illegible]logy Collection is that they have at least one and preferably more points of recognition (e.g. characteristic articular surfaces, protuberances or ridge for muscle attachment, foramina, or peculiar surface patterns such as the ribbing on the outer surface of giant beaver incisors and the prune-like wrinkling on wolverine canines). Usually limb bones are not kept unless a full articular surface is preserved. Rodent incisors were collected for a few years, but are no longer kept unless they are found in place where rodents have not been reported previously. Large bones like those of mammoths are not kept unless they are almost complete or belong to an articulated or partly articulated skeleton. Shipping costs from the Yukon to Ottawa are high. Occasionally poor but identifiable specimens are collected for radiocarbon dating.

Well-preserved fossils are picked up from the surface by walking along river banks at productive localities. The fossils are placed in collecting bags and later cleaned in river water using brushes with bristles of varying stiffness. Softer brushes are used on the smaller or more fragile specimens. Then the fossils are dried before being placed in cloth collecting bags on which the area, locality number, date and sometimes more detailed information are printed with a felt pen. When specimens seem to be of great importance (e.g. representing a rare species or artifacts) they are labelled directly with a field number such as "CR-74-35". The letters are collector's initials (CR), the next two digits indicate the year of collection (1974), and the next numbers specify the bone in a sequence of specimens collected in that year. The field numbers are then entered on the left page of a field notebook; the specimens are briefly described and sometimes sketched or photographed. The fossils are stored in bags or boxes in the boat, and after each trip are transferred to a storage building at Old Crow.

Excavations are usually undertaken at exposures where fossils are highly concentrated. They are first collected from the weathered surface; then, where overburden is not too thick, it is cut back using long-handled spoon shovels or by chopping it away with short folding spades. Depending upon the size and fragility of the specimens, either the edge of a folding spade is used to scrape out sediment from the fossil layer, or excavations are conducted using a flat, sharp-tipped archeological trowel. Often the piles of excavated matrix were sluiced down with buckets of water to see if any valuable specimens had been missed. Sluicing was used most effectively at Old Crow Locality 29 where fossils happened to be concentrated in a thin oxidized gravel directly overlying a tough basal clay that sloped gradually down to the river like a ramp. Sluicing was facilitated because the site was at the water's edge.

Where microvertebrate (e.g. fish, bird or small mammal) remains are common, fossil-bearing sediments are trowelled through from top to bottom and then spread out on the surface behind the excavation. For this type of excavation it is important to have fairly direct sunlight on the deposit. In fact, I did not notice microvertebrate fossils in the sediments until a few weeks after I began collecting at Old Crow, when I chanced to be in a position where low sunlight illuminated the fossils in moist [illegible]dized sands. The small bones were black and shiny in contrast to the matrix.

Excavations are halted when: (a) fossils become too scarce; (b) permafrost is encountered (e.g. at Old Crow Localities 11(1), 20 and 44); (c) sandy overburden repeatedly covers the excavation; or (d) when steep clay or gravel banks show signs of collapsing. To counter some of these problems, it is occasionally possible to melt back permafrost by damming and diverting stream or creek water against the fossil-bearing exposures, or to wash them with water from a fire pump and hose. In some cases the deposits are left for a few weeks, allowing frozen sediments to thaw slightly. Where overburden is dangerous but not too thick (e.g. Old Crow Locality 29), it is levered down from above using spades. A fire pump (Wajax Mark 3, 4-stage high pressure centrifugal pump with frame) with 30 m of hose was used effectively at Old Crow Locality 10 to blast off the upper 1 m of muck and vegetation (including two birch trees), thus exposing a broad area of fossil-bearing sediments. Occasionally the pump was used to cut back sandy overburden or to clear slumped exposures for stratigraphic examination (e.g. Old Crow Locality 69).

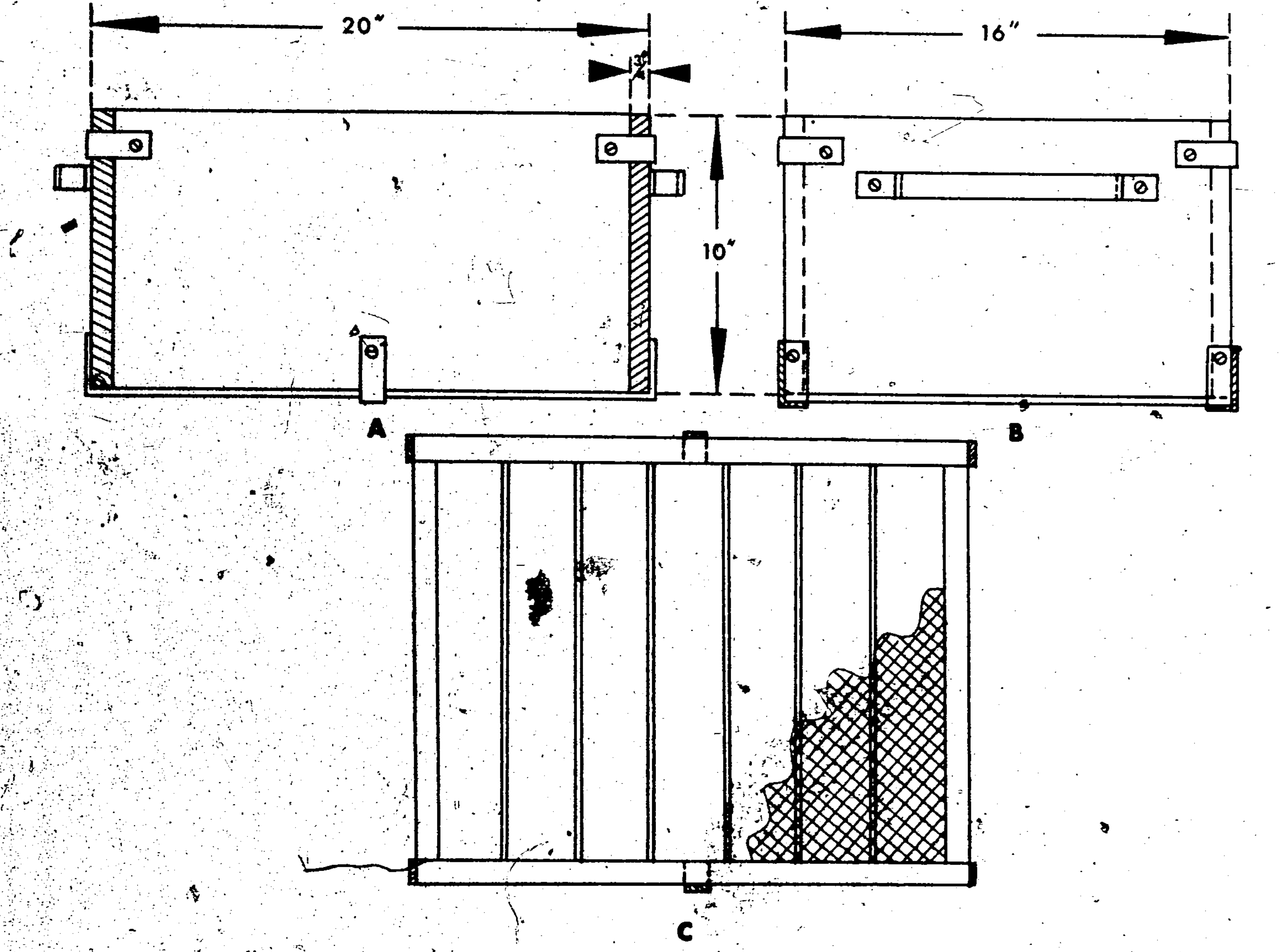
Microvertebrate remains and large specimens are placed in small plastic boxes and plastic pails respectively. They are kept well back from the excavation where there is a danger of collapsing banks. To promote paleoenvironmental studies, collections of associated organic material, such as plants (e.g. leaves, fruiting bodies, cones, bark and peat), mollusc shells, beetles and mammal droppings (e.g. moose pellets) are made and sealed in plastic bags or padded boxes. The bags are marked directly with a felt pen, and sticky labels (Denison Pres-a-Ply 52813) are applied to the plastic boxes and labelled using a ball-point pen. In some cases, series of pollen or ostracode samples are taken at regular intervals, in case they may shed some light on past environments or climates. The samples are collected from freshly cleaned exposures and are sealed in plastic bags. Volcanic ash samples are collected similarly. Sometimes a variety of pebbles is collected in plastic bags from a fossil-bearing gravel in order to obtain information on the source or sources of the gravel.

After a few day's collecting at a very productive site like Old Crow Locality 11A, the large bones are laid out on a tarpaulin to dry after cleaning. Then, they are separated preliminarily according to genus and element and placed in cloth bags. Microvertebrates are washed and cleaned separately with soft brushes, dried on paper or tarpaulin and grouped under the following categories: fish, bird, rodent. They are laid in layers, according to taxon and skeletal element, on tissue in large plastic boxes. Layers are added until the box can be closed firmly without the specimens shifting. This way many specimens can be kept separately in an economical, well-protected space.

At localities such as 27W and 44, which produced high concentrations of microvertebrate fossils, the matrix is wet-screened after the manner described by Hibbard (1949). As the screen had to be shipped between Ottawa and the Yukon, G.R. Fitzgerald constructed the parts separately, so that they could be packed flat in a field container and then bolted together when required (Figure 4). Small, tough clay balls resulted from screening matrix at Old Crow Locality 44 and made sorting difficult, whereas the cleaner sandy gravel from Old Crow Locality 27W allowed rapid sorting of fossils from the coarser fraction remaining on the screen.

Screening techniques have not yet been applied to any of the localities near Dawson. Screening is the next logical step in the collecting program there, particularly considering its effectiveness in the Fairbanks area of Alaska (Guthrie 1968a), which is similar stratigraphically and paleontologically to the Dawson Area (Harington 1970, p. 43). Furthermore, a potential site that has already produced microvertebrates is already known on Dominion Creek.

Figure 4. P[illegible]owing construction of a collapsible wet-screen box for separating Pleistocene microvertebrate material from its surrounding matrix. A. Side view. Wood for frame is ¾ inch plywood. Star nuts hold rectangular metal corner brackets in place (no bolts project into the interior). B. End view. Metal handles are bolted on (nuts facing outside). C. Top view. Screen of hardware cloth (eight holes to the inch) is attached to the inside of the steel frame with epoxy glue and is supported on the underside by six metal bars welded across the frame. Flanges are welded to the steel frame so that it can be attached to the box.


20"
3/4
16"
10"
A
B
C

Stratigraphy

Exposures from which many fossils have been excavated, or which have yielded important specimens, or which seem to record a large or critical part of the Pleistocene geological history of the area, have been measured from river level to the surface. Generally I have used gross stratigraphic units like those of O.L. Hughes (Lichti-Federovich 1973, Figure 2) in the Old Crow Area. Our sections at Locality 44, made separately a few years apart, are very similar, for example. More detail has been recorded at localities like 22 and 14N in order to obtain a more precise idea of the sequence of deposition in constructional terraces over the past few thousand years.

Where sections can be climbed, generally an Abney level is used to record thicknesses of the various units. Sometimes the stratigraphic sections recorded include segments that are slightly offset so that information could be shown that would otherwise be obscured by slumped material. Occasionally fresh surfaces are cleared by spade or trowel in order to determine more precisely the unit boundaries (e.g. the buff silt - upper glaciolacustrine unit boundary at Old Crow Localities 12 and 15).

Horizontal relationships and orientations of fossils have been measured in a few cases (particularly in relation to the discovery of artifacts) by using a Brunton compass and tape (30 m Lufkin chrome clad). A 2 m tape (Lufkin chrome clad) was used to measure shorter distances.

Color, and black and white photographs (35 mm and 126 Instamatic) have been taken of the most important sections. Such photographs are usually supplemented by black and white Polaroid (101 Automatic) prints on which unit boundaries, descriptions and locations of fossils are marked directly in pen.

Preserving, Cataloging and Curating of the Specimens

Most Yukon Pleistocene mammal bones are solid in structure and present few problems as far as preservation is concerned. In fact, it is sometimes difficult to tell fossils from the Dawson Area, which yield dates between 20,000 and 30,000 years B.P., from modern bone. The former tend to be manila to tan rather than white in color. The same applies to late Wisconsin bison bones from Locality 11(1) in the Old Crow Area. Presumably their excellent preservation is at least partly attributable to burial in permafrost for most of the time since they were deposited. Even deeply stained bones from older ice age deposits in the

Old Crow Basin are quite durable. But there are exceptions.

Problems sometimes arise with mammoth bones, perhaps because of their large size and spongy interior. If such bones are found dry and are washed to clean off dirt adhering to them, they often make a fizzing sound and start to crack, presumably because silt inside expands on wetting and the strength of the surface bone is unable to withstand it. If this kind of breakage is suspected, it is usually better to try to remove the surface dirt with a stiff-bristled brush.

Mammoth teeth (including tusks) are notoriously difficult to preserve. The lamellar plates of the molars offer many vertical lines of weakness. Because they are composed of various, highly segregated materials (enamel, dentine and cementum) that apparently expand at different rates, they will crack vertically on drying after lying in a moist situation, or on wetting after having been in a dry condition. If sufficient time and care can be given to individual specimens that are moist, it is advisable to slow the rate of drying by wrapping them in moist cloths or burying them in moist sand and letting the sand and teeth dry slowly. Then tests can be made to see if preservatives can be applied. If no cracking occurs when preservative is applied to small test areas on the tooth surface, then twine is wrapped around the molars and ring clamps (expandable stainless steel hose clamps) are tightened around the tusks before they are immersed for several days in a thin solution of polyvinyl acetate. Then they are allowed to dry. Supports are removed and any pieces of tooth adhering to the twine or clamps should be cemented in place. Surface cracks are then filled with polyester resin, plaster or epoxy. Finally the specimens may be coated with clear shellac.

Where breaks in fossils are noted during field work, the pieces are glued together directly and placed in a protected container. Or, if the breakage is complex, the pieces are temporarily packaged together and repaired after the bones are washed, dried and ready for packing. Some are left for later repair in the laboratory. In order to preserve bones most satisfactorily in the cloth sample bags, usually the heaviest, most durable specimens are placed at the bottom, tough limb bones are placed around the outside like splints, and the more fragile bones are wrapped in tissue, put in plastic bags and placed near the upper central part of the bags. As noted previously, microvertebrate remains are cleaned, dried and placed systematically in padded, labelled plastic boxes. At the end of the field season the most important specimens are well packed and taken as personal luggage from the Yukon to Ottawa. The field sample bags are packed in wooden or strong cardboard boxes or fibrecases, padded with paper and carefully tied around all surfaces with clothesline rope.

When the bones are received in the laboratory in Ottawa, they are given a final cleaning. Broken bones are glued together using household cement for smaller breaks and epoxy for breaks needing extra strong bonding. A thin, penetrating coat of Gelva (Gelva V-15, a preservative produced by Monsanto Canada Ltd. which is thinned with alcohol or acetone) is applied by brush to bones with damaged or cracked surfaces, and progressively thicker coats are applied until the bone is sufficiently hard. Most of the ice age mammal specimens from the Yukon do not require this treatment.

Bones are then labelled by painting 3 mm x 2 mm patches of white auto enamel in unobtrusive places on each. Care is taken to avoid covering tooth surfaces or foramina. On each patch the NMC catalog number, the district (Y.T. for Yukon Territory), the area (e.g. Old Crow River) the locality number, and date of collection are printed in black drawing ink (Pelikan 17 black) with a rapidograph pen (No. 1 Koh-I-Noor). On smaller bones only the NMC numbers are printed. Then a sealer coat of Gelva is brushed over each label and allowed to dry. Catalog cards and separate 8 cm x 4.5 cm cards to be placed with each specimen are filled in. The latter provide the following data: catalog number, accession number, scientific name, skeletal element represented, locality, collector(s), date of collection and identifier's name. Identifications and identifier's name are in pencil; the remaining data are in ink.

The fossils are filed in trays in metal cabinets (Model 301-RD Geology-Paleontology specimen cabinets supplied by Lane Science Equipment Corporation, New York) organized by: (a) district (e.g. Yukon Territory) - Old Crow and Dawson area collections are separated for convenience; (b) taxa (in the order given by Simpson (1945)); and (c) skeletal element (Table 4). Where possible, bones from the right side are separated from those of the left.

The largest specimens, such as mammoth limb bones and bison skulls, are organized on open steel racks near the back of the laboratory. Large bones, such as horse limb bones, are filed in trays padded with "Air Cap", which prevents damage and checks rolling and sliding of specimens when trays are moved. Intermediate sized specimens are placed in open cardboard trays. Rare or fairly complete

Table 4. Organization of Yukon Quaternary mammal fossils in cabinets according to skeletal elements.

Skull	1.	Cranial elements and upper teeth (including horncores and hornsheaths).
	2.	Mandibles and lower teeth.
Axial Skeleton	3.	Vertebrae: (a) cervical. (b) thoracic. (c) lumbar. (d) sacral. (e) caudal.
	4.	Ribs.
Forelimb	5.	Scapulae.
	6.	Humeri.
	7.	Radii and ulnae.
	8.	Carpals and sesamoids.
	9.	Metacarpals.
	10.	Phalanges.
Hindlimb	11.	Pelves.
	12.	Femora.
	13.	Tibiae and fibulae.
	14.	Tarsals, sesamoids and patellae.
	15.	Metatarsals.
	16.	Phalanges.

specimens of medium to small size are packed in clear plastic boxes with snap lids. Pads of cotton wool are placed below them and the specimen cards laid below the pads facing down, so that they can be read instantly by turning the box over or lifting it up. For example, specimens the size of a wolf maxilla fragment, a fox mandible, and a marten mandible are stored in plastic boxes of the following dimensions, respectively: 12 cm x 9 cm x 4 cm; 7 cm x 5 cm x 3 cm; and 5.5 cm x 5.5 cm x 2.3 cm. The smallest specimens, such as rodent jaws and limb bones, are placed in 5.5 cm x 1 cm (diameter) glass vials, which are glued to the back of the specimen card. The ends of the vials are padded with cotton wool to prevent damage. The cards stop the vials from rolling around in the trays and provide a ready source of information. The "card vials" are then placed with the card up in cardboard trays according to taxon and elements, and the cardboard trays are filed in the metal cabinet trays.

Skeletal Measurements

Measurements taken usually follow those used in current or standard reviews of the particular taxa concerned, in order to facilitate comparisons. Where fossils of existing species are concerned, it is difficult to duplicate the numerous measurements taken by mammalogists, because fossils are usually incomplete. In such cases, a few particular measurements are taken, and recognizing the limitations of this method, they are compared with the same measurements of the appropriate Pleistocene or Recent mammal specimens. Care is taken to note where original measurements were larger, or where measurements are estimated or approximate. Except where fossils are considered to be of critical importance despite their condition, generally only the more complete specimens in the collection have been measured. Statistical summaries and comparisons of skeletal elements of the species of Yukon Pleistocene mammals will be left until the scheduled close of the project in 1985, when more data will be available.

The largest specimens, such as mammoth limb bones or bison crania, are measured with a pair of metal claw calipres (Starrett; Atholl, Massachusetts) with a span of about 1.2 m used in conjunction with a 2 m chrome clad tape. For more precise large measurements a pair of 75 cm Mitutoyo vernier calipres are used. Medium-sized fossils are measured with 32 cm Carl Mahr vernier calipres. Small fossils are measured with Mitutoyo 20 cm dial calipres.

For measuring, identifying and photographing microvertebrate specimens a Tessovar Photomacrographic Zoom

System (Carl Zeiss) was found to be excellent. Illumination, which is operated by a transformer, is good, and the zoom lens allows the detailed focussing necessary for the study of rodent teeth. An automatic 35 mm (C-35-M) camera is attached.

Radiocarbon dates

In order to get an indication of the age of various species of Pleistocene mammals in the unglaciated part of the Yukon, a series of more than 20 radiocarbon analyses were obtained form Teledyne Isotopes (Westwood, New Jersey) by the Quaternary Zoology Section of the National Museum of Natural Sciences. It was hoped that the dates would provide evidence concerning the times and patterns of extinction of some of the ice age mammals in Eastern Beringia. Occasionally this series of radiocarbon dates has been supplemented by those obtained through the Geological Survey of Canada and Geochron. Except for the dates from Geochron, which involved analyses of bone apatite, all are based on bone collagen fractions of mammal fossils. These data are limited to approximately the last 50,000 years. Some Yukon fossils have yielded infinite radiocarbon dates, which are often greater than 39,000 years B.P. Radiocarbon dates referring to Yukon and Alaskan Pleistocene mammals are included in Tables 5 and 6 respectively.

In a few cases, casts are made of the original

Table 5. Radiocarbon dates on bone from Yukon Pleistocene mammals.*

SPECIES	RADIOCARBON DATE (years before present (1950))		LABORATORY NUMBER	MATERIAL	LOCALITY	REMARKS
Mammuthus sp. (mammoth)	16,000	± 150	GSC-1893	Tusk	Scroggie Ck. Loc. 1	Collected by Bostock from ground surface near a muck bank cut by a stream.
" "	22,600	± 600	I-3573	Femur	Old Crow Loc. 14N	
" "	25,700	+ 1800 − 1500	GX-1568	Long bone shaft	Old Crow Loc. 14N	Fractured by heavy blows when fresh. Artifact. Bone apatite date.
" "	29,100	+ 3000 − 2000	GX-1567	Radius	Old Crow Loc. 14N	Flakes removed from shaft when fresh. Bone apatite date.
Mammuthus primigenius (woolly mammoth)	30,300	± 2000	I-3576	Ribs	Whitestone Loc. 43	From an individual mammoth. Many semi-articulated elements were excavated.
Mammuthus sp. (mammoth)	32,250	± 1750	I-4226	Thoracic vertebra	Dawson Loc. 32	From Schink and Lamontagne's placer operation.
" "	> 39,900		I-4228	Thoracic vertebra	Old Crow Loc. 44	Excavated from fossiliferous unit above basal clay unit.
Equus (Asinus) lambei (Yukon wild ass)	14,870	± 260	I-3569	Metacarpal	Dawson Loc. 28	Excavated from interface of muck and gold-bearing gravel.
Equus sp. (horse)	34,000	± 2600	I-4222	Metatarsal	Old Crow Loc. 28	Appears to represent a large horse.
" "	> 39,900		I-4223	Pelvis	Old Crow Loc. 44	Appears to represent a large horse. Excavated from fossiliferous [illegible] above basal clay unit.
Cervus elaphus (wapiti)	4,570	± 100	I-4224	Humerus shaft	Old Crow Loc. 1	Faceted on distal ends, whic[illegible] preserved.
Alces latifrons (giant moose)	33,800	± 2000	I-4229	Antler beam	Old Crow Loc. 22	Excavated from gravels f[illegible]ctional terraces.
Rangifer tarandus (caribou)	5,010	± 100	I-8642	Radio-ulna	Dawson, Loc. 9	Excavated from a blackish vegetative layer [illegible] above gravel.
" "	6,450	± 135	I-4221	Antler	Old Crow Loc. 69	
" "	23,900	± 470	I-8580	Antler	Dawson Loc. 15	Most of antler preserved in NMC collection. From Erickson's placer operation.
" "	27,000	± 3000 2000	GX-1640	Tibia	Old Crow Loc. 14N	Fleshing tool with serrated edge. "Blade" is preserved. Bone apatite date.
Bison bison athabascae (wood bison)	1,350	± 95	I-[illegible]	Frontal	Dawson Loc. 6	Right horncore preserved. From Schmidt's placer operation.
Bison crassicornis (large-horned bison)	11,910	± 180	I-7765	Scapula	Old Crow Loc. 11(1)	From late Wisconsin fossil bison site.
" "	12,275	± 180	I-7764	Horncore	Old Crow Loc. 11(A)	Found on surface of bar. Presumably derived from Loc. 11(1) a short distance upstream.
" "	12,460	± 220	I-3574	Lumbar vertebra	Old Crow Loc. 11(1)	From late Wisconsin fossil bison site.
" "	22,200	± 1400	I-3570	Horncore	Dawson Loc. 32	From Schink and Lamontagne's placer operation.
" "	24,900	± 1000	I-3575	Horncore and frontal	Dawson Loc. 25	From Strachan's placer operation on a bench above the Klondike River.
" "	30,300	± 1850	I-3571	Horncore	Dawson Loc. 7	From [illegible]'s placer operation.
" "	33,800	± 2000	I-4227	Humerus	Old Crow Loc. 14N	Evidently from a large bison, like *B. crassicornis*.
Bison alaskensis (Alaskan bison)	> 39,900		I-3605	[illegible]	Dawson Loc. [illegible]	[illegible] of left horncore preserved. From [illegible] and Lamontagne's placer operation.
Ovibos moschatus (muskox)	[illegible]	± [illegible]	I-[illegible]	[illegible]	[illegible] Loc. 1	[illegible]
Ovis dalli (Dall sheep)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

* All radiocarbon analyses [illegible]

Table 6. Radiocarbon dates referring to Alaskan Pleistocene mammals. (Mainly after Péwé 1975a, Table 13).

SPECIES	RADIOCARBON DATE (years before present (1950))	LABORATORY NUMBER	MATERIAL	LOCALITY	REMARKS
Spermophilus parryi (ground squirrel)	14,510 ± 450	W-2703	Ground squirrel droppings	Chatanika River, (right limit)	From about 1.5 m above Chatanika Ash Bed.
" "	14,760 ± 850	GX-0250	Ground squirrel nest.	Chatanika River, (right limit)	From about 2 m below Chatanika Ash Bed.
Castoridae (probably *Castor canadensis*)	3,700 ± 150	L- 434	Beaver-gnawed wood	Cook Inlet area (Third Bay)	From beneath a 5 to 9-foot (1.5 to 2.7 m) thick peat unit.
Castor canadensis	[illegible] 260	W-1[illegible]08	Beaver-gnawed wood	Tofty area (Sullivan Ck.)	In peaty silt about 2 m below surface at Sullivan placer operation. Possibly reworked.
" "	6,8[illegible]0 ± 200	W- 733	Large beaver-gnawed log	Tofty area (Sullivan Ck.)	From dam covered by 5 feet (1.5 m) of yellow silt.
" "	9,330 ± 300	W-2160	Beaver-gnawed wood	Kotzebue area (Washington Ck.)	From dam at base of 8-foot (2.4 m) thick silt-unit overlying gold-bearing gravel.
Panthera leo atrox (American lion)	28,680 ± 300	SI- 456	Tendon from left tibia	Fairbanks area (Upper Ester Ck.)	From frozen muck.
Mammuthus primigenius (woolly mammoth)	15,380 ± 300	SI- 453	Flesh from lower [illegible]	Fairbanks area (Fairbanks Ck.)	From frozen muck.
Mammuthus sp. (mammoth)	?21,300 ± 1300	L- 601	Skin and flesh of baby mammoth	Fairbanks area (Fairbanks Ck.)	Associated with gravel stringers and a beaver [illegible]. Date seems reasonable, but may be invalid as hide was evidently soaked in glycerine by collector.
" "	32,700 ± 980	ST-1632	Hair from mammoth skull	Fairbanks area (D[illegible]e Ck.)	From frozen muck.
Equus sp. (horse)	15,750 ± 350	K-1210	[illegible] scapula	Kotzebue area (Trail Ck.)	From lower clay layer outside entrance at Cave 9.
" "	26,760 ± 300	SI- 355	Bone	Lost Chicken Ck.	From frozen muck.
Camelops sp. (extinct camelid)	24,900 ± 1100/1000	I-2117	Metapodial	?Fairbanks area	Personal communication J.V. Matthews, Jr. 1975.
"*Bison (Bison) preoccidentalis*" (type specimen)	11,735 ± 130	ST-1631	Piece of horn-[illegible]	Fairbanks area (Upper Cleary Ck.)	From frozen muck. Possibly a female of *Bison crassicornis* ?
Bison crassicornis (large-horned Bison)	11,980 ± 135	ST-1633	[illegible]	Fairbanks area (Fairbanks Ck.)	From frozen muck.
"*Bison (Bison) preoccidentalis*" (type specimen)	12,460 ± 320	SI- 290	Pieces of hornsheath	Fairbanks area (Upper Cleary Ck.)	From frozen muck. Compare to date ST-1631 on the same specimen.
Bison sp.	13,070 ± 280	K-1327	Bison calcaneum	Kotzebue area (Trail Ck.)	From lower clay layer outside Cave 9. Cracked by man.
Bison crassicornis	16,400 ± 2000	M- 38	Hornsheath	Fairbanks area (unknown creek)	From frozen muck.
Bison sp.	17,170 ± 840	SI- 838	Hornsheath	Fairbanks area (Fairbanks Ck.)	From frozen silt.
" "	18,000 ± 200	SI- 841	Hornsheath	Tanana area (near Manley Hot Springs)	From frozen silt.
" "	20,445 ± 885	SI- 837	Hornsheath	Fairbanks area (Fairbanks Ck.)	From frozen silt.
" "	21,065 ± 1365	SI- 839	Hornsheath	Fairbanks area (Cripple Ck.)	From frozen silt.
Bison crassicornis	> 28,000	L- 127	Dried tissue from carcass	Fairbanks area (Dome Ck.)	From frozen silt in contact with gold-bearing gravel.
Bison sp.	29,295 ± 2440	SI- 842	Hornsheath	Fairbanks area (Cripple Ck.)	From frozen silt.
Bison crassicornis	31,400 + 2040 − 1815	ST-1721	Hide and hair from carcass	Fairbanks [illegible]	From frozen silt in contact with gold-bearing gravel. (From same carcass as [illegible]).
"*Bison preoccidentalis*"	31,980 ± 4490	SI- 843	Hornsheath	[illegible]	From frozen silt. Possibly a female of *Bison crassicornis*.
Bison sp.	> [illegible],000	SI- 844	[illegible]	Fairbanks area (Little [illegible] Ck.)	[illegible]
Bison sp.	> [illegible]	SI- 840	[illegible]	(Cripple Ck.)	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

" "	9,330 ± 300	W-2160	Beaver-gnawed wood	Kotzebue area (Washington Ck.)	From dam at base of 8-foot (2.4 m) thick silt unit overlying gold-bearing gravel.
Panthera leo atrox (American lion)	22,680 ± 300	SI- 456	Tendon from left tibia	Fairbanks area (Upper Ester Ck.)	From frozen muck.
Mammuthus primigenius (woolly mammoth)	15,380 ± 300	SI- 453	Flesh from lower leg	Fairbanks area (Fairbanks Ck.)	From frozen muck.
Mammuthus sp. (mammoth)	?21,300 ± 1300	L- 601	Skin and flesh of baby mammoth	Fairbanks area (Fairbanks Ck.)	Associated with gravel stringers and a beaver dam. Date seems reasonable, but may be invalid as hide was evidently soaked in glycerine by collector.
" "	32,700 ± 980	ST-1632	Hair from mammoth skull	Fairbanks area (Dome Ck.)	From frozen muck.
Equus sp. (horse)	15,750 ± 350	K-1210	Right scapula	Kotzebue area (Trail Ck.)	From lower clay layer outside entrance at Cave 9.
" "	26,760 ± 300	SI- 355	Bone	Lost Chicken Ck.	From frozen muck.
Camelops sp. (extinct camelid)	24,900 ± 1100 1000	I-2117	Metapodial	?Fairbanks area	Personal communication J.V. Matthews, Jr. 1973.
"*Bison (Bison) preoccidentalis*" (type specimen)	11,735 ± 130	ST-1631	Piece of hornsheath	Fairbanks area (Upper Cleary Ck.)	From frozen muck. Possibly a female of *Bison crassicornis* ?
Bison crassicornis (large-horned bison)	11,980 ± 135	ST-1633	Hide	Fairbanks area (Fairbanks Ck.)	From frozen muck.
"*Bison (Bison) preoccidentalis*" (type specimen)	12,460 ± 320	SI- 290	Pieces of hornsheath	Fairbanks area (Upper Cleary Ck.)	From frozen muck. Compare to date ST-1631 on the same specimen.
Bison sp.	13,070 ± 280	K-1327	[illegible]	Kotzebue area (Trail Ck.)	From lower clay layer outside Cave 9. Cracked by man.
Bison crassicornis	16,400 ± 2000	M- 38	[illegible]	Fairbanks area (unknown creek)	From frozen muck.
Bison sp.	17,170 ± 840	SI- 838	Hornsheath	Fairbanks area (Fairbanks Ck.)	From frozen silt.
" "	18,000 ± 200	SI- 841	Hornsheath	Tanana area (near Manley Hot Springs)	From frozen silt.
" "	20,445 ± 885	SI- 837	Hornsheath	Fairbanks area (Fairbanks Ck.)	From frozen silt.
" "	21,065 ± 1365	SI- 839	Hornsheath	Fairbanks area (Cripple Ck.)	From frozen silt.
Bison crassicornis	> 28,000	L- 127	Dried tissue from carcass	Fairbanks area (Dome Ck.)	From frozen silt in contact with gold-bearing gravel.
Bison sp.	29,295 ± 2440	SI- 842	Hornsheath	Fairbanks area (Cripple Ck.)	From frozen silt.
Bison crassicornis	31,400 + 2040 - 1815	ST-1721	Hide and hair from carcass	Fairbanks area (Dome Ck.)	From frozen silt in contact with gold-bearing gravel. (From same carcass as L-127).
"*Bison preoccidentalis*"	31,980 ± 4490	SI- 843	Hornsheath	Fairbanks area (unknown creek)	From frozen silt. Possibly a female of *Bison crassicornis*.
Bison sp.	> 33,000	SI- 844	Hornsheath	Fairbanks area (Little Eldorado Ck.)	From frozen silt.
Bison sp.	> 39,000	SI- 840	Hornsheath	Fairbanks area (Cripple Ck.)	From frozen silt.
Ovibovini (muskoxen) (*Bootherium?*)	17,210 ± 500	SI- 454	Hair from hind limb of muskox carcass	Fairbanks area (Fairbanks Ck.)	From frozen silt.
"	24,140 ± 2200	SI- 455	Muscle from scalp of muskox carcass	Fairbanks area (Fairbanks Ck.)	From frozen silt. From same specimen as SI-454.
Bootherium sargenti ("*Bootherium nivicolens*")	22,540 ± 900	SI- 292	Hornsheath	Fairbanks area (Fairbanks Ck.)	From frozen silt.
Symbos cavifrons	17,095 ± 445	SI- 851	Hornsheath	Fairbanks area (Dome Ck.)	From frozen muck.
" "	25,090 ± 1070	SI- 850	Hornsheath	[illegible]	From frozen muck.
Symbos cavifrons ("*Symbos giganteus*")	> 40,000	SI- 291	Winter droppings (pellets) associated with skeleton and hair	Fairbanks area (Little Eldorado Ck.)	From frozen muck.

specimens before they are sacrificed for dating, and a file of photographs, measurements and notes are kept on them. Where bone is left after analyses, it has been returned. In this way, diagnostic parts which are still useful as specimens can be retained in the collection, or excess bone may be available in sufficient quantity to provide a check date from another laboratory. Very small samples insufficient for radiocarbon dating are kept in the hope that new techniques of dating requiring smaller amounts of bone will be developed in the future. The amino acid racemization technique being developed by Bada (Anonymous 1975, p. 349) seems to have potential in this respect.

In a number of cases radiocarbon dates have been received on organic material other than bone, where it had some bearing on the age of Pleistocene mammals or on changing Pleistocene environments in the field areas. Thus analyses have been carried out on mollusc shells, wood, peaty material and plant detritus (Table 7). Of particular interest are the two analyses on freshwater clam (*Anodonta beringiana*) shells from different sites in the Old Crow Basin, both of which have yielded dates of about 10,800 years B.P., indicating the period of major postglacial downcutting. A piece of wood from the fossil-bearing unit at Old Crow Locality 44 provided a minimum age of more than 54,000 years B.P. for the Pleistocene fauna represented in

Table 7. Radiocarbon dates on organic material other than bone from the Old Crow, Dawson and Donjek areas, Yukon Territory.

SPECIMEN IDENTIFICATION	RADIOCARBON DATE (years before present (1950))	LABORATORY NUMBER	LOCALITY	REMARKS
Freshwater Mollusc Remains				
Anodonta beringiana (shells of fresh-water clams)	10,850 ± 160	I-4224	Old Crow Loc. 69	Evidently dates maximum downcutting of Old Crow River after late Wisconsin glacial lake was drained.
" "	10,700 ± 160	GSC-1167	Old Crow Loc. 141	Excavated. Well preserved. As above.
Mainly *Pisidium idahoense* (shells of small molluscs)	32,400 ± 770	GSC- 952	Porcupine Loc. 100	Unreworked shell from a layer about 5 to 8 ft. (1.5 to 2.4 m) below late Wisconsin glacial lake deposits. Dates grayling *(Thymallus arcticus)* and lemming *(Lemmus sibiricus)* remains.
Plant Remains				
Salix sp. (willow wood)	> 42,000	GSC-1297	Old Crow Loc. 12	From unit overlying basal clay unit, sample from about 5 ft. (1.5 m) below base of late Wisconsin glacial lake deposits.
Unidentified wood (small twigs and branches)	14,390 ± 160	GSC- 730-2	Old Crow Loc. 14N	Excavated from point bar deposits estimated to be a few thousand years old. Wood is probably of mixed ages.
Unidentified wood (large piece 24 cm. in diameter)	41,280 ± 1600	GSC- 730	Old Crow Loc. 14N	Excavated from point bar deposits estimated to be a few thousand years old.
Organic detritus	7,620 ± 160	GSC-1252	Old Crow Loc. 15	From near base of postglacial peat unit.
Organic detritus	1,740 ± 100	I-2756	Old Crow Loc. 22	From organic layer in a constructional terrace 13 ft. (4.0 m) above basal clay unit and 16 ft. (4.9 m) below the surface.
Unidentified wood	2,420 ± 80	I-2755	Old Crow Loc. 22	From oxidized sandy gravel unit producing mammal fossils which overlies basal clay unit.
[illegible] organic matter	6,430 ± 140	GSC- 372	Old Crow Loc. 32	From postglacial peat unit (about 6 ft. (1.8 m) below surface).
Wood	7,650 ± 150	GSC-1175	Old Crow Loc. 32	From postglacial peat unit (about 20 ft. (6.1 m) below surface).
Peat	8,100 ± 160	GSC-1243	Old Crow Loc. 32	From postglacial peat unit (about [illegible].6 m) below surface).
Organic detritus	31,300 ± 640	GSC-1191	Old Crow Loc. 32	From unit overlying basal clay unit, sample from about 5 ft. (1.5 m) below base of late Wisconsin glacial lake deposits.
Populus sp. (poplar or aspen wood)	8,270 ± 140	GSC-1329	Old Crow Loc. 44	Minimum date for formation of postglacial peat.
Unidentified wood (part of a log)	> 39,900	I-3572	Old Crow Loc. 44	Excavated from fossil-bearing unit above basal clay.
Picea sp. (spruce wood)	> 44,000	GSC-1593	Old Crow Loc. 44	From fossil-bearing unit above basal clay unit.
Picea sp. (spruce) (stick 26 cm. long)	> 54,000	GSC-2066	Old Crow Loc. 44	From fossil-bearing unit above basal clay. Suggests fossil-bearing unit could be of Sangamon interglacial age.
Picea sp. (spruce wood)	> 42,000	GSC-1589	Old Crow Loc. 88	From unit overlying basal clay unit.
Peat	10,740 ± 180	GSC- 121	Porcupine Loc. 100	Dates beginning of peat formation after drainage of late Wisconsin glacial lake.
Unidentified wood (two large pieces)	> 37,000	GSC- 958	Porcupine Loc. 100	Possibly reworked and therefore older than the layer in which it was found. See freshwater mollusc shell date GSC-952.
Wood	> 41,300	GSC- 199	Porcupine Loc. 100	Indicates deposition of silt and sand (Unit 5 of Hughes (1969 p. 210)) began more than 41,300 years ago.
Populus sp. (poplar or aspen) (Stick 27 cm. long)	9,040 ± 140	GSC-1454	White River (across from Donjek)	*Bison* cf. *crassicornis* collected with this wood about 30 ft. (9.1 m) above the base of a 54-foot thick (16.5 m) organic silt unit which was dated at >38,000 years B.P. Date seems too recent.
Peat	9,310 ± 230	GSC- 196	Dawson Loc. 12	From silty peat layer 10 ft. (3.0 m) below the surface of the muck at [illegible] and Norback placer site (Unit 5, see below). Pleistocene mammals lay below this unit.
Picea sp. (spruce wood)	> 35,000	GSC- 181	Dawson Loc. 12	Provides a minimum date for mud overlying gold-bearing gravel (Unit 2 of O.L. Hughes (see [illegible] and Langston 1963, p. [illegible]) at [illegible] and Norback placer site. Possibly [illegible] derived from above this unit.

it. Furthermore, radiocarbon dates on sticks from Locality 14N first alerted me to the fact that the fossiliferous zone at the site contained organic material of greatly varying ages. The reason for this phenomenon was then sought.

Because the cost for radiocarbon analysis of a single specimen is currently about $160, samples for dating are chosen with care. First the specimen must be free from organic preservatives (e.g. polyvinyl acetate, Gelva, Glyptal, Alvar, etc.) or deeply penetrating rootlets or other organic material that would destroy the validity of the date. I have usually kept the dried specimens in aluminum foil, bags or boxes until they are submitted. Each specimen is cleaned with water before it is sent to the laboratory.

The radiocarbon dates are of greater significance if the specimens to be analyzed can be identified to species. Then it is possible to arrive at certain conclusions concerning the evolutionary history or time of extinction of a species. I have avoided submitting very good specimens, such as skulls, for radiocarbon analysis because of their primary value in the collection. Exceptions exist, however (e.g. the caribou fleshing tool from Old Crow Locality 14N). Where species are rare and specimens are small, as in the short-faced bear, giant beaver, ground sloth or camel, no attempt has been made to radiocarbon date them.

Does the fact that ice age mammal bones have been enclosed in permafrost for long periods affect the validity of radiocarbon dates they yield? James Buckley of Teledyne Isotopes advised that he knew of no way that cold temperatures could influence radioisotopic breakdown rates. He stated that bacterial action was one of the main factors to consider in destroying the validity of radiocarbon dates, and he suggested that the freezing permafrost environment would be ideal for preserving bone for reliable radiocarbon dating. James A. Lowdon of the Geological Survey of Canada Radiocarbon Dating Laboratory replied similarly. He suggested that bone from permafrost areas would be more reliable to radiocarbon date than bone that has had the chance of being contaminated by humic acid.

The method of analysis used by Teledyne Isotopes for radiocarbon dating bone submitted by the Quaternary Zoology Section is as follows. Bone was processed according to the method of Berger *et al.* (1964, p. 999) and subsequently modified by C.V. Haynes. The modification involves treating the collagen with a dilute sodium hydroxide solution to remove the possibility of humic acid contamination. Bone analyzed by the Geological Survey of Canada Radiocarbon Dating Laboratory is pretreated with hydrochloric acid and sodium hydroxide. More details concerning this laboratory and the techniques used there are provided by Dyck (1967).

STRATIGRAPHIC AND PALEOENVIRONMENTAL BACKGROUND

Before describing mammal remains found in Yukon Pleistocene deposits, it seems appropriate to comment on their source beds in the sedimentary sequence, the possible ages and relationships of these deposits, and on the characteristics of the environments in which the mammals lived, as [illegible] as can be determined by fossils and the nature of the deposits themselves. Only a few of the more important localities in the unglaciated parts of the Yukon Territory and Alaska will be mentioned. The sites are chosen on the basis of the relative completeness of the Pleistocene record exposed, and on the degree of information available at each.

Old Crow Area

Porcupine River (Locality 100)

This locality is of key importance to Pleistocene geological and paleoenvironmental studies in the Old Crow Area. It is situated about 9 miles (15 km) downstream from the settlement of Old Crow on the left limit of a large bend in the Porcupine River. The stratigraphy of this approximately 200-foot (61 m) high bluff has been described by Hughes (1969, p. 210; 1972, p. 8) and in slightly revised form by Lichti-Federovich (1974, p. 5) in consultation with Hughes. My interpretation of the sequence of deposits is largely based on their data, but is supplemented by observations resulting from several personal collecting trips to the locality during the 1966 - 1973 period. The section is described in geochronological sequence from bottom to top.

Lichti-Federovich (1974, p. 5) observed that all pollen assemblages recorded here and along the Old Crow River lack significant amounts of Tertiary pollen types, and suggested that the oldest unit at Locality 100 (pollen assemblage type Va) is of mid- or early Quaternary age.

Unit 1 consists of deltaic, lacustrine and fluvial sediments. The lower subunit is composed of reddish, partly cemented, oxidized grit with silt lenses containing many large spruce logs and cones. The latter are intermediate in size between those of modern white spruce (*Picea glauca*) and the extinct *Picea banksii* discovered by L.V. Hills (Hills and Ogilvie 1970) in upper Miocene deposits (Beaufort Formation) on northern Banks Island.

No vertebrate fossils have been found in place in the unit, although I have examined it carefully in successive years. However, indirect evidence of the presence of beavers is provided by a long, highly-compressed lens of beaver-cut sticks, which I (Harington 1971a, p. 80) tentatively interpreted to be part of a dam. These facts suggesting that boreal forest with standing water and streams formerly existed in the area are corroborated by pollen data (Lichti-Federovich 1974, p. 4). Birch, pine and spruce were common. Alder was locally common, and hazel occurred sporadically. The presence of hazel is significant because it is now confined to the southern fringes of the boreal forest and is most abundant in the aspen parkland and deciduous forest zone. At the time this unit was deposited, probably the area was drained by streams that flowed eastward through the Richardson Mountains at McDougall Pass (Hughes 1969, p. 211).

Hughes (1972, p. 7) states: "The large logs in Unit 1 suggest a climate at least as warm as that of today, in which white spruce to 15 inches {38.1 cm} diameter are common on the Porcupine flood plain and a few trees even attain 20 inches {51 cm} diameter." Thus an interglacial climate is implied. Lichti-Federovich (1974, p. 4) suggests that Unit 1 is of "pre-Wisconsin (?Sangamon) interglacial" age. On the basis of rates of sedimentation (calculated according to radiocarbon dates and sediment thicknesses in the upper part of the section, extrapolated downward in the section), the abundant large logs and flattened wood, the apparent primitive nature of the spruce cones, the degree of induration of the red grit, and the recapitulation of glaciolacustrine units higher in the section (which I tentatively consider were deposited during glacial maxima), I (Harington 1971a, p. 80) speculated that this deposit is interglacial, and of Yarmouth age or perhaps older. At present, there seems to be no reason for changing this view.

The upper 4 feet (1.2 m) of the unit are convoluted due to frost action. This seems to indicate the onset of a glaciation resulting in the formation of a deep, cold glacial lake, which is demonstrated by the thick glaciolacustrine deposits which overlie Unit 1.

Unit 2 consists of the lower glaciolacustrine sediments which, according to Hughes (1972, p. 7), were laid down when Laurentide ice advanced westward against the Richardson Mountains blocking eastward drainage through McDougall Pass, forming a vast cold lake that discharged westward at what is now known as The Ramparts. The cold, biologically arid nature of this early glacial lake is indicated by the virtual absence of ostracodes in this unit as noted by Delorme (Hughes 1969, p. 209). I wish to point out the similarity of this unit with the basal clay unit on Old Crow River. Both are significantly jointed with oxidized joint surfaces, both are gray when moist and brownish when dry, and both contain organic detritus and ironstone concretions (noted by O.L. Hughes his section at Locality 100 made on July 2, 1970, a copy of which is in my files).

Pollen in this unit is similar to that of Unit 1, but it lacks hazel pollen and it is rich in pollen of herbaceous plants and bryophytes - perhaps indicative of cooler climatic conditions.

Hughes (1969, p. 212) believes that this glacial lake stage is probably of "pre-classical Wisconsin or older age". Lichti-Federovich (1974, p. 4) gives its age as "Early Wisconsin Glaciation". I suggest that the glacio-lacustrine sediments were laid down during the maximum of the Illinoian glaciation. The fact that this lower glacio-lacustrine unit is much thicker than the upper glacio-lacustrine unit (Unit 5) formed during the peak of the Wisconsin glaciation (i.e. during the late or classical Wisconsin), may be indicative of the relatively greater severity and longer duration of the Illinoian glaciation. Perhaps Laurentide ice did not penetrate far enough westward to block McDougall Pass during early Wisconsin time.

Unit 3 consists of lenses of gravel, twigs and wood which I think are of Sangamon interglacial age. In contrast to Hughes (Lichti-Federovich 1974, p. 5), who makes this a lower subunit of a thicker mass of deltaic, lacustrine and fluvial sediments, I prefer to regard it as a separate unit. Wood from near the top of this unit yielded a radiocarbon date of more than 41,300 years B.P. (GSC-199).

Pollen evidence suggests that boreal forest conditions gave way to a tundra landscape after the deposition of this unit had commenced, which could also imply that the unit is, at least in part, Sangamon. But there is a difficulty involved in comparing two sections made by Hughes, the first with radiocarbon dates in 1968, the second with pollen samples in 1970 (Lichti-Federovich 1974, Figure 2).

Convolutions in the upper 3 to 4 feet (0.9 to 1.2 m) of Unit 3 may have resulted from frost action occurring at the onset of the Wisconsin glaciation.

Unit 4 is composed of thick brownish silts, much like those of the upper part of Unit 2 and Unit 3 at Old Crow Locality 44. The sediments appear to have been laid down mainly under lake and delta conditions.

Grass, sedge and herb communities were dominant according to analyses of pollen samples from the unit. There is a preponderance of pollen of grasses and sedges (50-70%), with lesser quantities of birch (5-30%), spruce (1-15%) and willow (1-5%) pollen.

A shell-rich layer about 3 feet (1.5 m) from the top of the unit yielded a radiocarbon date of 32,400 ± 770 years B.P. (GSC-952), which indicates its Wisconsin age. Presumably the material from this shell-zone was deposited during the early part of a mid- Wisconsin interstadial that would correlate best with the Karginsky interstadial of Siberia (Kind 1967, p. 181) and the Olympia Interglaciation of southwestern British Columbia and northwestern Washington (Armstrong *et al.* 1965). This layer has been called the "*Cytherissa lacustris* zone" because Delorme (1968) found a great preponderance of this species of ostracode in samples from it. Perhaps a better name would be the "*Pisidium idahoense - Cytherissa lacustris* zone", because the former species of small freshwater mollusc is the main visible indicator of the layer. I (McAllister and Harington 1969,

p. 1189) have suggested that this zone may correlate with the extensive late Pleistocene Gubik Formation of northern Alaska, which lies at similar depth and is characterized by *Cytherissa lacustris* (Swain 1963). It could be a useful marker horizon for Wisconsin deposits of northern Alaska and the Yukon.

In addition to plant, insect, ostracode and mollusc fossils, scales of grayling *(Thymallus arcticus)* and remains of brown lemming *(Lemmus sibiricus)* were collected and identified from this zone (Table 8). Preliminary paleoenvironmental interpretation (McAllister and Harington 1969, p. 1188-1189) based on limited data (particularly where seeds and insects are concerned) suggests the former presence of a large, cool, shallow lake with a mud bottom and *Potamogeton* near its margin. Wet meadow habitat was nearby. Spruce trees and herbaceous plants probably occupied drier areas in the region. A more precise paleoenvironmental description of the zone is provided by Matthews (1975). He notes the large numbers of tundra-adapted insects and plants among the fossils (Table 8) 40% obligate tundra, 55% forest and tundra, 5% obligate forest. As several of the insects are flightless, tundra-dwelling carabid bettles, their presence means that tundra communities were located near the Porcupine site and that treeline

Table 8. List of animal and plant fossils of mid-Wisconsin (34,200 ± 770 years B.P.) age from Porcupine River Locality 100*.

Animals

Vertebrates

Mammals

Lemmus sibiricus (brown lemming)

Fishes

Thymallus arcticus (grayling)

Invertebrates

Insects

?Lygaeidae	(bug)
Elaphrus lapponicus	(ground beetle)
Bembidion (Peryphus) sp.	(ground beetle)
Pterostichus (Cryobius) spp.	(ground beetle)
Pterostichus (Cryobius) soperi	(ground beetle)
Pterostichus (Cryobius) cf. *kotzebuei*	(ground beetle)
Pterostichus (Cryobius) tareumiut	(ground beetle)
Pterostichus (Cryobius) parasimilis	(ground beetle)
Pterostichus (Cryobius) ventricosus	(ground beetle)
Pterostichus (Cryobius) brevicornis	(ground beetle)
Pterostichus (Cryobius) nivalis	(ground beetle)
Pterostichus costatus	(ground beetle)
Pterostichus haematopus	(ground beetle)
Amara alpina	(ground beetle)
Amara ?bokori	(ground beetle)
Colymbetes sp.	
Silpha coloradensis	(beetle)
Aphodius spp.	
Curimopsis sp.	(pill beetle)
Morychus sp.	(pill beetle)
Sitona sp.	

Table 8. cont'd...

Invertebrates	
Insects	
Leptopiinae, cf. *Ophryastes*	(weevil)
Lepidophorus lineaticollis	(weevil)
pyrus sp.	(weevil)
Cleonus plumbeus	(weevil)
Trichoptera	
Diptera	(biting flies)
Ichneumonoidea	(parasitic wasps)
Molluscs	
Pisidium idahoense	
(and other genera and species)	
Ostracodes	
Cytherissa lacustris	
Candona acutula	
Candona willmani	
Candona rawsoni	
Candona candida	
Candona ikpikpukensis	
Candona aphthalmica	
Candona protzi	
Cypria ophthalmica	
Limnocythere liporeticulata	
Limnocythere camera	
Cyprinotus glaucus	
Eucypris foveata	
Prionocypris glacialis	
Ilyocypris bradyi	

Table 8. cont'd...

Plants	
Gymnosperms	
Picea mariana	(black spruce)
Angiosperms	
Potamogeton perfoliatus subsp. Richardsonii	(pond weed)
Potamogeton ?filiformis	(pond weed)
Potamogeton ?gramineus	(pond weed)
Eleocharis sp.	(sedge)
Carex sp.	(sedge)
Ranunculus trichophyllus	(buttercup)
Ranunculus cf. *pedatifidus*	(buttercup)
Potentilla sp.	

---

* Data on *Pisidium idahoense* - *Cytherissa lacustris* zone fossils are from J.V. Matthews, Jr. (insects and plants) and L.D. Delorme (ostracodes).

was lower and climate colder than at present. Probably the open areas in this parkland type of environment were richer in grasses than in contemporary forest-tundra areas, and the abundant remains of grazers in a fauna from Old Crow Locality 14N (Harington 1971a, p. 79) which seem to be of this period imply that this type of range was present and well-suited to these herbivores.

Unit 5 consists of laminated silty clay, which is poorly exposed and affected by slumping and flowing comparable to that of the upper glaciolacustrine unit (Unit 4) in the Old Crow Basin. Presumably a readvance of Laurentide ice blocking McDougall Pass at the peak of the Wisconsin (late Wisconsin) glaciation resulted in a re-establishment of the glacial lake and deposition of this unit. Shorelines at elevations between 1,000 and 1,800 feet (305 and 549 m) along the margin of the Bluefish Basin (Porcupine valley between Berry Creek and The Ramparts; Hughes 1972, p. 6) and Old Crow Basin probably relate to this second glaciolacustrine stage and record the gradual downcutting of the outlet at The Ramparts (Hughes 1969, p. 211). Samples from this unit are virtually devoid of ostracodes, indicating the presence of a deep, cold, turbid lake into which glacial melwater was being discharged. No pollen record is available for the upper glaciolacustrine unit.

Unit 6 is composed of transitional deposits between glacial lake and fluvial sediments. It is tentatively separated as a unit here, because the gray-brown silt with thin, peaty layers and lenses of wood suggest the predominance of fluvial rather than lacustrine deposition. No pollen record is available for the unit. I correlate it with Unit 5 at Old Crow Locality 44. Both units are of late Wisconsin age.

Unit 7 consists of peat and wood overlain by probably wind-deposited silt. It is of postglacial age as indicated by a radiocarbon date of 10,740 ± 180 years B.P. (GSC-121) from the base of the peat.

Deposition of the unit apparently commenced following drainage of the glacial lake, when the western outlet at The Ramparts eroded below the level of McDougall Pass. Laurentide ice retreated from McDougall Pass about the same time, and meltwater stopped flowing into the Bluefish Basin.

Old Crow River (Locality 44) -

This locality is situated 4 miles (6.4 km) northwest of the mouth of Timber Creek. It is a steep bluff on the left limit of the Old Crow River and is considered of key importance in the area because of a relatively rich fossil zone near its base. Hughes (Lichti-Federovich 1973, p. 556 "Locality 2") and I have measured and described this approximately 100-foot (30.5 m) thick section. We are in basic agreement except that I prefer to demarcate approximately the lower half of Hughes' Unit 2 as a separate unit, which, I think, is traceable in various parts of the Old Crow Basin, but which is covered or partly eroded in some sections.

Unit 1, the basal clay unit, is seen at most exposures on the banks of the river in the central part of Old Crow Basin. It appears to be mainly lacustrine (?glaciolacustrine) in origin. The clay varies from dark gray when moist to brown when dry. Typically it is oxidized along the joint surfaces. It includes occasional mats of organic material and exhibits a rolling surface varying about 18 feet (5.5 m) in elevation at some sites, suggesting a period when the lake became shallower and some erosion occurred in late ?Illinoian time prior to deposition of Unit 2. Unit 1 is more than 3.5 m thick at this locality. Hughes (personal communication 1975) has demonstrated to me in the field that ~~the~~ basal clay unit actually consists of two parts, a lower, apparently thick, biologically arid ?glaciolacustrine portion, and a shallower upper portion occasionally containing bone, plant and mollusc remains. I tentatively regard the lower part as a subunit representing Illinoian glacial lake deposits, and the upper subunit as of latest Illinoian age.

No vertebrate remains have been found in the basal clay unit at this locality, but mammoth, horse and caribou teeth have been collected *in situ* from the upper subunit at Old Crow Localities 11 and 12. H.B. Herrington has identified the following molluscs that I collected 3 feet (0.9 m) below the contact between Units 1 and 2 at this site: *Valvata sincera*, *Valvata tricarinata*, *Amnicola limosa*, *Gyraulus* sp., *Pisidium casertanum*, *Pisidium idahoense* or *Sphaerium* sp. The abundance of *Amnicola limosa* in this sample suggests that patches of shallow or quiet water with nearby vegetation once existed there. *Candona ikpikpukensis*, an ostracode, has been identified by Delorme. From a highly compressed organic lens also located in the upper subunit of the basal clay (1 m above stream level), Lichti-Federovich has identified the following species from plant megafossils: *Menyanthes trifoliata*, *Andromeda polifolia*, Cyperaceae, *Salix* sp. (bud scales), *Picea glauca* (wing), *Abies?*, *Larix?* Therefore the upper organic subunit of the basal clay could be transitional in nature between glacial lake deposits and interglacial deposits. Perhaps Unit 5 in this section or Unit 6 at Porcupine Locality 100 are more recent analogs of this kind of transition. Evidently these deposits were laid down between the peak of a glacial (Wisconsin) and the beginning of the following interglacial (present).

Pollen data from this unit indicate that shrub tundra vegetation, dominated by dwarf birch, but with a rich local herb element, prevailed in the region (Lichti-Federovich 1973, Figure 3, p. 562). This evidence for cold tundra climate, in conjunction with the similar composition and weathering characteristics of the deposits, leads me to suspect that Unit 1 is of Illinoian age, and that it correlates with the lower glaciolacustrine deposits (Unit 2) at Porcupine Locality 100.

Unit 2 consists of a lower fossil-bearing subunit of gray sand with silt and minor gravel, and an upper subunit of brownish clayey silt. The fossil zone contains spruce logs up to 11 inches (28 cm) in diameter, thick layers of sticks, and remains of smaller plants, mollusc shells, ostracodes, bryozoans, insects, fishes, birds and mammals (Table 9). Many of the species represented have aquatic affinities and suggest the former presence of ephemeral shallow ponds and lakes in a river flood-plain with sandy margins in places, and with forested areas, or at least open forest nearby (Harington 1974, p. 42). Ostracode fossils and the great abundance of small pond snail

Table 9. List of animal and plant fossils of ?Sangamon (>54,000 years B.P.) age from Old Crow Locality 44*.

Animals

- Vertebrates
  - Mammals
    - *Ochotona princeps* (pika)
    - *Lepus arcticus* (arctic hare)
    - *Spermophilus parryi* (arctic ground squirrel)
    - *Castor canadensis* (beaver)
    - *Castoroides ohioensis* (giant beaver)
    - *Dicrostonyx torquatus* (collared lemming)
    - *Lemmus sibiricus* (brown lemming)
    - *Clethrionomys* cf. *rutilus* (red-backed vole)
    - *Ondatra zibethicus* (muskrat)
    - *Microtus xanthognathus* (chestnut-cheeked vole)
    - *?Canis* sp. (large canid)
    - *Alopex lagopus* (arctic fox)
    - *Gulo gulo* (wolverine)
    - *Spilogale* sp. (spotted skunk)
    - *Mammuthus* sp. (mammoth)
    - *Equus* sp. (horse)
    - Camelinae (camel, genus and species undetermined)
    - *Rangifer tarandus* (caribou)
  - Birds
    - Anatinae or Aythyinae (surface feeding or diving ducks)
    - Anserinae (geese)
    - Tetraonidae (ptarmigan or grouse)
  - Fishes
    - (genera and species undetermined)

Table 9. cont'd...

Invertebrates

Insects

- Odonata (genus and species undetermined) (dragon flies)
- *Bembidion* sp. (ground beetle)
- *Dyschirius subarticus* (ground beetle)
- *Pterostichus (Cryobius)* spp. (ground beetle)
- *Pterostichus (Cryobius) brevicornis* (ground beetle)
- Dytiscidae (genus and species undetermined) (predaceous diving beetles)
- *Olophrum* sp. (rove beetle)
- *Micralymma brevilingue* (rove beetle)
- *Tachinus* sp. (rove beetle)
- *Colon* sp. (small carrion beetle)
- *Aphodius* spp. (dung beetle)
- *Symplocaria ?arctica* (pill beetle)
- *Morychus* sp. (pill beetle)
- *Donacia* sp. (leaf beetle)
- *Lepidophorus lineaticollis* (weevil)
- *Vitavitus thulius* (weevil)
- Trichoptera (genus and species undetermined) (caddisflies)
- Ichneumonoidea (genus and species undetermined) (parasitic wasps)
- *Formica* or *Camponotus* (ants)

Crustaceans

- *Lepidurus* sp. (tadpole shrimp)
- *Daphnia* sp. (water flea)

Bryozoans

- *Cristatella* (bryozoan)

Molluscs

- *Helisoma* sp.
- *Promenetus exacuous*

Table 9. cont'd...

Invertebrates
- Molluscs
  - *Valvata tricarinata*
  - *Valvata sincera*
  - *Valvata* cf. *mergella*
  - *Gyraulus* sp.
  - *Amnicola limosa*
  - *Amnicola* sp.
  - *Lymnea* sp.
  - *Pleurocera* sp.?
  - *Sphaerium simile*
  - *Sphaerium striatinum*
  - *Pisidium idahoense*
  - *Pisidium lilljeborge*
  - *Pisidium casertanum*
  - *Oxyloma* sp.
- Ostracodes
  - *Cytherissa lacustris*
  - *Candona ikpikpukensis*

Plants
- Gymnosperms
  - *Picea ?glauca* (white spruce)
  - *Picea mariana* (black spruce)
- Angiosperms
  - *Sparganium simplex* (bur reed)
  - *Najas flexilis* (pond weed)
  - *Potamogeton perfoliatus* subsp. *Richardsonii* (pond weed)
  - *Potamogeton ?filiformis* (pond weed)
  - *Potamogeton praelongus* (pond weed)
  - *Eleocharis* sp. (sedge)
  - *Carex* sp. (sedge)

Table 9. cont'd...

Plants

Angiosperms

- *Salix* sp. (willow)
- *Betula* sp. (birch)
- *Alnus incana* (alder)
- *Rumex* sp. (dock)
- *Nuphar* sp. (water lily)
- *Ranunculus trichophyllus* (buttercup)
- *Ranunculus ?gmelini* (buttercup)
- *Ranunculus ?abortivus* (buttercup)
- *Ranunculus* cf. *pedatifidus* (buttercup)
- *Rubus idaeus* (rose)
- *Potentilla palustris* (cinquefoil)
- *Potentilla* sp. (cinquefoil)
- *Myriophyllum spicatum* (water milfoil)
- *Hippuris vulgaris* (water milfoil)
- *Empetrum nigrum* (crowberry)
- *Menyanthes trifoliata* (gentian)

---

* I am grateful to the following people for identifications based on samples collected between 1967 and 1973 from the fossiliferous zone at the base of Unit 2: J.V. Matthews, Jr. (insects, crustaceans, bryozoans and plants); M.F.I. Smith, A.H. Clarke, G.L. Mackie and the late H.B. Herrington (molluscs); L.D. Delorme (ostracodes). Plants identified from pollen samples in Unit 2 (Pollen assemblage type II, pollen zone 2-B) collected by O.L. Hughes are listed elsewhere (Lichti-Federovich 1973, Figure 4, Old Crow 2).

(Amnicola limosa) shells indicate shallow or quiet water with nearby vegetation, as do the shells in the upper part of Unit 1 at this site. Fish, goose, duck, muskrat, beaver and giant beaver fossils support this view of the past environment.

The fossil zone seems to be concentrated in protected pockets on the rolling surface of Unit 1. Whereas the erosion on the surface of Unit 1 may have occurred during the late Illinoian, perhaps the large logs and other fossils were deposited near the peak of the Sangamon interglacial, and the finely banded clayey silts were laid down near its end.

Analyses of pollen samples from the unit show high values for spruce, birch; sedges and grasses. Compared to pollen in Unit 1, the increase in spruce at the expense of dwarf birch is remarkable, and suggests warmer, moister climatic conditions with a deeper active layer in the ground. I assume on the basis of pollen data that this unit includes sediment from the upper surface of the basal clay to a height of about 30 feet (9.1 m) in the rather homogeneous clayey silt. At this point there is a clear zonal boundary at which spruce, birch and alder decrease significantly, giving way to the grasses and sedges of a cooler climate (Lichti-Federovich 1973, p. 558).

Many radiocarbon analyses have been carried out on specimens of bone and wood from the lower, fossil-bearing subunit. Mammoth and horse bones yielded dates of >39,900 years B.P. (I-4228 and I-4223). Two samples of spruce (*Picea* sp.) and one of unidentified wood gave dates of >44,000 years B.P. (GSC-1593), >54,000 years B.P. (GSC-2066) and >39,000 years B.P. (I-3572) respectively. These dates show that the radiocarbon technique cannot measure the full age of the specimens in the fossil zone: they are more than 54,000 years old.

In summary, I (Harington 1974, p. 42) suspect that Unit 2 was deposited during the Sangamon interglacial, which ended about 70,000 years ago, for the following reasons: (a) analyses of plant and invertebrate macrofossils indicate that climate was probably as warm as the present (Matthews 1975, p. 249). Some specimens even suggest a warmer climate. One of the plants, *Najas flexilis*, has a contemporary northern limit far to the south of the Yukon Territory as does the spotted skunk (*Spilogale*). It is worth mentioning that A.H. Clarke has identified a specimen of the freshwater mollusc *Fluminicola* sp. from a unit I correlate with Old Crow Locality 44 Unit 2 at Old Crow Locality 64, a few bends downstream from the former site. This genus is "mild temperate" in habitat. Clarke (personal communication 1970) says that its present range is far to the south of Old Crow Basin; (b) pollen data show that Unit 2 was deposited under warmer climatic conditions than the overlying and underlying units; (c) an important erosional surface exists between the gravels of the fossil zone of Unit 2 and the underlying basal clay of Unit 1; (d) large spruce logs with roots are common in the fossil zone; (e) radiocarbon dates on wood (*Picea* or *Larix*, and *Salix*) of >42,000 years B.P. (GSC-1589, GSC-1297) from positions 25 to 70 feet (7.6 to 21 m) above the contact of Units 1 and 2 (Lichti-Federovich 1973, Figures 4, 5), suggest a much older date for the fossil zone, which is more than 54,000 years old; and (f) the great depth of burial of the fossil zone, and the fact that it lies between two geographically widespread and apparently thick deposits which were probably laid down during glacial phases.

I tentatively correlate Unit 2 at this locality with Unit 3 at Porcupine Locality 100.

Unit 3, at Locality 44, like the upper part of Unit 2, was deposited in deltaic and lacustrine situations according to Hughes (Lichti-Federovich 1973, p. 557). It consists of brown and gray banded clayey silt, and is characterized by very high values (40 to 60%) of grass pollen, lower values for birch and spruce, and an increase in sedge pollen and in several herb types. This assemblage indicates a treeless landscape with extensive tundra dominated by sedges and grasses. It is unlikely that spruce and alder occurred in the vegetation of the basin at this time - perhaps their pollen was transported from adjacent areas of forest-tundra or forest (Lichti-Federovich 1973, p. 562). This cool, rich grassland is the type of range on which many Pleistocene mammals, such as mammoths, large-horned bison, and horses would flourish. Presumably it was toward the close of this period, represented by the upper layers of Unit 3, that man was actively hunting these animals near the lake margins in the Old Crow Basin.

The late H.B. Herrington identified mollusc shells of *Valvata sincera* and *Pisidium casertanum* from the central part of Unit 3. L.D. Delorme reported the following ostracodes from the same sample: *Candona acutula*, *Candona bretzi*, *Candona rawsoni*, *Cypria ophthalmica* and *Limnocythere liporeticulata*.

At Old Crow Locality 32, organic detritus a few feet from the top of Unit 3 has yielded a radiocarbon date of 31,300 ± 640 years B.P. (GSC-1191). Therefore, I suggest that Unit 3 at Locality 44 consists of sediments deposited during early and middle Wisconsin time, and consider it to be correlative with Unit 4 at Porcupine Locality 100.

Unit 4 is composed of laminated dark gray clays deposited in a cool, deep, glacial lake. Where exposed to the sun, much of the frozen clay has melted and moved downslope in the form of solifluction lobes, so there is difficulty in measuring its thickness. This upper glaciolacustrine unit is of late Wisconsin age and is correlative with Unit 5 at Porcupine Locality 100.

Unit 5 consists of fine, yellow-brown silt which may have been deposited under deltaic conditions at the close of the Wisconsin glaciation as the glacial lake was draining. It correlates with Unit 6 at Porcupine River Locality 100.

Unit 6 is composed of silt and peaty material. Pollen data from the equivalent of this unit at Locality 32 show that about 6,500 years ago there was a change from a forest-tundra type environment to a bog or swamp environment (Lichti-Federovich 1973 Figure 4, p. 562). Poplar or aspen (*Populus* sp.) wood from near the base of the unit provided a radiocarbon date of 8,270 ± 140 years B.P. (GSC-1329), suggesting that the glacial lake had drained earlier. The unit is of postglacial age and correlates with Unit 7 at Porcupine

River Locality 100.

Before attempting to relate the Pleistocene sedimentary sequence in the Old Crow Area with that in the Fairbanks area, a few general points will be mentioned about other sections in the Old Crow Basin. High bluff sections at various points along the Old Crow River (e.g. Localities 11, 12, 15, 32, 45, 64, 88) are basically similar to Locality 44, and many produce deeply-stained vertebrate fossils from ?Sangamon sediments lying in pockets on the surface of the basal clay. In a few cases (e.g. Localities 12, 15), bones have been excavated at levels in the brownish silts that would probably lie close to the pollen boundary separating the spruce-birch environments of ?Sangamon interglacial age from the tundra grassland environment of early Wisconsin age.

Locality 11(1), which is exposed along a deep gully cutting the upper part of the high bluff at Locality 11, is unique in the Old Crow Basin because it is the only one where many late Wisconsin vertebrate fossils have been found in place. Here, large quantities of large-horned bison (*Bison crassicornis*) bones have been recovered that are about 12,000 years old. The bones have been moved only a short distance by fluvial processes, and seem to have collected as a result of some natural catastrophe. There are no traces of human butchering on the bones, nor have artifacts been found in the deposits from which the bison specimens are derived. Presumably they died near the western slope of Schaeffer Mountain just before Glacial Lake Old Crow drained.

A younger phase of basin history is exemplified by numerous shells of large, freshwater clams (*Anodonta beringiana)* that are found at more than 13 localities (some in their original position) at, or slightly above, the level of the Old Crow River. Although these shells have a very fresh appearance, there is no record of their Recent occurrence in this part of the Yukon Territory. Two samples have yielded dates of 10,850 ± 160 years B.P. (I-4224) and 10,700 ± 160 years B.P. (GSC-1167), suggesting that the glacial lake was drained about 11,000 years ago - a date which coincides with the time of drainage of the glacial lake in the Bluefish Basin as indicated by a date on the base of peat at Porcupine Locality 100 of 10,740 ± 180 years B.P. (GSC-121). I tentatively refer to this initial stage of deep incision of the Old Crow River as the "*Anodonta* phase." In plotting various localities where these shells have been collected [illegible] *situ*, I find that they give some idea of the former st[illegible]er) course of the river. They are occasionally exposed [illegible] buried fluvial deposits cut into the surface of the basal clay on opposite sides of meanders of the present river.

Following the *Anodonta* phase, the Old Crow River ceased downcutting and began aggrading, which accounts for the many constructional terraces in the central part of the basin. A radiocarbon date on peaty material in a fossil-bearing layer of brown sand and grit overlying the basal clay at Locality 22 has yielded a date of 2,420 ± 80 years B.P. (I-2755), suggesting that aggradation had begun by that time. A log 13 feet (4.0 m) higher in the section near the base of a 16-foot (4.9 m) thick stratified brown silt and silty clay unit overlying the brown sand unit yielded a date of 1,740 ± 100 years B.P. (I-2756), which implies that aggradation was slowing down about that time and may have ceased about 1000 years ago or less. A number of other localities (e.g. 5, 19, 14N, 20, 29) are similar to Locality 22. At locality 14N, the fossiliferous zone overlying the basal clay units evidently represents a point bar deposit laid down during the *Anodonta* phase. The overlying deposits are probably similar in age to those at Locality 22.

The origins of Locality 11A, one of the thickest, most productive Pleistocene vertebrate fossil sites so far discovered in the Old Crow Basin, are difficult to explain. It yielded specimens that appear to be of Nebraskan age (e.g. *?Planisorex* cf. *dixonensis* and *Mammuthus meridionalis*), and of Kansan to Illinoian age (e.g. *Soergelia* cf. *elisabethae* and *Praeovibos priscus*). Specimens of *Bison crassicornis* of late Wisconsin age and a few species of Recent vertebrates (e.g. *Lepus* and Aves) on the surface of this point bar indicate that reworked fossils from Locality 11(1) upstream and elements of the modern fauna are occasionally deposited there. The mixed nature of this site is remarkable.

The Old Crow River probably began its second period of postglacial incision within the last 1000 years, once more cutting into the surface of the basal clay. If this renewed period of incision cannot be related to a shift in climate, such as an increase in precipitation or decrease in evapotranspiration or both, it may relate to a readjustment of basement rocks in the region resulting in establishment of a lower base level and increased erosion.

The peculiar rectangular shapes of larger lakes in the Old Crow Basin have been attributed by various people to control by rectangular joint systems in the basement rocks, a tilting of the basin floor, or direction of prevailing winds (O.L. Hughes and J. Westgate, personal communications 1976). An attempt to explain this phenomenon would constitute an interesting research project.

Suggested Stratigraphic Relationships between the Old Crow and Fairbanks Areas -

The following views are offered in the belief that it is useful to have a hypothetical regional stratigraphic framework available for future revision or refinement.

Péwé (1975b, p. 9) described a section from Eva Creek near Fairbanks, Alaska which evidently covers a period in the Pleistocene extending from pre-Yarmouth? to Recent. I wish to emphasize a broad similarity in the section at Porcupine Locality 100 and the Eva Creek section near Fairbanks. Both consist of two thick sedimentary deposits bounded at the top and bottom, and separated in the middle by thinner units having relatively high concentrations of vegetation (some are called "forest beds"). I speculate that the two thicker deposits show relatively high rates of deposition to be expected during glacial periods in such unglaciated regions, and that the three thinner deposits display lower rates of deposition (more active erosion) and consolidation by well-developed plant cover including boreal forest, to be expected during interglacial periods in these areas.

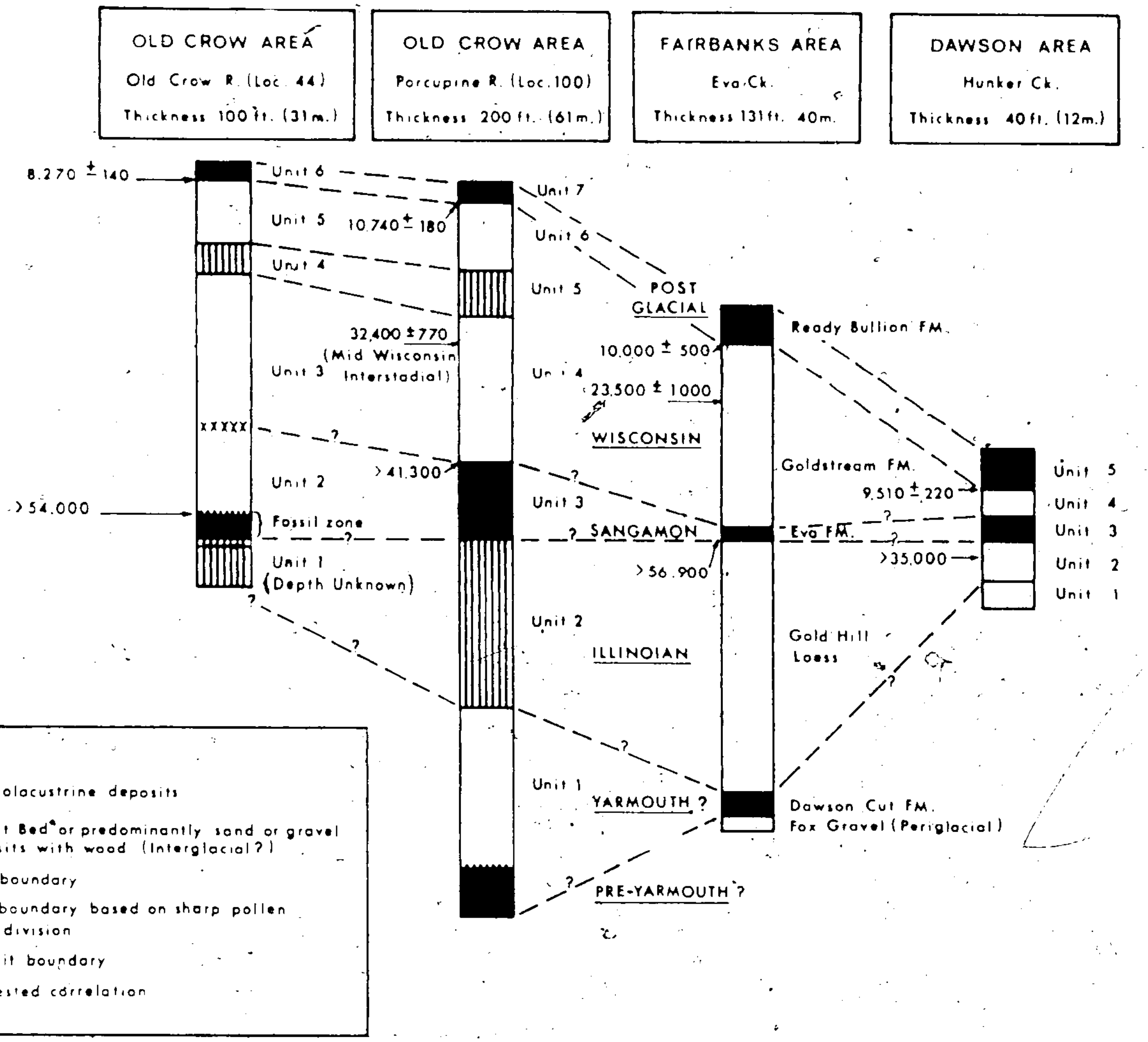
There is no doubt that the uppermost unit (Ready Bullion Formation) at Eva Creek, a thin widespread deposit of frozen silt, rich in organic material, is of postglacial age and correlative with the uppermost peat units at Porcupine Locality 100 and Old Crow Locality 44, because radiocarbon dates from it span the period from 3,750 ± 200 years B.P. (L-117H) to 10,000 ± 500 years B.P. (L-137S).

At Porcupine Locality 100 and Old Crow Locality 44, glacial maxima seem to have been well marked by the formation of two, successive glacial lakes evidently caused by Laurentide ice dams at McDougall Pass. The cold, deep lake stages are expressed stratigraphically in the upper and lower glaciolacustrine units. In the Fairbanks area of central Alaska, where drainage was better, the glacial periods are evidently marked in the lowest parts of the valleys (e.g. Eva Creek) by another process - a great influx of wind blown loess from the margins of large ice masses to the north (Brooks Range) and south (Alaska Range) or accumulation of reworked loess through mass wastage. Thus, the glacials are stratigraphically expressed in the Eva Creek section by thick loess units (Goldstream

Formation and Gold Hill Loess).

Tentatively assuming that these separate processes were operating during the same periods in the Old Crow and Fairbanks areas, I suggest: (a) that the Goldstream Formation (Wisconsin), which has yielded radiocarbon dates from 23,300 ± 1000 years B.P. (W-435) to over 30,000 years B.P. (L-163J), is correlative with the upper glaciolacustrine unit (5) and its associated units (4 and 6) at Porcupine Locality 100, and the upper glaciolacustrine unit (4) and its associated units (3 and 5) at Old Crow Locality 44; (b) that the Eva Formation (Sangamon) "forest bed" correlates with the gravel layer with wood (Unit 3) at Porcupine Locality 100 and the layer with fossils and big logs (Unit 2) at Old Crow Locality 44. A stump from the forest bed at Eva Creek yielded a radiocarbon date of >56,900 years B.P. (Hv-1328), which corresponds to those of >54,000 years B.P. (GSC-2066) from a large piece of wood from Unit 2 at Old Crow Locality 44 and a date of >41,300 years B.P. (GSC-199) from wood in the upper part of Unit 3 at Porcupine Locality 100; (c) that the Gold Hill Loess (Illinoian) correlates with the lower glaciolacustrine sediments (Unit 2) at Porcupine Locality 100 and with the basal clay (Unit 1) at Old Crow Locality 44; and (d) that the Dawson Cut Formation (Yarmouth?) forest bed is correlative with Unit 1 at Locality 100 (Figure 5).

Figure 5. Suggested stratigraphic relationships among some Pleistocene deposits bearing vertebrate fossils in Eastern Beringia (Old Crow, Fairbanks, and Dawson areas).


OLD CROW AREA
Old Crow R. (Loc. 44)
Thickness 100 ft. (31m.)
OLD CROW AREA
Porcupine R. (Loc. 100)
Thickness 200 ft. (61m.)
FAIRBANKS AREA
Eva Ck.
Thickness 131 ft. 40m.
DAWSON AREA
Hunker Ck.
Thickness 40 ft. (12m.)
8.270 ± 140
Unit 6
Unit 5
Unit 4
Unit 3
xxxxx
Unit 2
>54.000
Fossil zone
Unit 1
(Depth Unknown)
10.740 ± 180
32,400 ± 770
(Mid Wisconsin Interstadial)
>41.300
Unit 7
Unit 6
Unit 5
Unit 4
Unit 3
Unit 2
Unit 1
POST GLACIAL
10,000 ± 500
23,500 ± 1000
WISCONSIN
SANGAMON
>56.900
ILLINOIAN
YARMOUTH ?
PRE-YARMOUTH ?
Ready Bullion FM.
Goldstream FM.
Eva FM.
Gold Hill Loess
Dawson Cut FM.
Fox Gravel (Periglacial)
9.510 ± 220
>35.000
Unit 5
Unit 4
Unit 3
Unit 2
Unit 1
?
LEGEND
Glaciolacustrine deposits
"Forest Bed" or predominantly sand or gravel deposits with wood (Interglacial?)
Unit boundary
xxx Unit boundary based on sharp pollen zone division
Subunit boundary
Suggested correlation

Péwé's (1975b, p. 9) description of the Dawson Cut Formation closely corresponds with my field notes on Unit 1 at Porcupine Locality 100: - "a well-developed organic silt crops out. This unit contains large stumps and logs that are partly flattened and deformed; it is thought to represent an interstadial or interglacial forest bed. One particularly fine white spruce stump from the Dawson Cut Formation of the Eva Creek sections with roots in the underlying gravel is more than 28,000 years old (L-137X)." He also noted peaty layers in the formation, gray to tan silt, and gravel and some basal silt cemented by an iron oxide compound (cf. Hughes 1972, Table 1, Unit 1).

It might be valuable if fossil spruce cones could be found in the Dawson Cut Formation and compared to those from Unit 1 at Porcupine Locality 100, the sizes of which indicate a stage of evolution between late Tertiary *Picea banksii* and *Picea glauca*, the living white spruce.

Another way of checking the correlation between Old Crow and Fairbanks areas would be to compare the results of analyses of a series of geomagnetic samples from various levels in the main sections, in the hope that certain reversals could be detected and used as marker horizons (e.g. Johnson *et al.* 1975). Tephrochronology also appears to offer a powerful tool for correlation between regions in Eastern Beringia, where Pleistocene ash falls derived largely from former volcanic activity in the St. Elias Range are widespread. The Dome Ash Bed, which is exposed within and near the surface of the Gold Hill Loess in the Fairbanks area, could be a useful Illinoian marker if microprobe analyses show some uniqueness in its composition. Another possible marker of early Illinoian time is the Ester Ash Bed which is exposed, in places, near the base of the Gold Hill Loess (Péwé 1975b, p. 12). Although tephra layers seem to be rare in the Old Crow Area, they are commonly found in the Dawson Area, so chances for using this method to correlate the Dawson and Fairbanks areas seem most promising.

Dawson Area

I have found no exposures in the Dawson Area which offer the stratigraphic detail and time range of the Eva Creek section near Fairbanks. Perhaps periodic heavy erosion has removed, or truncated early and middle Pleistocene deposits, leaving only a vestige of the Pleistocene record. On the other hand, a lack of detailed stratigraphic study near Dawson may, at least in part, be responsible for gaps in our knowledge of the Pleistocene history of the region. The sequence of deposits at Pleistocene mammal localities in the Dawson Area is commonly as follows: (1) schistose bedrock; (2) oxidized gold-bearing gravels of ?interglacial age; (3) a muck layer of probable Wisconsin age; (4) a surface layer of postglacial peat. Sections like this do not appear to offer much scope for the stratigrapher. A possible exception is found on Hunker Creek.

Hunker Creek (Dawson Locality 12) -

This locality, now abandoned and largely overgrown by vegetation, is situated on the left limit of Hunker Creek between Too Much Gold and Gold Bottom creeks. Stratigraphic relationships at the site have been summarized and illustrated by Hunter and Langston (1964, Figure 1) on the basis of O.L. Hughes' field notes.

Unit 1 consists of gold-bearing gravel which overlies bedrock.

Unit 2 is an organic silt or muck deposit. Where this unit has been eroded away, mammal bones are concentrated on the surface of the gold-bearing gravel (Unit 1), and are overlain by silt and peat equivalent to Units 4, 5 and 6 of Hughes. Radiocarbon analysis of spruce *(Picea* sp.) wood from the unit has yielded a radiocarbon date of >35,000 years B.P. (I(GSC)-181).

Unit 3 consists of silty gravel. Hughes considered that mammal bones from the locality were derived from this unit. However, bone from a complete skull of "*Equus lambei*" that was collected from this layer yielded a Recent radiocarbon date. In my opinion the skull represents a modern horse (*Equus caballus*); for example, the anteroventral margin of the mandible lies flat on a horizontal surface like *Equus caballus*, and unlike *Equus (Asinus) lambei*, which rises at this point (Harington and Clulow 1973, p. 717). Small strings of decayed flesh adhering to the bone reinforce this view of the skull's recency. The horse may have been buried in a pit by early miners, and exposed in the course of monitoring back the frozen muck. Other bones that were evidently found in this unit may have been concentrated from Unit 2 during a minor erosional cycle.

Unit 4 is composed of organic silt or muck.

Unit 5 consists of silty peat with abundant wood near the bottom. It lacks wood in the upper surface. Although Hughes treated this as two separate units (5 and 6), I prefer to recognize it as a single unit deposited during the postglacial time. Peat from near the base of the woody portion yielded a radiocarbon date of 9,510 ± 220 years B.P. (GSC-196).

At this site, the possibility exists that the silty gravel of Unit 3 indicates a period of erosion that cut away muck of ?Illinoian age (Unit 2) during Sangamon interglacial time. If so, then Unit 4 would correlate with the Goldstream Formation at Fairbanks, which Péwé (1975b, p. 15) says - "is the greatest repository of remains of Pleistocene vertebrates in Alaska, if not in North America", and Unit 2 would be equivalent to the Gold Hill Loess (Figure 5). Apparently most of the pre-Wisconsin valley bottom deposits near Dawson have been removed, otherwise more radiocarbon dates on Pleistocene bone would be infinite. Only one specimen out of 12 from the Dawson Area has produced an infinite radiocarbon date (Table 5).

Analyses of volcanic ash layers may help to solve this stratigraphic problem. O.L. Hughes has collected tephra samples from the area, and I have collected others from the muck at the mouth of 80 Pup on lower Hunker Creek (Dawson Locality 10), on the right limit of Gold Bottom Creek (Dawson Locality 15), and at Glacier Creek (Sixtymile Locality 4). These samples have been sent to J. Westgate for electron microprobe analyses, in an attempt to ascertain their composition, age and correlative value.

RESULTS

I. Faunal List

Class Mammalia

Order Insectivora

Family Soricidae
?Planisorex cf. *dixonensis* (plains shrew)

Order Primates

Family Hominidae
Homo sp. (man)

Order Endentata

Family Megalonychidae
Megalonyx cf. *jeffersoni* (ground sloth)

Order Lagomorpha

Family Ochotonidae
Ochotona cf. *whartoni* (giant pika)
Ochotona princeps (pika)

Family Leporidae
Lepus americanus (snowshoe hare)
Lepus arcticus (arctic hare)

Order Rodentia

Family Sciuridae
Marmota cf. *monax* (woodchuck)
Spermophilus parryi (arctic ground squirrel)

Family Castoridae
Castor canadensis (beaver)
Castoroides ohioensis (giant beaver)

Family Cricetidae
Dicrostonyx cf. *henseli* (Hensel's lemming)
Dicrostonyx torquatus (collared lemming)
Lemmus sibiricus (brown lemming)

- Family Cricetidae
  - *Clethrionomys* cf. *rutilus* (red-backed vole)
  - *Ondatra zibethicus* (muskrat)
  - *Microtus (Stenocranius) miurus* (singing vole)
  - *Microtus xanthognathus* (chestnut-cheeked vole)

Order Cetacea

- Family indeterminate
  - Genus and species indeterminate (large whale)

Order Carnivora

- Family Canidae
  - *Canis lupus* (wolf)
  - *Canis familiaris* (domestic dog)
  - *Alopex lagopus* (arctic fox)
  - *Vulpes vulpes* (red fox)
  - *Cuon* sp. (dhole)
- Family Ursidae
  - *Arctodus simus yukonensis* (Yukon short-faced bear)
  - *Ursus* cf. *americanus* (American black bear)
  - *Ursus arctos* (brown bear)
- Family Mustelidae
  - *Mustela erminea* (ermine)
  - *Mustela (Putorius) eversmanni* (black-footed ferret)
  - *Martes nobilis* (noble marten)
  - *Martes pennanti* (fisher)
  - *Gulo gulo* (wolverine)
  - *Taxidea taxus* (badger)
  - *Spilogale* sp. (spotted skunk)
  - *Lontra canadensis* (Nearctic river otter)
- Family Felidae
  - *Felis (Lynx) canadensis* (Canada lynx)
  - *Felis (Puma)* cf. *concolor* (mountain lion)
  - *Panthera leo atrox* (American lion)
  - *Homotherium serum* (American scimitar cat)

Family Phocidae

Phoca cf. *(Pusa) hispida* (ringed seal)

Order Proboscidea

Family Mammutidae

Mammut americanum (American mastodon)

Family Elephantidae

Mammuthus meridionalis (southern mammoth)

Mammuthus cf. *armeniacus* (steppe mammoth)

Mammuthus primigenius (woolly mammoth)

Order Perissodactyla

Family Equidae

Equus cf. *(Plesippus) verae* (large horse

Equus sp. (giant horse)

Equus cf. *scotti* (medium-sized horse)

Equus (Asinus) lambei (Yukon wild ass)

Equus (Asinus) cf. *kiang* (kiang - like wild ass

Order Artiodactyla

Family Camelidae

Camelini (genus and species undetermined) (large camel)

Camelops hesternus (western camel)

Family Cervidae

Cervus elaphus (wapiti)

Alces latifrons (giant moose)

Alces alces (moose)

Rangifer tarandus (caribou)

Cervidae (genera and species undetermined)

Family Bovidae

Bison alaskensis (Alaskan bison)

Bison crassicornis (large-horned bison)

Bison bison occidentalis (western bison)

Bison bison athabascae (wood bison)

Family Bovidae

Soergelia cf. *elisabethae* (Soergel's muskox)

Boötherium sargenti (Sargent's Muskox)

Symbos cavifrons (helmeted muskox)

Praeovibos priscus (Staudinger's muskox)

Ovibos moschatus (tundra muskox)

Ovis ?dalli (Dall sheep)

II. Systematic Description of Yukon Pleistocene Mammals

Class Mammalia

Order Insectivora

Family Soricidae

?Planisorex cf. *dixonensis* (plains shrew)

A single specimen of a shrew (Figure 6A-B, Table 10) has been collected from Yukon Pleistocene deposits. It is not only of interest because of its rarity, but because it appears to represent a kind of shrew that lived in southern North America during the early Pleistocene.

Referred specimen

OCR 9448 from Old Crow Locality 11A is a right mandibular fragment with well-worn RM_2-RM_3. The angular process is damaged and the mandible anterior to RM_2 is lacking. The specimen is stained black. I consider it to be of pre-late Wisconsin age. A field crew under W.N. Irving collected the specimen in 1975, and I am grateful to him for allowing me to examine and describe it.

The fossil differs from any Recent Canadian shrew mandibles to which it was compared, being much larger than *Sorex arcticus* or *Microsorex hoyi*, and slightly smaller than the short-tailed shrew,

Figure 6. Posterior of right mandible with RM_2-RM_3 of a Plains shrew (*?Planisorex* cf. *dixonensis*) (OCR 9448) from Old Crow Locality 11A. A. Lateral view. B. Medial view.


A
B
3 MM

Table 10. Measurements of a Pleistocene plains shrew (*?Planisorex* cf. *dixonensis*) mandible from the Yukon Territory compared to those of early Pleistocene plains shrew (*Planisorex dixonensis*) mandibles from Kansas and Nebraska.

Specimens	Measurements (mm)*						
	1	2	3	4	5	6	7
?Planisorex cf. *dixonensis*, Pleistocene, Y.T. OGR 9448 Old Crow Loc. 11A	5.5	2.9	1.8	1.5	1.0	1.1	0.7
Planisorex dixonensis, Early Pleistocene, U.S.A. (Skinner *et al.* 1972, Table 6).							
UMMP V31986 (type) Kingman Co., Kansas	-	-	-	1.54	0.95	0.93	-
UMMP V57083 Brown Co., Nebraska	-	-	-	1.68	1.06	1.10	-

* 1 - Height of ascending ramus
2 - Anteroposterior diameter of ascending ramus at sigmoid notch
3 - Minimum depth of mandible posterior to M_3
4 - M_2 length
5 - M_2 width
6 - M_3 length
7 - M_3 width

Blarina brevicauda. It also differs from *Blarina brevicauda* in its more upright ascending ramus (that of the short-tailed shrew flares outward superiorly), in its markedly smaller diameter of the ascending ramus (at the level of the sigmoid notch), and in its lower coronoid spicule.

The original specimen was sent to C.A. Repenning for identification. The following paragraph is basically a summary of his (C.A. Repenning, personal communication 1976) comments, which are gratefully acknowledged. The Yukon fossil is definitely assigned to the Tribe Soricini. The long trigonid, the well developed entoconid crest of RM_3, and the lack of an interarticular plate (broad interarticular area) between the superior and inferior condyles indicate that OCR 9448 does not belong to the Tribe Blarinini. The extreme anterior position of the superior condyle, the nature of the internal temporal fossa, the high external temporal fossa, and the apparent lack of similarity with any known neomyine genus evidently rules out the possibility of its belonging to the Tribe Neomyini. There is, however, a considerable similarity between OCR 9448 and the mandible of the extinct plains shrew, *Planisorex dixonensis*, in the situation of the mandibular condyles, the low, well developed coronoid spicule, the elongate talonid on RM_2 and RM_3, the low cusps, and the prominent labial cingulum on the teeth (Hibbard 1956, pp. 162-163; Skinner *et al.* 197 pp. 78-79).

As no direct comparison has been possible between OCR 9448 and the type specimen of *Planisorex dixonensis*, a posterior part of a left mandible with LM_1-LM_3 (UMMP V31986) from the early Pleistocene (Nebraskan) Belleville Formation of Kingman County, Kansas, the exact generic designation of the Yukon specimen is doubtful. Pending detailed comparisons with the type, OCR 9448 is referred to *?Planisorex* cf. *dixonensis*.

Discussion

This is the first report of the plains shrew in Canada and Eastern Beringia. OCR 9448 is almost certainly of pre-late Wisconsin age because of its deep staining, and I suspect it is of early Pleistocene age because all other fossils referred to *Planisorex dixonensis* have been collected from early Pleistocene sediments. The only other shrew remains reported from Canada are of *Blarina brevicauda* from Lake Iroquois deposits at Hamilton, Ontario, which may date between 5,000 and 6,000 years B.P. (Wetmore 1958, pp. 9-10; Churcher and Karrow 1963, p. 153).

Shrew remains from the Pleistocene sediments of Alaska are nearly as rare. Two partial mandibles identified as *Sorex* sp. by Guthrie and Matthews (1971, p. 404) are recorded from the Cape Deceit Formation (?Nebraskan) near Deering. In 1955, W.O. Pruitt, Jr. found well preserved skeletal remains of a shrew *in situ* in an arctic ground squirrel *(Spermophilus parryi)* nest that was enclosed in permafrost approximately 25 feet (7.6 m) below the surface of the ground at Fairbanks Creek. The matrix consisted of silt and fine pebbles. A letter from Pruitt to C.W. Hibbard dated February 4, 1957, with the shrew remains (now preserved in the Museum of Paleontology, University of Michigan) mentions the discovery of a nest with an arctic ground squirrel curled up inside it in a position typical of hibernation. Pruitt thought the shrew had died going after the ground squirrel or its seed cache - evidently a fascinating record of "fossil behavior". Hibbard tentatively identified the specimen as a tundra shrew *(Sorex tundrensis)*. The shrew bones are quite fresh looking, and are probably of late Wisconsin age.

The shrews evidently began their radiation before the Oligocene (Repenning 1967, Figure 42). *Crocidosorex*, of late Oligocene and early Miocene age, probably gave rise to the three tribes of Soricinae (Blarinini, Neomyini, Soricini). Probably the Soricinae first reached North America from Eurasia via the Bering Isthmus in the early Miocene (Repenning 1967, p. 63). *Alluvisorex* was near the stem of the two generic groups within the Soricinae: (a) *Blarinella* and its associated genus, *Petenyia*; and (b) *Sorex* and its associated genera (*Planisorex*, *Drepanosorex* and *Microsorex*). Repenning (personal communication 1976) notes a considerable similarity of OCR 9448 and *Planisorex dixonensis* to the European middle Pleistocene genus *Drepanosorex*.

Planisorex dixonensis, a monotypic species, is only known from early Pleistocene (late Blancan) deposits of Kingman County, Kansas and Brown County, Nebraska. Evidently OCR 9448 extends the Pleistocene range of this species some 2,400 miles (3,860 km) northward from Nebraska.

Thus, the plains shrew may have had its origins in southern North America in the early Pleistocene and ranged from southern Kansas to the northern Yukon. Probably *Planisorex dixonensis* was slightly smaller in size than the short-tailed shrew, *Blarina brevicauda*, which is one of the largest (5 inches (12.7 cm) long) living American shrews. Probably insects formed the bulk of its diet. Nothing is known of the environmental requirements of this species.

Order Primates

Family Hominidae

Homo sp. (man)

So far, only indirect evidence of early man in the Yukon is available. Nevertheless, it is quite persuasive. On July 12, 1966, during my first trip up Old Crow River, I located a productive fossil locality (14N) between the mouth of Schaeffer and Johnson creeks. At this site, Peter Lord found a fleshing tool (Figure 7A) made from the tibia of a small caribou. Examination of the artifact showed that someone had applied a few glancing blows to the upper tibial shaft. The edges of the resulting fracture had then been pared down with a sharp cutting tool of stone, and the spatulate "blade" was notched to form about 12 tines or teeth, eight of which are preserved. A number of Canadian Indian groups still make similar fleshing tools from moose metapodials. They are used to remove excess tissues from the inside of a hide. The methods of making them may vary considerably and none is identical to the Old Crow example.

Because further work indicated that the fossil-bearing sediments at the site - in this case oxidized sandy gravel - were point bar deposits laid down a few thousand years earlier and contained relatively recent and very old wood, W.N. Irving and I decided to obtain radiocarbon dates on the fleshing tool and two other bones worked by man. The flesher yielded a date of 27,000 $^{+3,000}_{-2,000}$ years B.P. Dates on a mammoth long bone fragment and the upper end of a mammoth radius, both of which had flakes removed by heavy blows when fresh, were 25,750 $^{+1,800}_{-1,500}$ years B.P. and 29,100 $^{+3,000}_{-2,000}$ years B.P., respectively.

We (Irving and Harington 1973) concluded that man had evidently lived in the eastern part of Beringia before the peak of the last glaciation. He had sharp stone tools for working bone, and he had developed ways of breaking large mammoth bones. Probably he hunted mammoth and caribou and prepared skins for use as clothing and shelter.

<u>Referred specimens</u>

During the course of this project, several specimens that appear to be artifacts have been collected since 1966 from other localities along the Old Crow River. Part of a deeply stained horse mandible from Old Crow Locality 22 bears facets that were made by man before the bone became mineralized. Hansjurgen Müller-Beck of the University of Freiburg (personal communication 1970) noted that the incisor teeth had been removed and that the sockets had been worked by man. A fossilized caribou antler with four well-

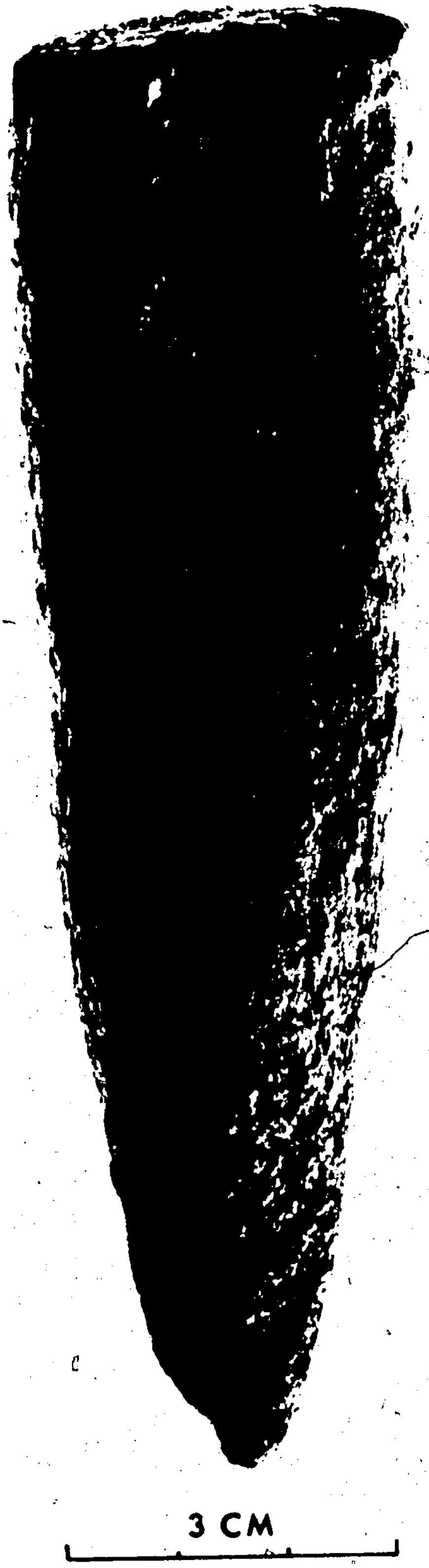
Figure 7. Human artifacts from Pleistocene deposits of the Yukon Territory.

A. Fleshing tool made from the tibia of a small caribou (*Rangifer tarandus*) from Old Crow Locality 14N.

B. Side view of a punch made from caribou antler (Dawson Locality 16).

A

B



defined facets on its base could have been used as a pestle or a skin softener (Figure 8C). It was collected at Old Crow Locality 29. Three more faceted bones were collected in 1975: a naviculocuboid (Old Crow Locality 108) with a facet on the upper surface; a lower cheek tooth of a horse (NMC 28601, Old Crow Locality 134) faceted on the labial surface; and the distal half of a horse humerus (NMC 28446, Old Crow Locality 143) with facets on either side of the olecranon fossa. As the facets on the latter specimen, although adjacent, are not on the same level or plane, working by man is indicated rather than smoothing by natural forces of friction.

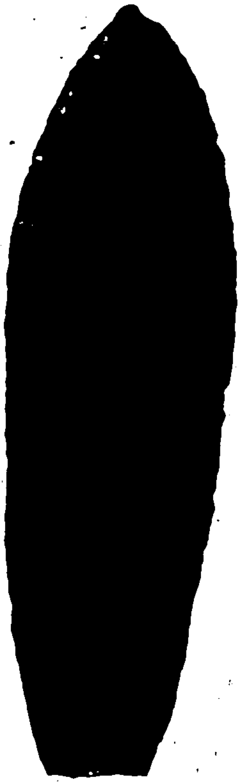
In 1975 the proximal part of a caribou antler (27115, Old Crow Locality 29) was collected. The brow tine had been removed, the base was faceted and impact-scarred, and there were paring surfaces on the bez tine. Apparently this antler fragment was used in a hammer-like fashion, with the bez tine as a handle, for striking off stone blades from a core by direct impact.

A bone tool has also been found in the Dawson Area (Harington 1975b, p. 5). In 1973 I collected a large, bullet-shaped piece of caribou antler evidently shaped by early man for use as a punch (a bone tool for making chert or obsidian tools by flaking) (Figure 7B). C. Borden (personal communication 1976) suggests the tool may have been used as a wedge. It came from the placer operation of John Erickson and Herman Liedtke on upper Hunker Creek (Dawson Locality 16). Specimens of woolly mammoth, American lion, Yukon wild ass, large-horned bison, extinct muskox *(Symbos cavifrons)* and other caribou fossils were found with the artifact. It appears to be the first tool recognized from ice age deposits in that part of the Yukon Territory. Radiocarbon analysis of a caribou antler from the same locality as the punch yielded a date of 23,900 ± 470 years B.P. (I-8580). Evidence of butchering was noted on the basal region of a bison skull collected from Sulphur Creek (Dawson Locality 17) in 1975 (Figure 8A).

Stone tools have also been found in gravel deposits along the Old Crow River (Harington 1975a, p. 121). In 1971 Charlie Thomas excavated a finely flaked, black obsidian biface at Old Crow Locality 20 near the mouth of Black Fox Creek. In 1973 a black chert biface was excavated at Old Crow Locality 11A. Its maximum measurements are 80 mm. long, 43 mm. wide and 10 mm. thick. The fact that one edge of the artifact is more heavily flaked than the other may indicate that it was used as a knife. In 1975, G.R. Fitzgerald collected a black chert bifacial "knife" from the

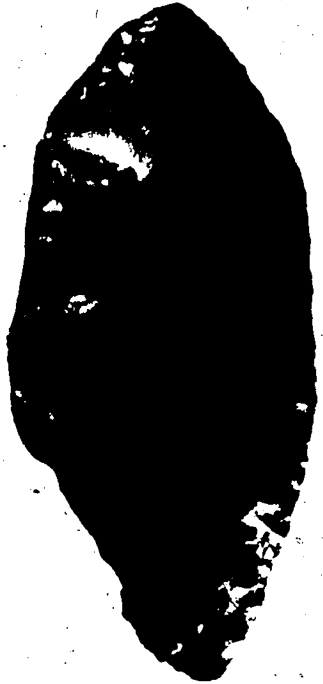
Figure 8. Human artifacts from Pleistocene deposits of the Yukon Territory. A. Ventral view of the basioccipital region of a ?young bison *(Bison* sp.*)* from Dawson Locality 17 showing butchering marks on the basioccipital and the paramastoid processes. B. Side view of a lanceolate spear point made from black chert (Old Crow Locality 138). C. Faceted base of a caribou *(Rangifer tarandus)* antler (Old Crow Locality 29). D. Side view of a bifacial "knife" made from black chert (Old Crow Locality 22).

A



B

C



D

bank of the Old Crow River at Locality 22 (Figure 8D). Like the specimen from Old Crow Locality 11A, it is finely retouched along one edge. The opposite edge is flat, providing a place where pressure could be applied by the index finger. Its maximum measurements are 99.4 mm. long x 43.7 mm. wide and 13.2 mm. thick. Later in 1975, I found a complete, lanceolate, black chert spear point at Old Crow Locality 138 (Figure 8B). Its maximum measurements are 112.2 mm. long x 32.9 mm. wide and 12.2 mm. thick. Although many Pleistocene vertebrate species were found in the gravel deposits from which these stone tools were derived, the age of the stone tools is unknown. All of the artifacts mentioned are preserved in collections of the Archaeological Survey of Canada.

Discussion

In the absence of deeply buried dwelling sites, which many archeologists require as evidence of the presence of early man, R. Bonnichsen had demonstrated by other means the validity of the present scanty evidence (Harington *et al.* 1975). His experiments indicate by use of comparative collections of different types of geologically, biologically and culturally altered material, how bones altered by man can be distinguished from those broken or polished by natural agencies, such as wind, water and freeze-thaw cycles in permafrost. Bones broken by man usually show spiral fractures instead of rectangular breaks characteristic of natural processes. But spirally-fractured bone, by itself, is not necessarily indicative of human modification. Negative impact scars and fracture surfaces that have features oriented toward the point of impact are additional clues in distinguishing bones broken by man from those altered by other agencies.

Bonnichsen found that more than 30 of 115 fossil localities in the Old Crow Area have yielded modified bones and artifacts, hundreds of which have been broken by spiral fractures. Mammoth, bison, horse and caribou bones have been modified in this way: in some cases they have been made into tools. Bonnichsen's experiments clearly demonstrate that it would not have been feasible for modern Indians to rework the fossils because of the brittleness and rectangular fracture patterns of mineralized bone; therefore, the radiocarbon date on the caribou fleshing tool and the mammoth limb bone fragments mentioned above evidently indicate the time when they were made.

There is a growing body of evidence to suggest that man entered North America over 20,000 years ago (Kennedy 1975, p. 274). Although it is possible that man may have reached other parts of America by sea at earlier periods, the data from Old Crow support the hypothesis that late Pleistocene hunters, seeking abundant game such as mammoths and bison, crossed the Bering Isthmus during a glacial interval prior to mid-Wisconsin time. Problems remain concerning the physical characteristics and ways of life of these early people, in addition to how and when they first penetrated the southern part of North America and South America. Hopefully, further research will yield answers to these questions.

Order Endentata

Family Megalonychidae

Megalonyx cf. *jeffersoni* (Jefferson's ground sloth)

Remains of Jefferson's ground sloth are rarely found in the Old Crow Area (Harington 1970, p. 45; 1971a, pp. 81-82). None has been found in the Dawson Area. Most specimens are fragmentary and are stained deep brown to black. Teeth and phalanges are best preserved.

Referred specimens

Four teeth are represented from the Old Crow Basin (Figures 9A-E, Table 11). A caniniform (NMC 24215, Old Crow Locality 66) is considered to be an LC_1, taking the narrower end as anterior and the thickest outer zone of the tooth as seen from the occlusal surface as the lateral surface (Lundelius 1972, p. 33, Figure 27). The occlusal surface is rough as if partly broken or chipped, whereas the

Figure 9. Ground sloth (*Megalonyx* cf. *jeffersoni*) remains from Yukon Pleistocene deposits.

A. Side view of an ungual phalanx of the third digit of the manus (NMC 26193, Old Crow Locality 11A). The hooked end of this claw is missing.

B. Left side view of a second phalanx of the third digit (NMC 28550, Old Crow Locality 144).

C. Posterior view of NMC 28550. D. Top view of a left astragalus (NMC 25148, Old Crow Locality 66). E. Bottom view of NMC 25148.

A

B

C

D

E

Table 11. Measurements of Pleistocene ground sloth (*Megalonyx* cf. *jeffersoni*) teeth from the Yukon Territory compared to those of *M. jeffersoni* from Robinson Cave, Tennessee (Guilday *et al.* 1969, p. 67).

Specimens	Tooth	Measurements (mm)*	
		1	2
NMC 24192 Old Crow Loc. 11A	M^1	15.7	20.8
CM 12528 Robinson Cave, Tenn.	M^1	16.0	19.0
CM 12527 (cast) Robinson Cave, Tenn.	M^1	14.0	18.0
NMC 19203 Old Crow Loc. 22	M^4	11.8	19.0
CM 12527 (cast) Robinson Cave, Tenn.	M^4	10.8	18.0
NMC 24215 Old Crow Loc. 66	C_1	36.0	16.0
CM 12528 Robinson Cave, Tenn.	C_1	40.0	17.0
TSM uncatalogued Robinson Cave, Tenn.	C_1	35.0	16.0
CM 12527 (cast) Robinson Cave, Tann.	C_1	34.0	17.0

* 1 - Maximum length.

2 - Maximum width.

inferior labial margin has been sharply fractured. Only the upper labial region shows the fine pattern of vertical striations characteristic of the original surface of the tooth. It compares closely in size to other lower caniniforms of *M. jeffersoni* from Robinson Cave, Tennessee. A fragmentary RM^1 (NMC 24192, Old Crow Locality 11A) lacks parts of the lingual and occlusal surfaces, and the base of the tooth. Vertical striations are apparent on the outer surface of the specimen. It compares closely with measurements of *M. jeffersoni* M^1s from Robinson Cave (Table 11). The lower part of an RM^4 (NMC 19203, Old Crow Locality 22) has a well preserved occlusal surface, except for the lingual margin. Again, it compares well with another *M. jeffersoni* M^4 from Robinson Cave. Another upper molar (NMC 14528, Old Crow Locality 22) is on display in the National Museum of Natural Sciences in Ottawa.

A left astragalus (NMC 25148, Old Crow Locality 66) is eroded on the margin of the fossa articulating with the scaphoid. It is comparable in size to adult *Megalonyx* astragali from Big Bone Cave (Wisconsin age), American Falls, Idaho (Illinoian? age) and a specimen from Alabama (Wisconsin? age) (G. McDonald, personal communication 1975).

A right calcaneum (NMC 24194, Old Crow Locality 66) lacks the distal half including the tuberosities, and also bone lateral to the articular facets for the astragalus. It is about half the size of calcanea of *M. jeffersoni* from

Rancho La Brea and other localities of Wisconsin age that are presently being studied by G. McDonald (personal communication 1975) at the University of Florida. The greatest distance across the articular facets for the astragalus is 79.4 mm. The minimum anteroposterior diameter at the neck of the calcaneum is 51.1 mm.

Six foot bones have been collected. A proximal phalanx (NMC 23042, Old Crow Locality 66), probably of the third digit, has a maximum length, width and height of 55.3 x 43.5 x 35.9 mm. A smaller proximal phalanx (NMC 22567, Old Crow Locality 11A), probably of the fourth digit, has badly damaged distal articular surfaces. Its maximum length and width are 43.8 x 36.3 mm. A second phalanx of the third digit (NMC 28550, Old Crow Locality 144) appears to be only slightly smaller in maximum length, width and height (74.9 x 39.8 x 52.1 mm.) than approximate measurements from a scaled figure of *Megalonyx jeffersoni* from Kentucky (79.2 x 35.0 x 57.2 mm.) illustrated by Leidy (1855, Plate X, Figures 4, 8). A penultimate phalanx (NMC 14883, Old Crow Locality 29), possibly of the second digit, is damaged proximally. Its maximum length and width are 53.1 x 30.8 mm. This specimen may articulate with an ungual phalanx of the second digit (NMC 14882, Old Crow Locality 29) which was collected at the same time and place. Its maximum height and width are 51.2 x 29.5 mm. A large ungual phalanx of the third digit of the manus (NMC 26193, Old Crow Locality 11A) has maximum height and width measurements of 60.8 x 33.4 mm. The distal, hooked ends of these ungual phalanges are lacking.

Discussion

It is worth noting that ~~the~~ ground sloth specimens are derived from relatively few localities (11A, 22, 29, 66), which are situated near the mouths of the present major tributaries of the Old Crow River: Johnson, Black Fox and Timber creeks (Figure 2). Most of the specimens appear to be smaller than Wisconsin age *Megalonyx*, which may be due to: (a) the younger chronological age of the individuals represented; (b) the fact that there may be a size difference due to sex, in which case the Old Crow specimens would likely be females; (c) the fact that they represent ground sloths living before Wisconsin time. A definite increase in size of *Megalonyx* from early to late Pleistocene has been noted by Romer (1966, p. 295) and G. McDonald (personal communication 1975). Of these explanations, I prefer the last.

Ground sloths evolved in South America during the early Tertiary, and the Megalonychidae first appeared in the early Oligocene of Patagonia. Hirschfeld and Webb (1968, Figure 22) suggest that *Megalonyx* was derived from the *Pliomorphus* - *Ortotherium* complex of South American megalonychids in early Pliocene time. When the Panamanian

Isthmus was re-established in the late Pliocene, for the first time since the beginning of the Tertiary, various ground sloths prevailed against the tide of Nearctic mammals, and moved into Central and North America. *Megalonyx*, although never reported from South America, ranged widely through North America reaching as far north as the Yukon and Alaska. The genus shows a great deal of skeletal (particularly dental) plasticity; consequently, a revision of *Megalonyx* would likely result in a reduction of species.

An Alaskan specimen, a proximal phalanx possibly of the fourth digit of the manus (F:AM 30844), was the first indication that *Megalonyx* had reached Eastern Beringia (Stock 1942, p. 552). Apparently no other ground sloth specimens have been reported from Alaska. Soon afterward, a second lower molar (ANSP 15208) of *Megalonyx* cf. *jeffersoni* was collected at Lower Carp Lake north of Yellowknife in the Northwest Territories (Stock and Richards 1949, p. 709). It was associat with a fragment of American mastodon molar, suggesting a relatively warm forest or open forest habitat. Considered together, the Alaskan, Yukon and Northwest Territories records suggest that *Megalonyx* occupied a rather broad east-west range in northwestern North America during a warm phase of the late Pleistocene (Harington 1971a, p. 82).

The only other *Megalonyx* specimens reported from Canada are an ungual phalanx (cast; ROM 3339) from river gravels near Quesnel, British Columbia, an undescribed tooth fragment (ROM 5538) from near Saskatoon, Saskatchewan (C.S. Churcher, personal communication 1970), and other specimens from Wellsch Valley, Saskatchewan (Stalker 1971, p. 180) and Medicine Hat, Alberta (Stalker and Churcher 1970).

Megalonyx was a long-haired, bear-sized ground sloth. In the more southerly regions of North America it is associated with Pleistocene forest faunas. Its broad blunt caniniforms suggest a leaf-stripping adaptation (Hirschfeld and Webb 1968, p. 291). It would be interesting to know what kinds of trees or shrubs *Megalonyx* preferred. The fact that Old Crow specimens appear to be smaller than most Wisconsin age fossils may indicate that they reached northwestern North America during the Sangamon, or possibly an earlier interglacial. No radiocarbon dates on *Megalonyx* bone from Eastern Beringia are available, nor does biostratigraphic information provide a clue as to the period when these ground sloths lived in the arctic. Evidently *Megalonyx* became extinct about 9,400 years ago (Martin and Guilday 1967, p. 19).

Order Lagomorpha

Family Ochotonidae

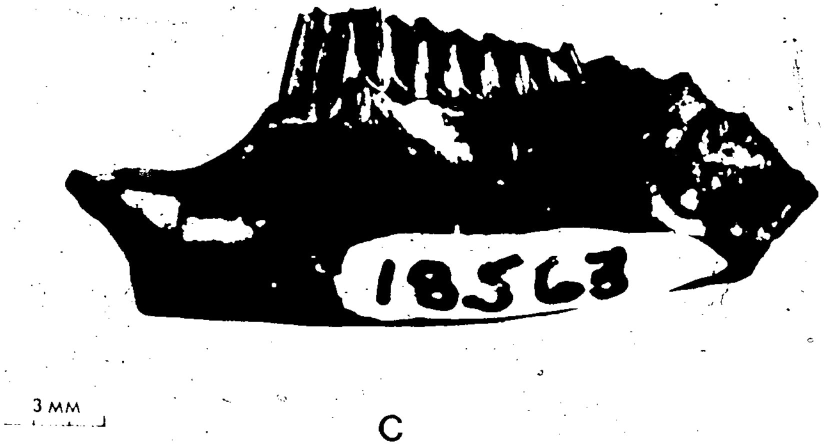
Ochotona cf. *whartoni* (giant pika)

Referred specimens

Two mandible fragments with teeth (Figure 10A-B, Table 12) from Quaternary deposits in the Old Crow Basin represent very large or giant pikas. The first specimen, a left mandible fragment with LM_1-LM_3 (NMC 16817), was collected in 1967 at Old Crow Locality 14N. M_3 consists of one loop, as in the Ochotonidae. I first mentioned this specimen in a faunal list from that locality as "Ochotonidae - giant pika" (Irving and Harington 1973, p. 339). The teeth, according to size and degree of wear, seem to be those of an adult. The specimen is stained brown. Mary Dawson (personal communication 1970), who kindly examined NMC 16817, suggested that it is best considered to represent a species of *Ochotona*, although P_3, which is of diagnostic importance in this group, is lacking.

The second specimen, a left mandible with LM_1-LM_2 and part of the alveolus for LM_3 (NMC 24380), was collected in 1973 at Old Crow Locality 11A. It has the same general proportions as NMC 16817, but is slightly larger. Again, the size and degree of wear on the teeth indicate that it represents an adult. The large mental foramen below LM_2

Figure 10. Left mandibul[illegible]agment with LM_1-LM_3 of a Pleistocene giant pika *(Ochotona* cf. *whartoni)* (NMC 16817, Old Crow Locality 14N). A. Lateral view. B. Occlusal view. Left mandible with LP_3-LM_3 of a Pleistocene American pika *(Ochotona princeps)* (NMC 18563, Old Crow Locality 29). C. Lateral view. D. Occlusal view.



C

A

D

B

Table 12. Measurements of Pleistocene giant pika (*Ochotona* cf. *whartoni*) mandibles from the Yukon Territory compared to Pleistocene *O. whartoni* from Alaska.

Specimens	Measurements (mm)*							
	1	2	3	4	5	6	7	8
Ochotona cf. *whartoni*. Pleistocene, Y.T.								
NMC 16817 Old Crow Loc. 14N	9.9	9.5	2.3^+	2.8	2.9	2.8	1.7	2.0
NMC 24380 Old Crow Loc. 11A	10.5	-	3.1	3.0	3.2	2.9	-	-
Ochotona whartoni. Pleistocene, Alaska								
UA 2000 Cape Deceit**	9.9	-	3.0	2.8	2.9	2.6	-	-
F:AM 101149 Gold Hill (Fairbanks Area)	9.3	7.9***	2.1	2.4	2.1	2.3	1.0	1.6

* 1 - Mandible depth below centre of M_1.
2 - Minimum mandible depth from posterior of M_3 to the concavity on the lower surface of the mandible.
3 - Length (anteroposterior) M_1.
4 - Width M_1.
5 - Length M_2.
6 - Width M_2.
7 - Length M_3.
8 - Width M_3.

** I am grateful to R.D. Guthrie of the University of Alaska for supplying these measurements.

*** Mandible depth taken below M_3 as the mandible is broken behind this tooth. John H. Wahlert of the American Museum of Natural History kindly provided the measurements on the specimen from Gold Hill, Alaska.

and other traces of foramina nearby are like those of NMC 16817 and are correct for *Ochotona*. A large cavity on the inside of the mandible is due to erosion of the thin bone near the swelling at the root of the incisor. Such cavities are not uncommon in fossil pika mandibles (e.g. *Ochotona princeps*; NMC 15834); one exists in the holotype of *Ochotona whartoni* (Guthrie and Matthews 1971, p. 499), a Pleistocene giant pika from Alaska. NMC 24380 is stained dark reddish brown.

Discussion

In 1971 Guthrie and Matthews described a partial mandible of a large pika with RM_1-RM_2 (UA 2000) from the Cape Deceit Formation (?Nebraskan) on Kotzebue Sound, Alaska as the holotype of a new species *Ochotona whartoni*. Two complete maxillary tooth rows, jaw fragments and incomplete molars from that formation were referred to this species, as was a relatively complete skull with mandibles (F:AM 101149) from Gold Hill Cut in the Fairbanks area of Alaska, which is in the collections of the American Museum of Natural History. It should be emphasized that the teeth of this specimen are much smaller than those of *O.* cf. *whartoni* from the Yukon Territory, and that they are similar in size to large fossils from that region referred to *O. princeps*. *O. whartoni* was differentiated on the basis of its large size, which, although seemingly practical in this case, is rather a tenuous criterion - especially when some species of Pleistocene pikas are known to vary in size. For example, it is important to note size variations in the Sardinian pika *Prolagus sardus*: postglacial forms average 15 to 20% larger than the middle Pleistocene ones (Kurtén 1968, p. 227). Size also differs between modern *O. princeps* and Old Crow Pleistocene pika specimens that I attribute to *O. princeps*. If better specimens of the giant pika are found in Yukon Pleistocene deposits, it may be possible to identify them more precisely. Meanwhile, I consider that the fossils NMC 16817 and 24380 are most closely comparable to *Ochotona whartoni* and may be referred to *Ochotona* cf. *whartoni*. These fossils are markedly larger than any specimens of Recent *O. princeps* that I have seen, and probably larger than any living pikas of Asia (M R. Dawson, personal communication 1970). Unfortunately, specimens of some large Pleistocene pikas from China (e.g. *O. koslowi* and *Ochotonoides complicidens*) were not available for comparison with the Yukon fossils. In overlaying NMC 16817 on a natural sized illustration of *Ochotonoides complicidens* (Teilhard de Chardin and Young 1931, Plate VI, 4), both specimens are seen to be of similar size but the mandible of the Yukon specimen is less deep, particularly posterior to M_3. "*O. daurica*", from the Pleistocene deposits of Gezidong Cave, China (Archaeological Team of the Provincial

Museum of Liaoning 1975, p. 129, Figure 10), also appears to be similar in size to the Yukon fossils.

Alaskan specimens of *O. whartoni* indicate that giant pikas lived in Eastern Beringia from early to middle Pleistocene time, for the fossil from Gold Hill, which is slightly smaller than those from Cape Deceit, may be of Illinoian age (Péwé 1975b, p. 12). Because of their dark staining, I suggest that Old Crow specimens are pre- late Wisconsin, perhaps early Pleistocene in age. They cannot be firmly dated because they were not found in place.

Some comments on the evolutionary history of the pikas are given in the section on *Ochotona princeps*. The "blossoming" of large pikas, like those mentioned above, in the early to middle Pleistocene of China is remarkable. Perhaps this influence extended in Nebraskan time to Cape Deceit, Alaska, and later (Illinoian?) to the Fairbanks area of Alaska and the Old Crow Area of the Yukon Territory. Guthrie (1973) gives evidence that *O. princeps*, considered a member of the alpine fauna, had spread into the lowlands of central Alaska during the late Pleistocene and occupied a drier more steppe-like environment than now prevails there. Shifts of habitat such as this could be largely responsible for variations in size that are seen among fossils from the Old Crow Basin. I postulate that *Ochotona* cf. *whartoni* occupied a relatively rich steppe grassland habitat in Eastern Beringia during the early to middle Pleistocene. Being approximately twice the size of the living American pika, it may ave benefited from access to m[illegible] abundant lowland fo[illegible]

Ochotona princeps (American pika)

More than 80 specimens (Figure 10C-D, Table 13-14) of the American pika have been collected from Pleistocene deposits in the Old Crow Basin. Most are mandibular fragments with teeth (only three are maxillary fragments), which lack the ascending ramus and complete diastema. Unless otherwise specified, all specimens are stained brown.

Referred specimens

NMC 19102 is a right maxillary fragment with RP^3-RM^2 and part of the alveolus for RP^2. The facial tubercle and part of the palate are preserved. The fossil is stained black, and was excavated from oxidized sandy gravel overlying the basal clay unit at Old Crow Locality 28. NMC 19109 is a right maxillary fragment with RP^3-RM^1 and part of the alveolus for RP^2. It also includes the facial tubercle and part of the right side of the palate. It is stained black and was also excavated at Old Crow Locality 28. NMC 25358 from Old

										-	2.0	[illegible]	2.2	2.3	2.1	2.1	1.2	1.4
NMC 25313	Loc. 27W	-	-	-	10.0	-	7.4	6.9	-	-	2.1	2.2	2.3	2.3	2.3	2.2	1.2	1.8
NMC 22208	Loc. 27W	-	-	-	-	-	7.3	7.0	-	-	2.1	2.0	2.1	2.1	2.1	2.2	1.1	1.5
NMC 22240	Loc. 27W	-	-	-	-	-	6.5	6.2	-	-	2.0	2.1	2.1	2.0	2.0	2.3	-	-
NMC 22231	Loc. 27W	-	-	-	10.2	-	7.8	6.1	-	-	2.0	2.4	2.1	2.2	2.2	2.2	-	-
NMC 25489	Loc. 44	-	-	-	-	-	6.9	6.6	-	-	1.9	2.2	1.9	2.3	2.1	2.2	1.0	1.4
NMC 22268	Loc. 27W	-	-	-	-	-	7.0	6.5	-	-	1.9	2.0	2.1	2.0	2.0	1.9	1.0	1.2
NMC 18269	Loc. 27W	-	-	-	-	-	7.0	6.6	-	-	-	-	2.0	2.2	1.9	2.3	1.1	1.2
NMC 22265	Loc. 27W	-	-	-	-	-	7.8	7.3	-	-	2.1	2.1	2.2	2.2	2.3	2.1	1.0	2.0
NMC 18224	Loc. 11A	-	-	4.1	-	7.3	6.6	-	-	-	-	-	2.0	2.1	1.9	2.0	-	-
NMC 22052	Loc. 27W	-	-	-	9.3	-	7.0	6.7	1.7	1.6	2.2	2.0	1.8	2.0	1.8	2.0	1.0	1.5
NMC 25053	Loc. 27	-	-	4.2	9.8	7.4	6.8	6.5	-	-	2.2	2.2	1.9	2.2	2.1	2.1	-	-
NMC 22165	Loc. 27W	-	-	-	9.5	-	7.0	6.8	-	-	2.1	2.0	2.0	2.1	2.0	2.0	0.9	1.5
NMC 22167	Loc. 27W	-	-	5.2	10.1	7.8†	8.0	7.5	-	-	2.0	1.9	2.1	2.2	1.8	2.0	1.1	1.7
NMC 22166	Loc. 27W	-	-	4.3	9.8	6.0	7.4	7.0	-	-	1.9	2.1	1.9	2.2	2.1	2.3	1.2	1.5
NMC 15636	Loc. 27	-	-	4.2	9.6	8.0	7.2	-	2.0	1.7	2.1	2.0	2.2	2.3	2.3	-	-	-
NMC 18635	Loc. 27	-	-	4.4	9.0	5.5†	5.8	5.3	-	-	-	-	-	-	-	-	-	-
NMC 25305	Loc. 27W	-	-	4.1	9.1	7.0	6.8	6.0	-	-	2.0	2.0	2.0	2.1	1.8	2.1	1.0	1.4
NMC 22241	Loc. 27W	-	-	-	-	-	-	6.8	-	-	-	-	-	-	1.9	2.1	-	-
NMC 18568	Loc. 29	-	-	3.8	9.1	7.2	6.6	6.3	-	-	1.9	1.7	2.0	2.0	1.9	2.0	1.0	1.4
NMC 18559	Loc. 29	-	-	-	-	-	8.3	7.1	-	-	2.2	2.3	2.2	2.4	2.2	2.3	1.0	1.8
NMC 25303	Loc. 27W	-	-	4.7	9.4	5.8†	7.1	6.6	-	-	2.2	1.9	2.0	2.0	2.0	2.0	1.0	1.5
NMC 22245	Loc. 27W	-	-	-	-	-	6.6	-	-	-	2.0	2.0	2.2	2.0	-	-	-	-
NMC 22279	Loc. 27W	-	-	-	-	-	6.9	-	-	-	2.1	2.0	2.0	2.0	2.1	2.0	-	-
NMC 24792	Loc. 45	-	-	-	-	-	7.2	6.8	-	-	-	-	-	2.0	1.9	2.0	0.9	1.5
NMC 22189	Loc. 27W	-	-	-	-	-	-	6.6	-	-	-	-	-	-	2.0	2.1	1.0	1.8
NMC 25291	Loc. 27W	-	-	4.3	-	8.1	-	-	-	-	-	-	-	-	-	-	-	-
NMC 15831	Loc. 44	-	-	-	-	-	6.7	-	-	-	-	-	2.1	1.9	1.8	1.7	-	-
NMC 15833	Loc. 44	-	-	-	8.3	-	6.0	5.6	-	-	1.6	1.8	1.6	1.9	1.5	1.8	-	-
NMC 15830	Loc. 44	-	-	-	9.4	7.0	7.0	6.2	-	-	1.8	2.0	2.0	2.1	2.1	2.0	-	-
NMC 15834	Loc. 44	-	-	-	-	-	-	5.7	-	-	-	-	-	-	1.7	1.7	0.8	1.3
NMC 15835	Loc. 44	-	-	-	9.2	-	6.8	6.5	-	-	2.0	2.0	1.9	2.1	1.9	2.1	1.0	1.4
NMC 15832	Loc. 44	-	-	-	-	-	6.9	7.2	-	-	1.9	2.1	2.1	2.0	2.0	2.1	1.1	1.5
NMC 15531	Loc. 44	-	-	-	9.7	-	6.7	6.0	-	-	1.9	2.0	2.1	2.0	1.9	2.0	1.0	1.5
NMC 15633	Loc. 28	-	-	-	-	-	-	6.2	-	-	-	-	-	-	1.9	1.8	-	-
NMC 20740	Loc. 44	-	-	-	9.1	-	6.1	5.6	-	-	1.7	2.0	1.8	2.0	1.9	1.9	0.9	1.3
NMC 18776	Loc. 20	-	-	3.7	8.6	7.1	6.6	6.0	-	-	1.9	1.9	2.0	2.1	1.8	1.8	1.1	1.2
NMC 22061	Loc. 27W	-	-	-	8.7	-	6.2	6.1	-	-	1.7	2.0	1.8	2.1	1.7	2.0	0.9	1.4
NMC 25488	Loc. 44	-	-	2.7	-	4.8	5.3	-	-	-	1.5	1.6	1.5	1.6	-	-	-	-
NMC 22162	Loc. 27W	-	-	-	-	-	5.9	-	-	-	-	-	1.9	2.1	1.7	2.1	-	-
NMC 25487	Loc. 44	-	-	-	9.2	6.1†	7.1	6.9	-	-	1.9	2.0	2.0	2.1	1.9	2.0	1.2	1.5
NMC 22247	Loc. 27W	-	-	-	-	-	-	-	-	-	-	-	-	-	1.8	1.8	-	-
NMC 24790	Loc. 45	-	-	-	-	-	6.8	6.5	-	-	2.2	2.2	1.9	2.1	1.9	2.1	0.9	1.5
NMC 24893	Loc. 11A	-	-	-	-	-	5.6	6.2	-	-	-	-	-	1.9	1.8	1.9	1.0	1.5
NMC 22276	Loc. 27W	-	-	-	6.7	-	4.4	4.7	-	-	-	-	1.5	1.5	1.5	1.4	-	-
NMC 22242	Loc. 27W	-	-	-	-	-	6.9	6.6	-	-	-	-	2.0	2.4	1.8	2.0	1.1	1.6
NMC 25284	Loc. 27W	-	-	3.6	9.3	6.0	6.4	6.0	-	-	2.0	1.8	2.1	1.9	2.0	2.0	-	-
NMC 24895	Loc. 11A	-	-	-	-	-	-	6.0	-	-	-	-	-	1.9	1.7	2.0	-	-
NMC 22215	Loc. 27W	-	-	3.6	8.8	5.3	5.5	-	-	-	-	-	1.8	1.8	-	-	-	-
NMC 22193	Loc. 27W	-	-	-	-	-	5.7	6.0	-	-	-	-	1.7	1.9	1.6	2.0	-	-
NMC 25277	Loc. 27W	-	-	-	-	-	6.0	5.8	-	-	1.8	1.9	1.7	2.0	1.5	2.0	0.9	1.4
NMC 22205	Loc. 27W	-	-	-	-	-	5.6	-	-	-	1.6	1.6	1.6	1.7	1.7	1.6	-	-
NMC 22140	Loc. 27W	-	-	-	-	-	6.6	6.5	-	-	-	-	2.1	2.0	1.9	2.1	1.0	1.5
NMC 22174	Loc. 27W	-	-	-	-	-	-	6.2	-	-	-	-	-	-	2.0	2.0	1.1	1.8
NMC 16646	Loc. 27	-	-	-	-	-	5.0	4.8	-	-	-	-	1.4	1.5	1.3	1.6	0.6	1.1
NMC 22135	Loc. 27W	-	-	-	7.5	-	5.0	4.8	-	-	1.6	1.5	1.6	1.5	1.7	1.6	0.8	1.0
NMC 28666	Loc.137	-	-	2.7	-	3.9†	4.2	-	-	-	-	-	1.4	1.4	-	-	-	-
NMC 28709	Loc. 27	-	-	4.0	9.1	-	6.6	6.4	-	-	1.8	1.9	2.1	2.0	2.2	2.0	1.1	1.4
NMC 28553	Loc. 22	-	-	-	9.0	-	5.9	6.3	-	-	1.8	2.0	1.9	2.0	2.1	2.0	1.2	1.5
NMC 28700	Loc. 22	-	-	-	9.3	-	6.2	6.1	-	-	1.9	1.8	1.9	1.9	1.8	1.9	1.1	1.4
NMC 28640	Loc. 65	-	-	-	9.5	6.3	7.4	6.9	-	-	2.0	2.1	2.2	2.1	2.1	2.1	1.1	1.5
NMC 28765	Loc.104	-	-	-	-	-	-	7.6	-	-	-	-	-	-	-	-	1.2	1.6
NMC 28733	Loc. 27	-	-	-	-	-	7.1	7.6	-	-	-	-	-	2.1	2.2	2.1	1.2	1.5
		-	-	-	-	-	-	7.0	-	-	-	-	-	-	2.1	2.0	1.2	1.6

Ochotona princeps. Recent

NMC 31162	Yukon Territory	♂	27.8	3.6	8.1	5.7	6.3	5.3	1.4	1.5	1.7	1.8	1.9	1.9	1.8	1.9	1.0	1.3
NMC 31172	Yukon Territory	♂	28.5	3.2	8.0	5.8	5.3	5.0	1.4	1.5	1.6	1.7	1.8	1.7	1.6	1.8	0.8	1.3
NMC 31173	Yukon Territory	♀	27.1	3.6	7.4	6.7	5.2	5.0	1.5	1.5	1.6	1.8	1.8	1.9	1.7	1.8	0.8	1.4
NMC 31166	Yukon Territory	♂	28.0	3.5	7.0	6.5	5.2	5.3	1.3	1.4	1.5	1.8	1.6	1.8	1.6	1.7	0.8	1.2
NMC 40302	Alaska	♂	27.4	3.5	7.6	6.2	5.3	5.0	1.4	1.4	1.6	1.8	1.9	1.8	1.9	1.8	0.9	1.2
NMC 31170	Yukon Territory	♀	27.8	3.2	7.5	6.6	5.3	4.9	1.4	1.6	1.6	1.7	1.6	1.7	1.8	1.8	0.8	1.2

---

* 1 - Mandible lehgth (superior alveolar margin of I_1 to posterior of angle).
2 - Diastema depth.
3 - Alveolar length (P_3-M_3).
4 - Diastema length (superior alveolar margin of I_1 to anterior alveolar margin of P_3.
5 - Mandible depth (M_1).
6 - Mandible depth (posterior of M_3).
7 - Length P_3.
8 - Width P_3.
9 - Length P_4.
10 - Width P_4.
11 - Length M_1.
12 - Width M_1.
13 - Length M_2.
14 - Width M_2.
15 - Length M_3.
16 - Width M_3.

Crow Locality 27W is a right maxillary fragment with RP^4 which is joined by alveolar bone to the facial tubercle.

NMC 19241 is a right mandibular fragment with RP_3-R and a broken incisor. P_3 rises vertically, rather than curving back near the occlusal surface as in a Recent specimen from the Yukon Territory (NMC 31162). The fossil was excavated from organic sandy gravel overlying the basal clay unit at Old Crow Locality 44. NMC 22256, a left mandible from Old Crow Locality 27W, is complete except for LP_3 and a tip of the angular process. The anterior mandibular foramen is well developed. NMC 22163 from Old Crow Locality 27W is a right mandibular fragment with RP_3-RM_3. NMC 18563, a left mandible with LP_3-LM_3, excavated from Old Crow Locality 29, is stained blackish brown. The bone has eroded to form a cavity on the inside of the mandible near the incisor root. NMC 22266 from Old Crow Locality 27W is a right mandible with RP_4-RM_3 and the alveolus for RP_3. It is stained black. NMC 18559 from Old Crow Locality 29 is a left mandible with LP_4-LM_3. NMC 20740, a left mandible containing LP_4-LM_3 and the alveolus of LP_3, was excavated at Old Crow Locality 44. NMC 24741 is a right mandible with RP_4-RM_3 and the alveolus for RP_3. It is from gravel deposits on a bar, Old Crow Locality 11A. NMC 28666 is a left mandible with LP_4-LM_3 and the alveolus for LP_3. NMC 18224 from Old Crow Locality 11A is a left mandible with LP_3-LM_3. It is stained dark brown with mottled oxidation specks on the lateral surface. NMC 22052 from Old Crow Locality 27N is a left mandible with LP_4-LM_2 and alveoli for the incisor, LP_3 and LM_3. It is stained reddish brown. NMC 22161 from Old Crow Locality 27W is a left mandible with LP_4-LM_3 and the alveolus for LP_3. It is stained dark brown on the inside and has a mottled dark and light brown surface on the outside. NMC 22167 from Old Crow Locality 27W is a right mandible with RP_4-RM_3 and the alveolus for RP_3. It is stained blackish brown. NMC 22241 from Old Crow Locality 27W is a left mandible with LP_4-LM_3 and the alveolus of LP_3. NMC 18636 from Old Crow Locality 27W is a right mandible with RP_4-RM_2 and alveoli for RP_3 and RM_3. It has a relatively shallow mandible compared to most fossils from the Old Crow Basin. It is comparable in this respect to a Recent specimen from the Yukon (NMC 31162). NMC 22267 is a right mandible with RP_3-RM_2. It is stained dark reddish-brown and was excavated at Old Crow Locality 27W. NMC 25053 from Old Crow Locality 22 is a left mandible with LP_4-LM_3 and the alveolus for LP_3. NMC 22166 from Old Crow Locality 27W is a right mandible with RP_3-RM_2 and the alveolus for RM_3. NMC 15834 is a right mandible with RP_4-RM_3 and the alveolus for RP_3. It was excavated from organic sandy gravel overlying the basal clay unit at Old Crow

Locality 44. NMC 15832, a left mandible with LP_4-LM_3 and the alveolus for LP_3, was excavated at Old Crow Locality 44. NMC 15633 from Old Crow Locality 28 is a right mandible with RP_4-RM_3 and the alveolus for RP_3. NMC 18776 from Old Crow Locality 20 is a left mandible with LP_4-LM_3 and the alveolus for LP_3. NMC 22162 from Old Crow Locality 27W is a right mandible with RP_4-RM_3 and the alveolus for RP_3. NMC 22242 from Old Crow Locality 27W is a left mandible with LP_4-LM_2 and alveoli for LP_3 and LM_3. NMC 18646 from Old Crow Locality 27 is a left mandible with LP_4-LM_3 and the alveolus for LP_3. NMC 28709 from Old Crow Locality 27 is a left mandible with LP_4-LM_3 and the alveolus for RP_3. NMC 28700 from Old Crow Locality 27 is a right mandible with RP_4-RM_3 and the alveolus for RP_3.

NMC 22247, a right mandible with RP_4 (fragmentary) -RM_3, is stained black. It is from Old Crow Locality 27W. NMC 22193 from Old Crow Locality 27W is a right mandible with RP_4-RM_2. It is stained black. NMC 15833, a right mandible with RP_4-RM_2 and the alveolus of RM_3, was excavated at Old Crow Locality 44. NMC 18269 from Old Crow Locality 27W is a left mandible with LP_4-LM_3. NMC 25489, a right mandible with RP_4-RM_3, is stained dark brown with traces of oxidation on the outside below RP_4. The specimen was excavated at Old Crow Locality 44. NMC 22231 from Old Crow

Locality 27W is a right mandible with RP_4-RM_3. A cavity on the inside of the mandible resulted from breakage of bone at a swelling near the root of the incisor. This swelling is characteristic of both giant pikas (*O.* cf. *whartoni*) and *O. princeps*. NMC 25313 from Old Crow Locality 27W is a right mandible with RP_4-RM_3. The mandible of this specimen is deep compared to that of a Recent Yukon pika (NMC 31162). NMC 24673 from Old Crow Locality 22 is a right mandible with RP_4-RM_3 and the alveolus for RP_3. It is stained black. NMC 15713 from Old Crow Locality 28 is a right mandible with RP_4-RM_3. It is a mottled brown color. NMC 18635 is a right mandible with RP_4-RM_3 with the alveolus for RP_3 and a complete diastema. It was collected at Old Crow Locality 27. NMC 18568 from Old Crow Locality 29 is a left mandible with LP_4-LM_3. It has a relatively deep mandible, but the teeth are smaller than those of *O.* cf. *whartoni*.

NMC 22240 from Old Crow Locality 27W is a right mandible with RP_4-RM_2 and alveoli for RP_3 and RM_3. NMC 15831 from Old Crow Locality 44 is a right mandible with RP_4-RM_2 and alveoli for RP_3-RM_3. The bone is thin, and RP_4 roots penetrate the ventrolateral wall of the mandible. Presumably the animal represented was immature at death. The specimen is stained light reddish brown as if its matrix were oxidized. NMC 15835 from Old Crow Locality 44 is a right mandible with RP_4-RM_3. The swelling in the bone near the medial side of the incisor root is broken. NMC 25277 from Old Crow Locality 27W with LP_4-LM_2 is relatively small and is stained dark reddish brown. NMC 22174 is a left mandible with LM_1-LM_3. It is from Old Crow Locality 27W, and is smaller than NMC 25277. NMC 22264 from Old Crow Locality 27W is a left mandible with LM_1-LM_3. The anterior half of the ascending ramus is preserved. The specimen is stained black. NMC 22208, a right mandible with RP_4-RM_2, was excavated at Old Crow Locality 27W. It is stained black. NMC 18368 from Old Crow Locality 29 is a right mandible with RP_4-RM_2 and alveoli for RP_3 and RM_3. The bony swelling near the medial side of the incisor root is broken. NMC 22268 from Old Crow Locality 27W is a left mandible with LM_1-LM_3 and partial alveoli for LP_3 and LP_4. NMC 22265, a left mandible with LM_1-LM_2 and alveoli for the premolars, is stained dark reddish brown. It was excavated from organic sandy gravel overlying the basal clay unit at Old Crow Locality 27W. NMC 22061 from Old Crow Locality 27W is a right mandible with RP_4-RM_1 and alveoli for the remaining cheek teeth. It is stained dark reddish brown. The unusually small size of this specimen suggests that a young individual is represented. NMC 24790 is a right mandible with RM_1-RM_3. The posterior of RM_1 is damaged. The specimen was excavated from sandy silt about 30 feet

(9.1 m) above the level of the Old Crow River at Locality 45. These sediments may be of late Sangamon or early Wisconsin age. NMC 22276 from Old Crow Locality 27W is a left mandible with LM_1-LM_3. The teeth are heavily worn, which may account for their relatively large size. The specimen is stained black. NMC 24893 from Old Crow Locality 11A is a right mandible with RM_1-RM_2 and alveoli for the remaining cheek teeth. The specimen is very small and may represent a juvenile. It is stained reddish brown. NMC 25277 from Old Crow Locality 27W is a left mandible with LP_4-LM_2. It is stained dark reddish brown. NMC 22140 from Old Crow Locality 27W is a left mandible with LM_2-LM_3 and the alveolus for LM_1. The teeth are well worn indicating that the individual represented was adult. The specimen has a mottled brown color.

NMC 28768 from Old Crow Locality 104 is the posterior part of a right mandible with the posterior loop of RM_1 and RM_2-RM_3. The mandible is relatively deep. NMC 24895 is a left mandible with LM_1 and alveoli for the remaining cheek teeth. It is from Old Crow Locality 11A. NMC 22215 from Old Crow Locality 27W is a right mandible with RM_1-RM_2 and the alveolus for RM_3. The specimen is stained black. NMC 22279, a left mandible with LM_1-LM_3, is from Old Crow Locality 27W. LM_1 is damaged. NMC 22245 from Old Crow Locality 27W is a left mandible with LP_4-LM_2 and the alveolus of LM_3. NMC 28733 from Old Crow Locality 27 is a right mandible with RM_2-RM_3. RM_1 is broken off at the alveolar margin. The specimen is stained blackish brown. NMC 22135 from Old Crow Locality 27W is a right mandible with RM_1 and alveoli for RP_3 and RP_4. Its small size may indicate that a young individual is represented. NMC 25488, a right mandible with RM_1-RM_2 and the alveolus for RM_3, was excavated at Old Crow Locality 44. NMC 15830 from the same site is a right mandible with RM_2-RM_3. The mandible anterior to RM_2 is lacking. The anterior half of the ascending ramus is preserved. The bone appears to be thin and fragile, suggesting that a young individual is represented.

NMC 25291 from Old Crow Locality 27W is a left mandible with LM_1-LM_2. NMC 24792 is a left mandible with LM_2-LM_3. It was collected from sandy silt about 30 feet (9.1 m) above the level of the Old Crow River at Locality 45. The enclosing sediments may be of Sangamon or early Wisconsin age. NMC 25303 from Old Crow Locality 27W is a left mandible with LP_4-LM_2 and the alveolus for RP_3. It is stained black. NMC 25284 from Old Crow Locality 27W is a right mandible with RM_1-RM_2 and the alveolus for RM_3. RM_1 is damaged. NMC 28649 is the posterior part of a right mandible with damaged RM_{-} and complete RM_3. This specimen from Old Crow Locality 65 was excavated from oxidized silty sands overlying the basal clay unit. NMC 15831 from Old Crow Locality 44 is a left mandible with LM_2 and alveolus for LM_3. NMC 22189 from Locality 27W is a left mandible with partial LP_4 and the alveolus for LP_3. It is stained dark reddish brown. NMC 25487 from Old Crow Locality 44 is a right mandible with RM_2 and the alveolus for RM_3.

A left humerus (NMC 22042) from Old Crow Locality 27W is slightly longer (29.3 mm) than that of a Recent male from the Whitehorse area of the Yukon (NMC 31162 - 27.0 mm).

Discussion

Pika fossils from Pleistocene deposits of the Old Crow Basin, although slightly larger on the average than Recent *Ochotona princeps collaris* specimens from the Yukon Territory I have seen, appear to differ in no other features. They are therefore referred to the American pika, *O. princeps*. Specimens collected *in situ* from the fossiliferous layer (Unit 2) at Old Crow Locality 44 indicate that *O. princeps* occupied the Old Crow Basin during the ?Sangamon interglacial (or earlier, if they are reworked from older deposits). Specimens collected from sandy silt pockets above the fossiliferous unit at Localities 44 and 45 suggest that the pikas survived in the region at least to late ?Sangamon or early Wisconsin time. The Old Crow Basin is just northwest of the present range of *Ochotona princeps collaris*, as mapped by Youngman (1975, p. 55). Presumably the fossils indicate that pikas occupied scree areas on the margins of the Old Crow Basin during the late Pleistocene, although they may have been able to spread to lower areas, as Guthrie (1973, p. 970) has indicated for Alaska. The abundance of fossils suggests that pikas were common in the Old Crow Area during the late stocene. *Ochotona* has not been reported previously f istocene deposits in Canada.

The only specimens of the American pika recorded from Alaskan Pleistocene deposits are a mummified carcass from a placer operation near Chatanika in the Fairbanks area, and pika fecal pellets from detritus covered by 50 feet (15.2 m) of muck in the Wilber Creek area (Guthrie 1973, p. 970). The pellets and carcass are probably of Wisconsin age.

Of the 10 living lagomorph genera, nine belong to the family Leporidae (rabbits and hares). The pika *Ochotona* is the only Recent representative of the Family Ochotonidae. However, this proportion was much different in the earlier Cenozoic. In the Miocene, for example, 13 of 18 genera of lagomorphs were ochotonids and only four were leporids.

The late Miocene presence of *Bellatona*, probably near the ancestral line, in central Asia suggests an Asian origin for *Ochotona*. The genus *Ochotona* first appears in the early Pliocene of Asia. By late Pliocene (Hemphillian) time it had crossed to North America, as documented by a record of *Ochotona spanglei* from Oregon (Shotwell 1956), and it had spread to Europe. *Ochotona* lived throughout the Pleistocene to the present interglacial in Eurasia and North America (Dawson 1967, p. 289-295).

In addition to the Yukon-Alaska region, pikas occurred in southern North America during the late Pleistocene. Remains from caves in the Appalachians are of particular interest. *Ochotona* has been reported from Cumberland Cave, Maryland, the lower levels of Trout Cave, West Virginia (both Illinoian age deposits), and from Rapps Cave, West Virginia (which is presently undated). Evidently *Ochotona* became extinct in the Appalachians before the Wisconsin glaciation, for it has not been found as yet in deposits of that period (Guilday 1971, p. 241). Pika fossils have also been reported from caves in the northwestern United States. For example, remains of at least 19 individuals are recorded from Wilson Butte Cave, Idaho, and a single specimen is known from Jaguar Cave in the same state (Guilday 1969, p. 50; Guilday and Adam 1967, p. 32). Remains of at least 82 individual pikas *(O. princeps)* are recorded from the late Pleistocene deposits of Little Box Elder Cave, Wyoming (Anderson 1968, p. 11). Thus, from what seems to have been a much broader range during Illinoian time, it appears that *O. princeps* subsequently withdrew to scree in the North American Cordillera.

It is interesting to consider briefly the possible relationships among living Siberian, Yukon-Alaskan and more southern North American pikas. The steppe pika *(Ochotona pusilla)*, a rather small form, now ranges from the Volga to western Siberia. It tends to occupy brushy valleys, where it lives on grasses and herbs. Unlike the American pika *(O. princeps)*, it is nocturnal (Kurtén 1968, p. 227). Vorontsov and Ivanitskaya (1973) have indicated a close relationship between these two species, which have the same chromosomal count. Broadbooks (1965) and Guthrie (1973) provide zoological and paleontological evidence to suggest that *O. princeps collaris* originated in Beringia, whereas *O. princeps princeps* had a southern North American origin.

These subspecies are separated presently by about 500 miles (800 km) of country in which pikas are not found (Youngman 1975, p. 56).

ly Leporidae

Lepus americanus (snowshoe hare)

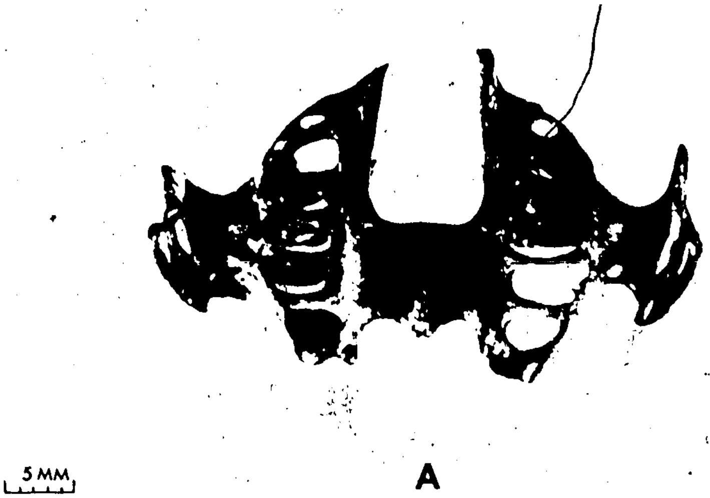
Snowshoe hare fossils (Figure 11A-C, Table 15) are relatively common in the Old Crow Pleistocene deposits compared to those of arctic hares (*Lepus arcticus*). Also, they are generally better preserved. Only mandibles are described, except for a single maxillary fragment. Unless otherwise indicated, these specimens are stained brown. They closely match in size and shape a series of Recent *Lepus americanus* specimens from the Yukon Territory and Alaska.

<u>Referred specimens</u>

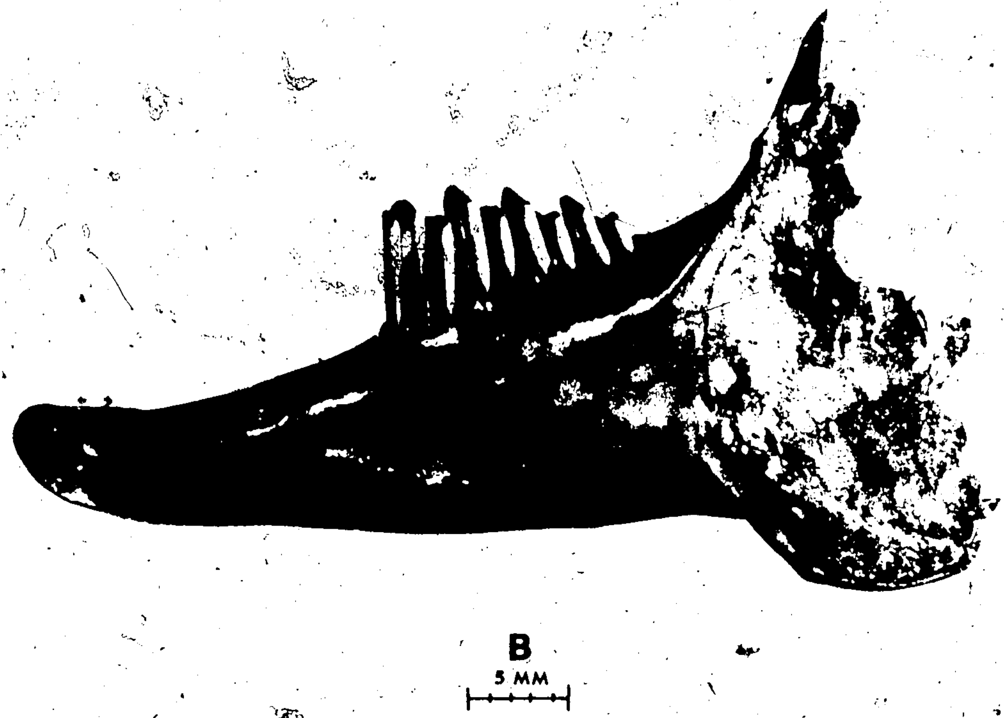
NMC 22324 from Old Crow Locality 27W is a maxillary fragment including: LP^3-LM^1 and the sockets for LP^2-LM^3; RP^4-RM^2, and the sockets for LP^2-LP^3; palatal region; anterior parts of the zygomatic arches.

NMC 28740 from Old Crow Locality 104 is a right mandible with the right incisor, RP_3-RM_2 and the alveolus for RM_3. The incisor is unusually light in color (ivory)

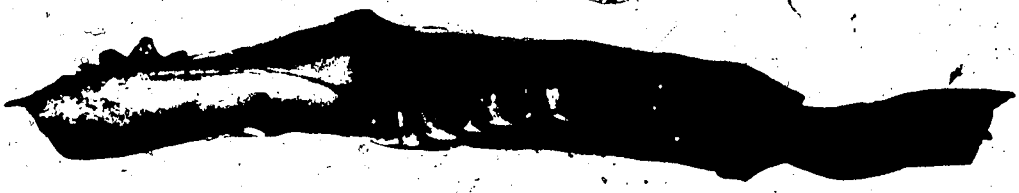
Figure 11. A. Maxillary fragment with LP^3-LM^1 and RP^4-RM^2 of a Pleistocene snowshoe hare *(Lepus americanus)* (NMC 22324, Old Crow Locality 27W). B. Lateral view of a left mandible with LP_3-LM_2 (NMC 19492, Old Crow Locality 65). C. Occlusal view of NMC 19492.



A



B



C

Table 15. Measurements of Pleistocene snowshoe hare (*Lepus americanus*) mandibles from the Yukon Territory compared to those of Recent North American snowshoe hares.

SPECIMENS	SEX	MEASUREMENTS (mm) * 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Lepus americanus. Pleistocene, Old Crow Area, Y.T.																	
NMC 28740 Loc. 104	-	-	7.1	15.6	17.6	13.2	16.5	3.4	2.9	2.9	3.3	3.3	3.5	3.2	3.3	-	-
NMC 28608 Loc. 65	-	57.4	8.0	16.0	18.4	13.6	16.1	-	-	3.2	3.5	2.9	3.4	3.1	3.2	-	-
NMC 26891 Loc. 22	-	-	7.7	15.1	17.3	13.8	15.9	3.2	2.6	3.1	3.1	2.8	3.0	2.6	2.8	-	-
NMC 19358 Loc. 65	-	-	7.3	15.7	16.9	12.9	15.5	3.2	2.9	2.9	3.4	3.0	3.2	2.9	3.2	-	-
NMC 25064 Loc. 20	-	-	7.3	16.1	16.5	12.6	16.4	3.2	2.8	2.8	3.4	3.1	3.2	3.0	3.1	-	-
NMC 19492 Loc. 65	-	-	7.1	16.4	17.4	13.3	15.2	3.5	2.9	2.8	3.6	2.9	3.4	3.0	3.4	-	-
NMC 19101 Loc. 28	-	-	7.6	15.5	16.7	12.1	15.0	3.1	2.7	2.9	3.3	2.9	3.3	3.0	3.1	-	-
NMC 19491 Loc. 65	-	-	8.0	15.1	17.4	13.8	15.4	2.6	2.7	3.1	3.2	2.8	3.2	2.9	3.0	-	-
NMC 28617 Loc. 65	-	-	7.3	15.6	17.7	12.6	15.7	-	-	2.8	2.9	2.7	2.9	2.9	2.9	-	-
NMC 19260 Loc. 65	-	-	-	-	-	13.1	14.8	-	-	2.8	3.1	3.1	3.1	2.9	2.9		-
NMC 15553 Loc. 20	-	-	7.1	16.0	16.7	13.1	14.8	-	-	[illegible]	3.2	2.9	3.0	3.0	3.1		-
NMC 18367 Loc. 27	-	-	8.5	-	17.7	13.2	-	3.2	2.9	2.7	3.5	3.1	3.4	-	-		-
NMC 19490 Loc. 65	-	-	7.5	16.0	16.6	12.4	15.2	-	-	2.9	3.4	2.9	3.3	2.9	3.2	-	-
NMC 18422 Loc. 29	-	-	8.1	16.0	-	12.3	15.6	-	-	3.1	3.4	2.8	3.3	2.8	[illegible]	-	-
NMC 13586 Loc. 11A	-	-	8.3	17.0	[illegible]	14.7	17.4	-	-	3.2	3.6	3.1	3.6	3.2	[illegible]	-	-
NMC 19257 Loc. 65	-	-	8.1	-	19.4	13.3	-	3.4	3.3	3.2	3.7	3.3	3.8	-	3.6		-
NMC 16901 Loc. 14N	-	-	8.1	-	18.0	-	-	3.6	2.7	3.1	3.5	2.9	3.4	2.9	3.1	-	-
NMC 24221 Loc. 22	-	-	-	-	-	13.5	15.7	-	-	2.7	3.4	2.9	3.2	3.0	3.1		-
NMC 24849 Loc. 11A	-	-	-	16.4	-	13.5	17.1	-	-	3.0	3.4	2.9	3.2	2.8	3.1	-	-
NMC 14801 Loc. 29	-	-	-	-	-	12.8	-	3.0	2.4	2.7	3.0	2.7	3.0	2.8	2.9	-	-
NMC 22254 Loc. 27W	-	-	-	-	-	10.8	-	-	-	2.7	3.1	2.9	3.0	3.4	2.9	-	-
NMC 19493 Loc. 65	-	-	8.4	-	17.3	-	-	3.1	2.6	2.7	3.2	-	-	-	-	-	-
NMC 27470 Loc. 127	-	-	9.1	-	18.4	[illegible]	-	3.5	3.2	3.1	3.6	-	-	-	-	-	-
NMC 19259 Loc. 65	-	-	8.2	-	18.8	-	-	2.9	3.3	3.0	3.5	-	-	-	-	-	-
Lepus americanus. Recent																	
NMC 20191 Y.T.	♀	55.5	7.1	14.1	17.1	11.9	13.3	3.0	2.7	2.7	3.1	2.6	3.1	2.5	2.9	2.0	1.9
NMC 31210 Y.T.	♂	52.1	6.6	14.4	15.8	12.0	13.3	3.1	2.7	2.8	3.1	2.8	2.9	2.7	2.8	1.8	2.2
NMC 33699 Y.T.	♀	57.4	7.9	16.0	17.0	13.5	14.8	3.3	2.6	2.7	3.4	2.8	3.3	2.7	3.2	2.2	1.9
NMC 2012 Y.T.	♂	53.6	6.6	15.0	16.2	12.1	14.3	3.2	2.8	2.8	3.1	3.0	3.0	2.8	3.1	2.0	1.9
NMC 40327 Alaska	♀	58.9	7.3	15.7	18.0	13.5	15.0	3.2	3.0	3.2	3.5	3.2	3.4	2.9	3.3	2.2	2.0
NMC 40324 Alaska	♂	55.4	7.5	15.7	17.0	12.1	14.1	3.2	2.8	2.8	3.2	2.8	3.1	3.1	3.0	2.2	1.8

* 1. Alveolar length P_2-M_3. 2. Length (anteroposterior diameter) P_3. 3. Width P_3. 4. Length P_4. 5. Width P_4. 6. Length M_1. 7. Width M_1. 8. Length M_2. 9. Width M_2. 10. Length M_3. 11. Width M_3.

Light copy

compared to the rest of the mandible, which is deep, reddish-brown. NMC 28608 is a right mandible with RP_4-RM_2 and alveoli for the incisor, RP_2 and RM_2. The ascending ramus is complete, except for a perforation in the centre, which presumably resulted from erosion of thin bone in that region. The specimen was excavated from a sandy layer at Old Crow Locality 65. NMC 26891 from Old Crow Locality 22 is a right mandible with a heavily worn incisor, RP_4-RM_2 and the alveolus for RM_3. NMC 19258 is a right mandible with incisor and RP_3-RM_2. The incisor is an ivory color, generally lighter than the reddish brown mandibular bone. The specimen was excavated from Old Crow Locality 65. NMC 25064 from Old Crow Locality 20 is a right mandible with incisor, RP_3-RM_2, the alveolus for RM_3, and much of the ascending ramus. NMC 19492 from Old Crow Locality 65 is a left mandible with LP_3-LM_2 and sockets for the incisors and LM_3. The specimen is stained orange brown. NMC 19101 from Old Crow Locality 28 is a left mandible with LP_3-LM_2 and the socket for the incisor and LM_3. NMC 19491 from Old Crow Locality 65 is a left mandible with LP_3-LM_2 and the socket for the incisor and LM_3. Cheek teeth are reddish ivory in color and lighter than the brown bone of the mandible. NMC 28617 from Old Crow Locality 65 is a right mandible with RP_4-RM_2 and sockets for the incisor, RP_3 and RM_3. NMC 19260 from Old Crow Locality 65 is a left mandible with LP_4-LM_2.

The anterior part of the mandible is lacking. The specimen is stained reddish brown. NMC 15558 from Old Crow Locality 20 is a right mandible with RP_4-RM_2 and the alveoli for the incisor, RP_3 and RM_3. NMC 18367 from Old Crow Locality 27 is a left mandible with LP_3-LM_1: NMC 19490 from Old Crow Locality 65 is a right mandible with RP_4-RM_2 and alveoli for the incisor, LP_4 and LM_3. NMC 18422 from Old Crow Locality 29 is a right mandible with RP_4-RM_2 and alveoli for RP_3 and RM_3. NMC 13586 from Old Crow Locality 11A is a right mandible with RP_4-RM_2 and alveoli for the incisor, RP_3 and RM_3. It is stained a dark reddish brown. NMC 19257 from Old Crow Locality 65 is a right mandible with a heavily worn right incisor and RP_3-RM_2. The specimen is stained blackish brown. NMC 16901 from Old Crow Locality 14N is a right mandible with incisor, RP_3-RM_2 and the medial half of the alveolus for RM_3 (part of the lateral surface is stripped away exposing the cheek teeth). The specimen is stained reddish brown. NMC 24221 from Old Crow Locality 20 is the posterior part of a left mandible with LP_4-LM_2 and the alveolus for LM_3. NMC 24849 from Old Crow Locality 11A is the posterior part of a right mandible with RP_4-RM_2 and alveoli for RP_3 and RM_3. The specimen is stained orange brown, and evidently was derived from an oxidized sandy matrix. NMC 22254 from Old Crow Locality 27W is a right mandible with unevenly worn cheek teeth (RP_4-RM_2), the alveolus and part of the root of RP_3, and part of the alveolus of RM_3. NMC 19493 from Old Crow Locality 65 is an anterior fragment of a right mandible with incisor and RP_3-RP_4. The teeth are lighter in color than the mandible. NMC 27470 from Old Crow Locality 127 is an anterior mandible fragment with the incisor and RP_3-RP_4. NMC 19259 from Old Crow Locality 65 is an anterior part of a left mandible with LP_3-LP_4 and a partial socket for the incisor. The specimen is stained blackish brown; the teeth are lighter.

Discussion

It is difficult to account for the fact that approximately 40% of the specimens described were derived from Old Crow Locality 65. The organic sandy gravel overlying the basal clay unit at this site may be part of a constructional terrace formed at the close of the Wisconsin glaciation, for at least one complete specimen of the freshwater mollusc *Anodonta beringiana* was found in the fossiliferous layer. This suggests that the organic sand cannot be correlated with Unit 2 at Old Crow Locality 44, but that it was deposited during the downcutting of the Old Crow River about 10,800 years ago, prior to a subsequent depositional phase in the area. Permineralization of the snowshoe hare mandibles resulting in their being stained brown indicates that they are of pre- late Wisconsin age.

The origins of *Lepus* are discussed in the section on the arctic hare *(Lepus arcticus)*. The snowshoe hare first appears during the Illinoian glaciation. It seems to be related to the Eurasian varying hare *(Lepus timidus)*, which is first well known in Eem (Sangamon) interglacial deposits of Europe (Kurtén 1968, p. 229). Although *Lepus* cf. *townsendi*, the white-tailed jackrabbit, has been reported from Sangamon and mid-Wisconsin age deposits at Medicine Hat, Alberta (Stalker and Churcher 1970), the snowshoe hare has not been definitely recorded before from Canadian Pleistocene deposits. However, it may occur in Champlain Sea age deposits at Montreal (Harington, 1972, p. 36).

The snowshoe hare is a medium-sized hare with large, broad hind feet. It is mainly confined to the northern forests of North America. Its northern limit in the Yukon Territory, Northwest Territories and Ungava is the tree line. The species presently occurs in the Old Crow Basin. It prefers forests, swamps and riverside thickets. During the summer snowshoe hares eat a wide variety of grasses and forbs, while in winter they live on buds, twigs, bark and evergreen leaves of woody plants. They are an important link in the food chains between plants and carnivorous animals. Major predators are owls, lynx, fox, wolf and mink (Banfield 1974, pp. 80-84).

Lepus arcticus (arctic hare)

Arctic hare specimens (Figure 12A-C, Tables 16-17) are less commonly found in the Old Crow Pleistocene deposits than those of snowshoe hares (*Lepus americanus*). Two maxillary fragments and 11 mandibular fragments are described here. The fine sculptural details preserved on the cranial bone of a Recent specimen of *Lepus arcticus* from the Northwest Territories (NMC 37775) are well matched in the Old Crow specimens. Also, the much larger size of arctic hares compared to snowshoe hares (*Lepus americanus*) allow the two species to be readily distinguished. All specimens are stained brown, unless otherwise indicated.

Referred specimens

NMC 24665 from Old Crow Locality 22 is a right maxillary fragment containing RP^3-RM^3, the alveolus for RP^2, and part of the right cheek area including the maxillary bone surrounding the teeth and the anterior part of the zygomatic arch. NMC 15584 from Old Crow Locality 28 is a right maxillary fragment with RM^1-RM^2 and the alveolus for RM^3.

NMC 28653 is a left mandible with LP_3-LM_3 and the

Figure 12. Left mandibular fragment with LP$_3$-LM$_1$ of a Pleistocene arctic hare *(Lepus arcticus)* (NMC 24233, Old Crow Locality 22).

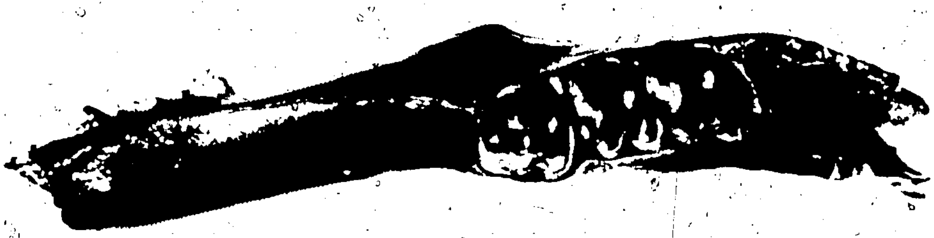
A. Lateral view.

B. Occlusal view. Left mandibular fragment with LP$_3$-LM$_1$ of a Pleistocene arctic hare *(Lepus arcticus)* (NMC 24647, Old Crow Locality 67).

C. Lateral view.

A

5 MM



B

5 MM

C

Table 16. Measurements of Pleistocene arctic hare (*Lepus arcticus*) maxillae from the Yukon Territory compared to those of Recent arctic hares from the Northwest Territories.

SPECIMENS	SEX	MEASUREMENTS (mm) *										
		1	2	3	4	5	6	7	8	9	10	11
Lepus arcticus, Pleistocene, Old Crow Area, Y.T.												
NMC 24665 Loc. 22	-	19.9	3.1	6.0	3.1	6.0	3.1	5.7	2.7	4.8	1.2	1.9
NMC 15[illegible] Loc. 28	-	-	-	-	-	-	3.1	5.4	2.9	4.7	-	-
Lepus arcticus, Recent, N.W.T.												
NMC 2870	♂	17.4	2.2	5.6	3.0	5.6	3.1	5.4	2.6	4.8	1.0	2.2
NMC 2864	♂	18.4	2.1	6.0	3.1	6.1	2.9	5.8	2.6	4.9	1.3	2.2
NMC 2672	♂	17.4	2.6	5.6	2.6	5.6	2.8	5.3	2.4	4.4	1.3	1.8
NMC 2859	♂	18.5	2.8	5.9	2.9	5.9	3.1	5.3	2.6	4.6	1.4	2.1
NMC 2862	♀	16.6	2.6	5.5	2.6	5.4	2.7	5.2	2.3	4.4	1.2	2.3
NMC 2863	♂	18.4	3.0	5.9	3.1	6.1	3.2	6.1	2.9	5.6	1.3	2.6

* 1. Alveolar length P^2-M^3.
2. Length (anteroposterior diameter) P^3.
3. Width P^3.
4. Length P^4.
5. Width P^4.
6. Length M^1.
7. Width M^1.
8. Length M^2.
9. Width M^2.
10. Length M^3.
11. Width M^3.

Light copy

Table 17. Measurements of Pleistocene arctic hare (*Lepus arcticus*) mandibles from the Yukon Territory compared to those of Recent arctic hares from the Northwest Territories.

SPECIMENS	SEX	MEASUREMENTS (mm) *															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Lepus arcticus, Pleistocene, Old Crow Area, Y.T.																	
NMC 28653 Loc. 136	-	-	8.6	20.0	24.2	17.9	19.0	4.2	3.4	3.2	3.8	3.7	4.0	3.7	3.9	2.7	2.3
NMC 24647 Loc. 67	-	-	8.8	-	-	16.8	-	4.3	3.3	4.1	3.7	3.9	4.3	-	-	-	-
NMC 24233 Loc. 22	-	-	8.9	-	23.7	17.9	-	4.6	3.8	4.3	4.4	3.8	4.4	-	-	-	-
NMC 27305 Loc. 29	-	-	-	-	20.9+	17.1	-	4.3	3.6	3.6	3.8	3.5	4.1	-	-	-	-
NMC 26745 Loc. 19	-	-	-	-	-	-	19.9	-	-	3.6	4.1	3.7	4.1	3.9	4.1	-	-
NMC 25310 Loc. 27W	-	-	-	-	-	18.2	-	-	-	3.7	4.2	4.0	4.2	4.0	4.2	-	-
NMC 23682 Loc. 27	-	-	8.8	-	22.7	-	-	4.3	3.5	3.8	4.0	-	-	-	-	-	-
NMC 15583 Loc. 28	-	-	9.0	-	23.3	-	-	4.0+	3.5	3.9	4.2	-	-	-	-	-	-
NMC 25208 Loc. 20	-	-	-	-	-	18.6	-	-	-	-	-	4.1	4.8	4.1	4.6	-	-
NMC 22252 Loc. 27W	-	-	8.4	-	21.2	-	-	-	-	-	-	-	-	-	-	-	-
Lepus arcticus, Recent, N.W.T.																	
NMC 2870	♂	70.2	8.2	18.4	23.8	15.9	17.4	3.9	3.4	3.4	3.9	3.8	[illegible]	[illegible]	[illegible]	2.5	2.3
NMC 2864	♂	66.5	8.1	19.0	21.2	15.2	16.8	4.1	3.5	4.6	4.0	3.6	[illegible]	[illegible]	[illegible]	2.6	2.3
NMC 2872	♂	72.7	8.9	18.6	25.5	16.8	18.4	4.1	3.4	3.4	3.7	3.5	[illegible]	[illegible]	[illegible]	2.6	2.4
NMC 2859	♂	74.6	9.0	20.2	24.0	16.8	18.4	4.0	3.5	3.7	4.0	3.6	[illegible]	[illegible]	[illegible]	2.7	2.4
NMC 2862	♀	68.6	8.2	17.5	21.5	16.3	16.8	3.9	3.2	3.3	3.6	3.2	[illegible]	[illegible]	[illegible]	2.2	2.3
NMC 2863	♂	70.2	8.4	19.9	22.5	16.5	17.7	4.2	3.6	3.4	4.2	3.3	[illegible]	[illegible]	[illegible]	2.4	2.3

* 1. Mandible length (superior alveolar margin of I_1 to posterior of angle). 2. Diastema depth. 3. Alveolar length (P_3-M_3) 4. Diastema length (superior alveolar margin of I_1 to anterior alveolar margin of P_3). 5. Mandible depth (M_1). 6. Mandible depth (posterior of M_3). 7. Length P_3. 8. Width P_3. 9. Length P_4. 10. Width P_4. 11. Length M_1. 12. Width M_1. 13. Length M_2. 14. Width M_2. 15. Length M_3. 16. Width M_3.

Light copy

complete diastema including the incisor socket. The ascending ramus is lacking. The specimen is from Old Crow Locality 136 and is stained blackish brown. NMC 24233 from Old Crow Locality 22 is the anterior part of a left mandible with LP_3-LM_1. NMC 24647 from Old Crow Locality 67 is the central part of a left mandible with LP_3-LM_1. Fragments of the incisor and LM_2 are lodged in their alveoli. NMC 27305 is an anterior fragment of a right mandible with RP_3-RM_1 and much of the diastema including a broken incisor. It was excavated at Old Crow Locality 29. NMC 26745 from Old Crow Locality 19 is a right mandible with RP_4-RM_2 and parts of the alveoli for RP_3 and RM_3. NMC 25310 from Old Crow Locality 27W is a left mandible with LP_4-LM_2. The jaw is stained blackish brown, and rust colored matrix adheres to the interior part of the angle. NMC 28682 from bar deposits at Old Crow Locality 27 is the anterior part of a right mandible with the complete incisor, diastema, RP_3-RP_4 and the alveolus for the anterior loop of RM_1. Compared to a Recent female arctic hare specimen from Banks Island, N.W.T. (NMC 37775), the incisor of the fossil is broad and well-worn. NMC 15583 from Old Crow Locality 28 is the anterior part of a right mandible with RP_3-RP_4. It includes the complete diastema and a right incisor which has broken off near the alveolar margin. NMC 25208 from Old Crow Locality 20 is the central part of a left mandible with

LM_1-LM_2, the complete alveolus for LP_4 and partial alveoli for LP_3 and LM_3. The teeth are relatively large. NMC 22252 from Old Crow Locality 27W is the anterior part of a left mandible including the anterior margin of the alveolus for LP_3, the diastema and a well worn incisor. NMC 24737 from Old Crow Locality 11A is an anterior fragment of a left mandible lacking teeth. Alveoli for the incisor and LP_3-LM_1 are present. The specimen is stained blackish brown. It is not complete enough to provide useful measurements.

Discussion

Evidently these are the first specimens of arctic hare from Canadian and perhaps North American Pleistocene deposits. Generally, they fall within the same size range as a series of Recent specimens from the Northwest Territories. Postcranial specimens that I have identified as *Lepus arcticus* have been excavated from the fossiliferous layer at Old Crow Locality 44, and therefore are possibly of Sangamon age. Another postcranial bone was collected from a patch of fine gravel approximately 30 feet (9.1 m) above the level of the Old Crow River at that locality, which may be of late Sangamon or early Wisconsin age.

The origins of *Lepus* are still rather obscure. The transition from such lagomorphs as *Alilepus*, *Pratilepus* and *Serengetilagus* seems to have occurred about late Pliocene time throughout the Holarctic. Probably an important factor in the extinction of *Hypolagus* was the flourishing populations of *Lepus* and *Sylvilagus* in the New World and *Lepus*, *Oryctolagus* and *Caprolagus* in the Old World during the early Pleistocene (Dawson 1967, p. 303). Among the earliest records of *Lepus* in North America are: *Lepus* sp. in the San Pedro Valley, California paleomagnetically dated at 1.9 million years, *Lepus* cf. *californicus* from the Borchers fauna (Aftonian) of Kansas, and *Lepus* sp. of the Vallecito Creek fauna (Johnson *et al.* 1975, p. 10). Ancestors of *Lepus arcticus* are not known. I suggest this species may have evolved from a smaller boreal varying hare with affinities to Eurasian *Lepus timidus* or the related snowshoe hare *(Lepus americanus)* in the middle Pleistocene of Beringia.

The arctic hare is a large, heavy-bodied hare of the arctic tundra of Canada and Greenland. In winter it is pure white with black-tipped ears. In summer it is grayish, particularly in the more southerly parts of its range. Females average slightly larger than males. A closely related species, *L. othus*, occupies northwest Alaska. The arctic hare no longer occurs in the Yukon Territory, but is found as close as the mouth of the Mackenzie Delta. In summer, arctic hares feed mainly on grasses, sedges, saxifrages, campions, mountain sorrel and the twigs and roots of arctic willow and crowberry. In winter they feed along wind-cleared slopes. Sometimes they break snowcrusts with their forepaws to reach grasses, sedges and willows. They are an important prey species for the arctic fox and wolf. Snowy Owls and Rough-legged Hawks also feed on them (Banfield 1974, pp. 85-87).

Order Rodentia

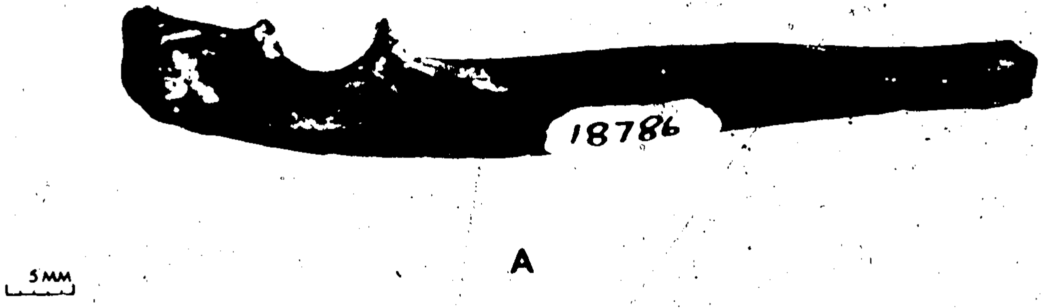
Family Scuiridae

Marmota cf. *monax* (woodchuck)

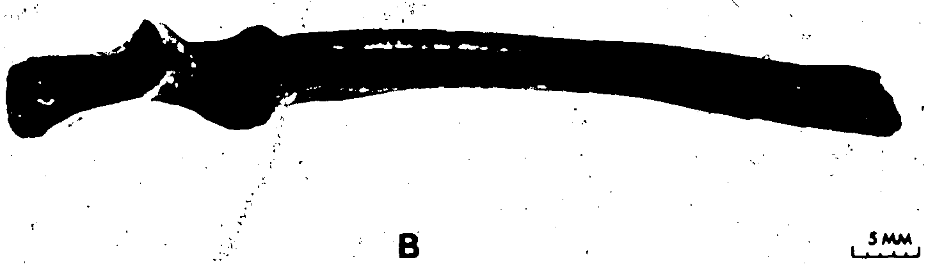
Referred specimen

A single specimen consisting of a left ulna lacking the distal end (NMC 18786; Figure 13A-C) was collected at Locality 20 on the Old Crow River. It is stained dark brown and was derived from oxidized sediment according to matrix adhering to the medial surface of the bone posterior ~~to~~ the semilunar notch. A well developed ridge is evident on the mediodistal part of the shaft of NMC 18786, which is seen also in a Recent specimen of *M. monax* to which it was compared. This ridge was not present on Recent specimens of the hoary marmot (*M. caligata*) that I examined, but this possibly diagnostic postcranial character should be checked in a larger series of Recent *Marmota* specimens.

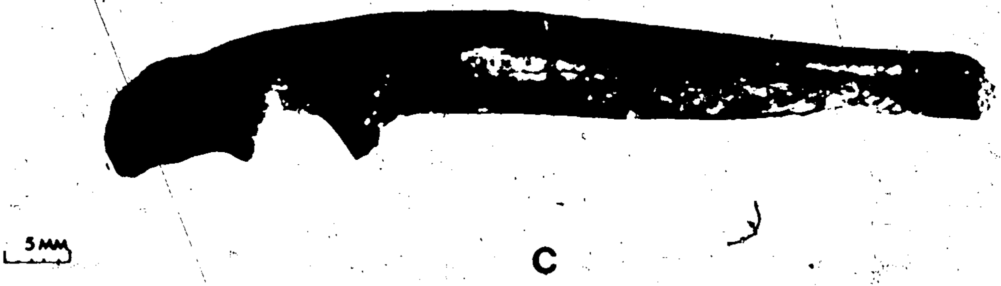
Figure 13. Left ulna, lacking the distal end, of a Pleistocene woodchuck (*Marmota* cf. *monax*) (NMC 18786, Old Crow Locality 20). A. Medial view. B. Anterior view. C. Lateral view.



A



B



C

The fossil is almost a perfect match for the same element of a Recent male woodchuck (*M. monax monax*; NMC 31943) from Pennsylvania. It is markedly smaller than two Recent female hoary marmot (*M. caligata caligata*) ulnae from Keno Hill, Yukon Territory (NMC 31241, 35342). The fossil probably represents the woodchuck, which presently has a spotty distribution in the southern half of the Yukon (Youngman 1975, p. 64).

Discussion

Because the Yukon fossil is so deeply stained, I suggest it is of pre-late Wisconsin age. Apart from it, the only published report of the woodchuck from Canadian Pleistocene deposits concerns a specimen from the Don Formation of Sangamon interglacial age in Toronto. In the United States, the woodchuck has been recorded from such Wisconsin sites as Cherokee Cave, Missouri (Hibbard 1958, p. 13) and Robinson Cave, Tennessee (Guilday *et al.* 1969, p. 49).

Marmots (*Marmota*) probably originated in the Nearctic during the Tertiary. Fossils differing only slightly from extant specimens have been found in middle Pliocene (Hemphillian) deposits in Nevada. The genus reached Asia in the late Pliocene (Csarnotan), but did not reach Europe until the mid- Pleistocene (Repenning 1967,

p. 298). The fossil marmots from China are referred to *M. bobak* (Kurtén 1968, p. 194). Rausch (1953) regards the alpine marmot *(M. marmota)* of Europe as conspecific with the hoary marmot *(M. caligata)*, which lives in mountainous areas of northwestern North America. The alpine marmot appeared in Europe as early as the Riss (Illinoian), but did not become widespread there until the Würm (Wisconsin) glaciation. The earliest record of woodchuck or marmot *(Marmota* sp.*)* from Eastern Beringia is based on teeth and fragmentary postcranial elements from the Cape Deceit Formation (?Nebraskan) of Alaska (Guthrie and Matthews 1971, p. 492).

Woodchucks are robust marmots which may reach 2 feet (0.6 m) in length and 14 pounds (6.4 kg) in weight. They hibernate in underground dens during the winter. Woodchucks are well adapted to living in forested regions where grassy clearings are available. They flourish in areas cultivated by people. Their diet consists mainly of green vegetation. At present, the red fox *(Vulpes vulpes)* is the woodchuck's greatest predator. During the late Pleistocene, probably wolves and some of the larger cats were more important as predators of these animals.

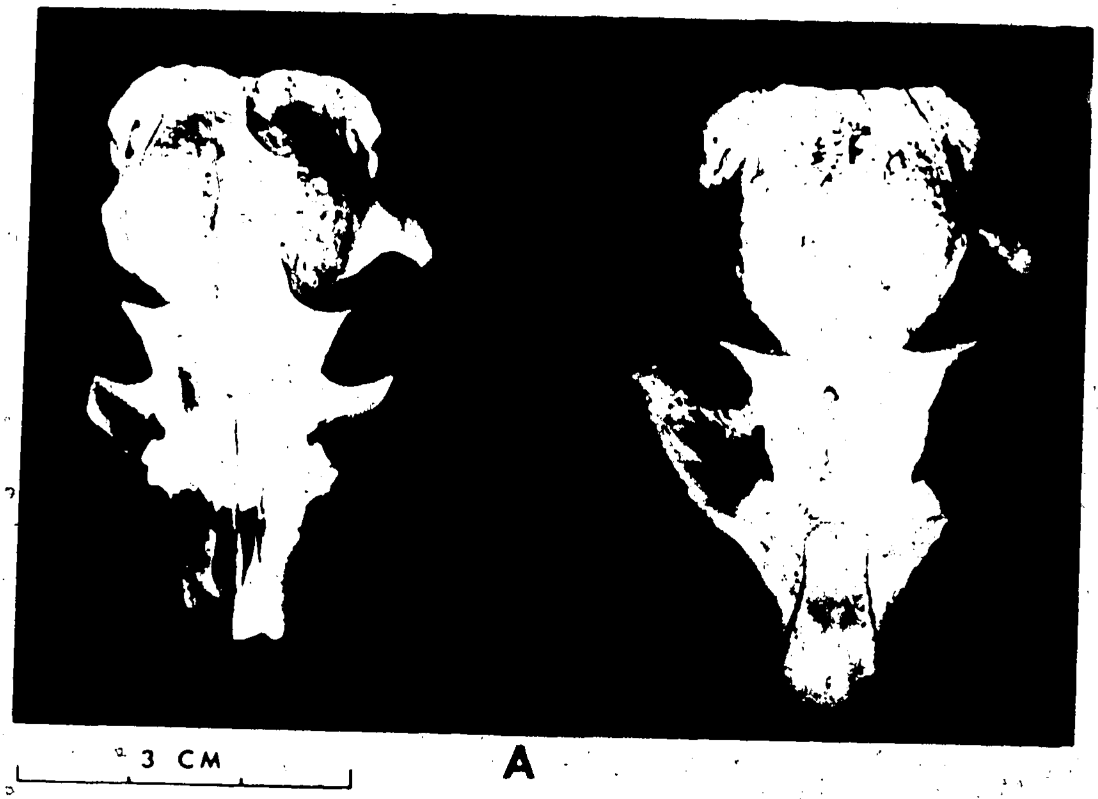
Spermophilus parryi (arctic ground squirrel)

Ground squirrel remains (Figure 14A-B, Tables 18-19) are among the most common rodent fossils from the Pleistocene deposits of the Yukon. Although many postcranial specimens have been collected from the Old Crow Basin, only some of the more complete maxillary and mandibular fragments are described. Unless otherwise noted the Old Crow specimens are stained dark brown. Occasionally, during monitoring of the muck faces at the placer operations near Dawson, parts of ground squirrel nests buried deeply in the permafrost are exposed. In the autumn of 1967, Harold Schmidt collected a complete nest with nesting grass, fecal pellets, surrounding matrix and parts of the skeleton of a relatively small individual (NMC 21094). A more detailed co-operative study of this material is planned, especially with regard to the paleoecological implications of the evidence. Only measurements on a maxilla and mandible from this skeleton are given here.

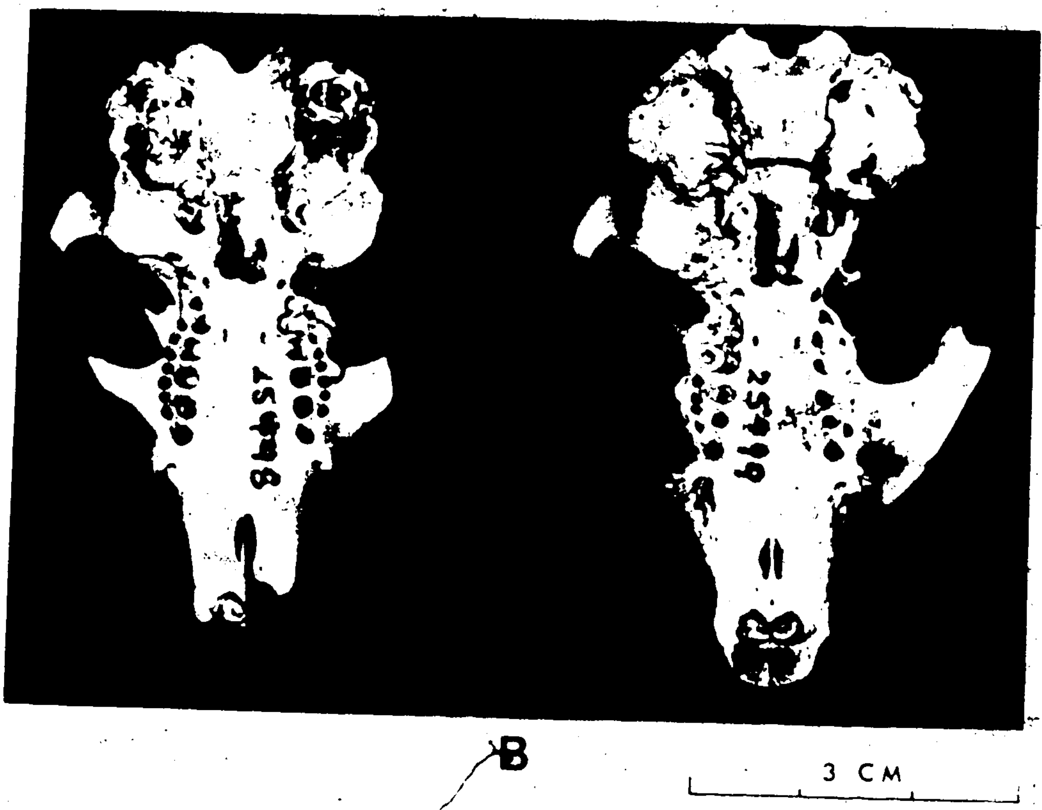
<u>Referred specimens</u>

In 1974 I collected two fairly complete ground squirrel crania at T. Kosuta's placer operation where 80 Pup enters Hunker Creek near Dawson (Dawson Locality 10). NMC 25999 is the larger of the two, having both upper incisors and LM^2-LM^3, in addition to alveoli for the

Figure 14. Fragmentary crania of Pleistocene arctic ground squirrels *(Spermophilus parryi)* from Dawson Locality 10. A. Dorsal views of NMC 25998 (left) and NMC 25999 (right). B. Ventral views of NMC 25998 (left) and NMC 25999 (right).



A



B

Table 18. Measurements of Pleistocene arctic ground squirrel (*Spermophilus parryi*) crania from the Yukon Territory compared to those of Recent arctic ground squirrels from the Yukon.

SPECIMENS	SEX	MEASUREMENTS (mm) * 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Spermophilus parryi. Pleistocene, Yukon Territory																
NMC 25998 Dawson Loc. 10		60.5	33.0	12.7	12.2	21.8	13.9	4.7	-	-	-	-	3.0	3.7	3.7	3.6
NMC 25996 Dawson Loc. 10	-	-	31.9	12.7	13.5	-	14.0	3.8	-	-	-	-	-	-	3.8	3.5
NMC 21094 Dawson Loc. 28	-	-	-	-	-	-	12.4	3.8	2.5	3.2	2.9	3.4	2.6	3.4	3.7	3.2
NMC 19108 Old Crow Loc.	-	-	-	-	-	-	15.5e	5.0	-	-	-	-	-	-	-	-
NMC 18225 Old Crow Loc.		-	-	-	-	-	13.9	4.4	-	-	-	-	-	-	-	-
NMC 20018 Old Crow Loc.		-	-	-	-	-	-	4.7	-	-	-	-	-	-	-	-
Spermophilus parryi. Recent, Y.T.																
NMC 33742	♀	-	-	-	-	-	13.4	4.0	2.4	3.2	2.4	3.7	2.9	3.5	3.7	3.6
NMC 33732	♂	-	-	-	-	-	13.1	3.9	2.8	3.1	2.9	3.5	3.0	[illegible]	3.7	3.5
NMC 29677	♂	-	-	-	-	-	13.2	3.8	2.8	2.9	2.7	3.3	3.0	3.5	3.8	3.4
NMC 29378	♀	-	-	-	-	-	12.5	3.9	2.5	3.1	2.7	3.3	2.6	3.6	3.7	3.4
NMC 33741	♂	-	-	-	-	-	13.8	4.3	3.1	3.5	3.1	3.8	3.3	4.0	4.1	3.7
NMC 30326	♂	-	-	-	-	-	12.9	3.9	2.6	3.1	2.9	3.9	3.2	3.6	3.8	3.6
NMC 33739	♀	-	-	-	-	-	12.8	3.7	2.4	2.5	2.7	3.3	2.9	3.5	3.5	3.2
NMC 33734	♀	-	-	-	-	-	12.8	3.9	2.4	2.6	2.9	3.4	3.1	3.6	3.7	3.4
NMC 33737	♀	-	-	-	-	-	13.8	4.0	2.7	3.2	2.9	3.6	3.1	3.8	3.9	3.5
NMC 33738	♀	-	-	-	-	-	13.2	3.9	2.3	2.5	2.9	3.4	3.2	3.5	3.7	3.5
NMC 33733	♂	-	-	-	-	-	13.2	4.0	2.4	2.6	2.9	3.4	2.9	3.7	3.6	3.5
NMC 30320	♂	-	-	-	-	-	13.2	3.6	2.4	2.8	3.4	3.0	3.5	3.5	3.9	3.6
Spermophilus parryi parryi. Recent, Y.T.																
(Youngman 1975, p. 68)	♂♂															
M		60.0	30.0	[illegible]	13.2	21.9	13.3	-	-	-	-	-	-	-	-	-
OR		58.4-62.2	28.6-30.5	11.[illegible]-13.6	12.3-14.2	21.0-23.2	11.1-13.9	-	-	-	-	-	-	-	-	-
N		10	10	10	10	10	10	-	-	-	-	-	-	-	-	-
SD		1.23	0.69	0.56	0.67	0.63	0.54	-	-	-	-	-	-	-	-	-
SE		0.39	0.23	0.19	0.21	0.20	0.17	-	-	-	-	-	-	-	-	-
M		57.1	28.7	12.1	13.5	20.8	13.1	-	-	-	-	-	-	-	-	-
OR		56.4-59.2	27.6-30.3	11.2-13.3	13.0-14.9	20.2-21.7	12.5-13.4	-	-	-	-	-	-	-	-	-
N		12	12	12	12	12	12	-	-	-	-	-	-	-	-	-
SD		0.83	0.80	0.64	0.50	0.54	0.38	-	-	-	-	-	-	-	-	-
SE		0.24	0.23	0.19	0.14	0.16	0.11	-	-	-	-	-	-	-	-	-

* 1. Greatest length of cranium. 2. Palatal length. 3. Least interorbital width. 4. Width at postorbital constriction. 5. Nasal length. 6. P^3-M^3 alveolar length. 7. Maximum width across alveoli. 8. Length P^4. 9. Width P^4. 10. Length M^1. 11. Width M^1. 12. Length M^2. 13. Width M^2. 14. Length M^3. 15. Width M^3.

Light copy

Table 19. Measurements of Pleistocene arctic ground squirrel (*Spermophilus parryi*) mandibles from the Yukon Territory compared to those of Recent arctic ground squirrels.

SPECIMENS	SEX	MEASUREMENTS (mm) * 1	2	3	4	5	6	7	8	9	10	11	12	13
Spermophilus parryi. Pleistocene, Yukon Territory.														
NMC 21094 Dawson Loc. 28	–	–	4.4	11.4	8.8	7.3	2.5	2.7	2.4	3.0	2.6	3.0	3.5	3.1
NMC 18803 Old Crow Loc. 20	–	–	6.1	13.6	10.8	9.4	2.8	3.2	2.9	3.3	3.1	3.5	4.2	3.6
NMC 15577 Old Crow Loc. 28	–	–	6.6	14.1	12.1	10.1	3.0	3.2	3.1	3.3	3.1	3.8	5.0	3.6
NMC 18624 Old Crow Loc. 27	–	–	5.8	12.2	10.0	9.1	3.0	3.1	2.7	3.0	2.8	3.2	4.0	3.5
NMC 27825 Old Crow Loc. 67	–	–	6.1	13.1	11.0	9.2	2.8	3.3	3.0	3.3	3.0	3.6	–	–
NMC 27826 Old Crow Loc. 67	–	–	6.0	14.2	10.0	9.6	–	–	3.0	3.2	3.1	3.5	4.3	3.8
NMC 15837 Old Crow Loc. 44	–	–	6.7	14.5	12.5	9.9	3.0	3.4	3.2	3.9	3.5	3.8	–	–
NMC 24362 Old Crow Loc. 11A	–	–	5.8	14.0	9.6	8.6	–	–	2.9	3.3	2.9	3.6	4.4	3.5
NMC 15712 Old Crow Loc. 28	–	–	–	15.0	–	9.7	3.4	3.7	3.0	3.8	3.4	4.0	–	–
NMC 22253 Old Crow Loc. 27W	–	–	5.7	14.2	–	8.5	3.0	3.2	3.5	3.4	3.2	3.3	–	–
NMC 15250 Old Crow Loc. 22	–	–	–	–	–	–	2.6	3.3	2.9	3.3	3.3	3.6	–	–
NMC 15578 Old Crow Loc. 28	–	–	7.1	14.0	11.4	10.7	–	–	–	–	3.5	3.5	4.5	4.0
NMC 25307 Old Crow Loc. 27W	–	–	–	–	–	7.7	–	–	2.8	2.9	3.0	3.0	–	–
NMC 15338 Old Crow Loc. 44	–	–	–	–	–	–	–	–	–	–	3.0	3.1	3.6	3.0
NMC 24875 Old Crow Loc. 11A	–	–	–	–	–	8.3	2.5	2.6	–	–	–	–	–	–
NMC 24358 Old Crow Loc. 11A	–	–	5.8	13.7	–	8.1	–	–	–	–	–	–	–	–
NMC 15816 Old Crow Loc. 44	–	–	–	14.9	–	9.0	–	–	–	–	–	–	–	–
NMC 24988 Old Crow Loc. 11A	–	41.8	6.0	15.0	10.9	9.5	–	–	–	–	–	–	–	–
NMC 22057 Old Crow Loc. 27W	–	–	–	15.0	–	9.3	–	–	–	–	–	–	–	–
NMC 28794 Old Crow Loc. 20	–	–	6.3	15.0	10.4	9.4	–	–	–	–	–	–	–	–
NMC 22250 Old Crow Loc. 27W	–	–	6.1	14.4	10.4	8.8	–	–	–	–	–	–	–	–
NMC 24994 Old Crow Loc. 11A	–	–	–	14.9	–	9.2	–	–	–	–	–	–	–	–
NMC 18625 Old Crow Loc. 27	–	–	–	13.3	–	–	–	–	–	–	–	–	–	–
Spermophilus parryi. Recent, Yukon Territory.														
NMC Uncataloged	♂	39.4	6.1	12.0	10.6	9.0	2.5	3.0	2.5	3.2	2.8	3.6	4.0	3.6
NMC 33742	♀	35.9	5.2	12.0	10.1	8.8	2.9	2.9	2.6	3.1	3.1	3.2	4.0	3.4
NMC 33732	♂	37.1	5.6	12.0	11.2	9.2	3.0	2.9	2.6	3.1	2.9	3.4	3.8	3.4
NMC 29879	♂	35.7	5.3	11.7	9.9	7.6	2.9	2.5	2.6	3.1	3.1	3.2	3.7	3.2
NMC 29678	♀	36.5	5.3	11.2	10.4	8.2	2.6	2.7	2.5	2.8	2.8	3.1	3.8	3.3
NMC 33741	♂	39.0	6.0	12.7	11.5	9.4	2.8	2.9	2.6	3.4	2.8	3.6	3.9	3.6
NMC 30326	♂	36.9	5.3	12.4	11.1	8.7	2.9	2.8	2.7	3.1	2.9	3.1	3.6	3.2
NMC 33739	♀	35.2	4.9	12.4	10.6	7.4	2.5	2.1	2.9	2.9	2.8	3.1	3.3	3.4
NMC 33734	♀	35.5	4.7	12.4	10.2	7.5	2.5	2.7	2.8	2.9	3.4	3.1	3.6	3.3
NMC 33737	♀	36.0	5.2	12.9	9.8	8.0	2.9	2.9	2.9	2.8	3.2	3.1	3.9	3.4
NMC 33738	♀	35.3	4.9	11.8	10.4	7.6	–	–	2.7	2.9	3.0	3.1	3.6	3.3
NMC 33733	♂	35.4	4.9	12.5	10.5	7.9	2.5	2.2	2.9	2.9	3.1	3.2	3.8	3.4

1. Mandible length (superior alveolar margin of I_1 to posterior of angle). 2. Diastema depth. 3. Alveolar length (P_4-M_3).
4. Diastema length (superior alveolar margin of I_1 to anterior alveolar margin of P_4). 5. Mandible depth (M_3). 6. Length P_4.
7. Width P_4. 8. Length M_1. 9. Width M_1. 10. Length M_2. 11. Width M_2. 12. Length M_3. 13. Width M_3.

Light copy

remaining teeth. The anterior portion of the right zygomatic arch is present, the left one is lacking. NMC 25998 is a cranium with the left upper incisor, RM^3, and the alveoli for the remaining cheek teeth. The nasals are missing and the otic capsules and zygomatic arches are damaged. Both specimens are light brown.

The alveolar length and palatal length of these crania, of probable late Wisconsin age, are at the upper limit or are slightly greater than the maxima noted by Youngman (1975, p. 68) in Recent samples of male and female ground squirrels from the northwestern Yukon Territory.

NMC 21094 is a left maxilla with LP^4-LM^3 and the alveolus for LP^3. It is stained reddish brown and was collected *in situ* in a ground squirrel nest near the base of the muck and just above the surface of the gold-bearing gravel at Dawson Locality 28. NMC 19108 from Locality Old Crow 28 is a left maxilla with alveoli for LP^3-LM^2 and part of LM^3. It is connected to the anterior part of the zygomatic arch. NMC 18225 from Old Crow Locality 11A is a right maxilla with alveoli for LP^3-LM^3. NMC 20018 from Old Crow Locality 65 is a left mandible with alveoli for LP^3-LM^2.

NMC 21094 from Dawson Locality 28 is a right mandible with all teeth. Only the angle of the jaw and the coronoid process are lacking. Like the maxillary fragment from the same specimen mentioned previously, it is stained reddish brown. NMC 18803 from Old Crow Locality 20 has all the cheek teeth, but the distal end of the incisor is missing. NMC 15577 from Old Crow Locality 28 is a right mandible with all cheek teeth and the partial alveolus for the incisor. NMC 18624 from Old Crow Locality 27 is a right mandible with complete cheek teeth. It lacks the distal end of the incisor. NMC 27825 from Old Crow Locality 67 is a left mandible with incisor, LP_1-LM_2 and the alveolus for LM_3. NMC 27826 from Old Crow Locality 67 is a left mandible with the incisor, LM_1-LM_3 and the alveolus for LP_4. NMC 15837 is a left mandible with LP_4-LM_2 and the alveoli for the incisor and LM_3. It was excavated from the fossiliferous layer at Old Crow Locality 44, and is, therefore, more than 54,000 years old. NMC 24362 from Old Crow Locality 11A is a right mandible with RM_1-RM_3 and alveoli for the incisor and RP_4. A perforation approximately 3 mm in diameter on the lateral surface of the mandible posterior to RM_3 may be the mark of a carnivore canine. NMC 15712 from Old Crow Locality 27W is a left mandible with LP_4-LM_2, broken incisor and alveolus for LM_3. NMC 15250 from Old Crow Locality 22 is a small right mandible fragment with RP_4-RM_2. Because the teeth are heavily worn, presumably an old individual is represented. NMC 15578 from Old Crow Locality 28 is a relatively large right mandible with RM_2-RM_3 and the roots of RP_4 and RM_1. The distal end of the incisor is missing. NMC 25307 from Old Crow Locality 27W is an anterior fragment of a left mandible with LM_1-LM_2, the alveolus for LP_4 and part of the incisor. NMC 15838 consists of LM_2-LM_3 and surrounding mandibular bone. It was excavated at Old Crow Locality 44 and may be of Sangamon interglacial age. NMC 24875 from Old Crow Locality 11A is a right mandible with RP_4 and alveoli for RM_1 and RM_2. Evidently it represents a small ground squirrel. NMC 24358 from Old Crow Locality 11A is a left mandible with the incisor lacking the tip. Alveoli for all cheek teeth are present. NMC 15816 from Old Crow Locality 44 is a left mandible with incisor and alveoli for the cheek teeth. It may be of Sangamon age. NMC 24988 from Old Crow Locality 11A is a right mandible with alveoli for the incisor and cheek teeth. The posterior part of the mandible including the angular process and condyloid process are preserved. NMC 22057 from Old Crow Locality 27W is a right mandible with part of the incisor and alveoli for the cheek teeth. NMC 28794 from Old Crow Locality 20 is a left mandible with part of the incisor and alveoli for the cheek teeth. NMC 22250 from Old Crow Locality 27W is a right mandible with well-worn incisor and alveoli for the cheek teeth. NMC 18625 from Old Crow Locality 27 is a left mandible with alveoli for the cheek teeth. NMC 28654 from Old Crow Locality 136 is a right mandible containing the root of the incisor and alveoli for RP_4-RM_2.

Discussion

These are the first records of the arctic ground squirrel from the Pleistocene deposits of Canada. Several specimens excavated at Old Crow Locality 44 suggest that the species occurred in the Old Crow Basin at least as early as the ?Sangamon interglacial. The specimens from near Dawson are probably of late Wisconsin age.

Teeth of ?Nebraskan age from the Cape Deceit Formation, Alaska appear to be very similar to those of living arctic ground squirrels (Guthrie and Matthews 1971, p. 492). It is interesting to note that this species was the first small rodent described from Pleistocene deposits near Fairbanks (Hill 1942, p. 1842). Since then, it has been reported from deposits of Illinoian and Wisconsin age at other localities in Alaska (Repenning *et al.* 1964, p. 187-190, Guthrie 1968, p. 233).

Spermophilus evidently arose in North America during the early Tertiary as a result of expanding grasslands in the Great Plains region. With other ground squirrels (*Tamias*, *Marmota*), *Spermophilus* first entered Eurasia from North America near the beginning of the Pleistocene (Thenius 1972, p. 174). Ground squirrels of the modern type first appear in Günz (?Nebraskan) deposits of Europe (Kurtén 1968, p. 196). Although more work is required to delineate the phylogenetic relationships of various species of *Spermophilus*, probably the Asian *S. undulatus* is closely related to *S. parryi*. On the basis of karyological data, Vorontsov and Liapunova (1973, p. 147) indicate that the latter species is amphi-Beringian and that it reached Asia during the Wisconsin glaciation. However, specimens possibly of this species have been recorded by Vangengeim (1961) from deposits on the Aldan River, Siberia, which are of probable Illinoian age, and by Sher (1971) from the Iedoma Suite in the Kolyma Lowland, which is of early Wisconsin age.

The arctic ground squirrel is the largest and most northerly [illegible] American ground squirrels. It is found from eastern Si[illegible] to Hudson Bay, and southward to northwestern British C[illegible] The fact that it is not found on any of the Canadian [illegible] Islands indicates that it seldom travels very far over [illegible]e. The species is colonial and spends about seven months each year hibernating in dens between 24 and 30 inches (36-76 cm) below the surface. *Spermophilus parryi* occupies tundra north of the tree line and clearings within northern forests. It is restricted to gravelly and sandy hillocks such as river banks, eskers and moraines, where good drainage prevents permafrost from occurring near the surface. Arctic ground squirrels eat a wide variety of tundra vegetation including grasses, forbs and woody species. In the late summer they cache seeds and leaves in their hibernation dens or in passages leading to them. This habit accounts for the presence of nests with grasses, seeds and fecal pellets found in late Pleistocene deposits near Dawson (e.g. NMC 21094). Arctic ground squirrels are an important part of the diet of the ermine, wolf, arctic fox, and grizzly bear.

Family Castoridae

Castor canadensis (beaver)

Many mandibles with teeth, but only a few maxillary fragments (Figure 15A-D, Tables 20-21) have been collected from Pleistocene deposits in the Old Crow Basin. A single mandible has been recovered from the Dawson Area of the Yukon Territory. This difference in incidence of specimens is attributed to greater abundance of standing water in the Old Crow Basin throughout the late Pleistocene compared to

Figure 15. Left mandible of a Pleistocene beaver *(Castor canadensis)* (NMC 17554, Dawson Locality 7). A. Lateral view. B. Occlusal view. Right mandible of a Pleistocene beaver *(Castor canadensis)* (NMC16407, Old Crow Locality 71). C. Lateral view. D. Occlusal view.

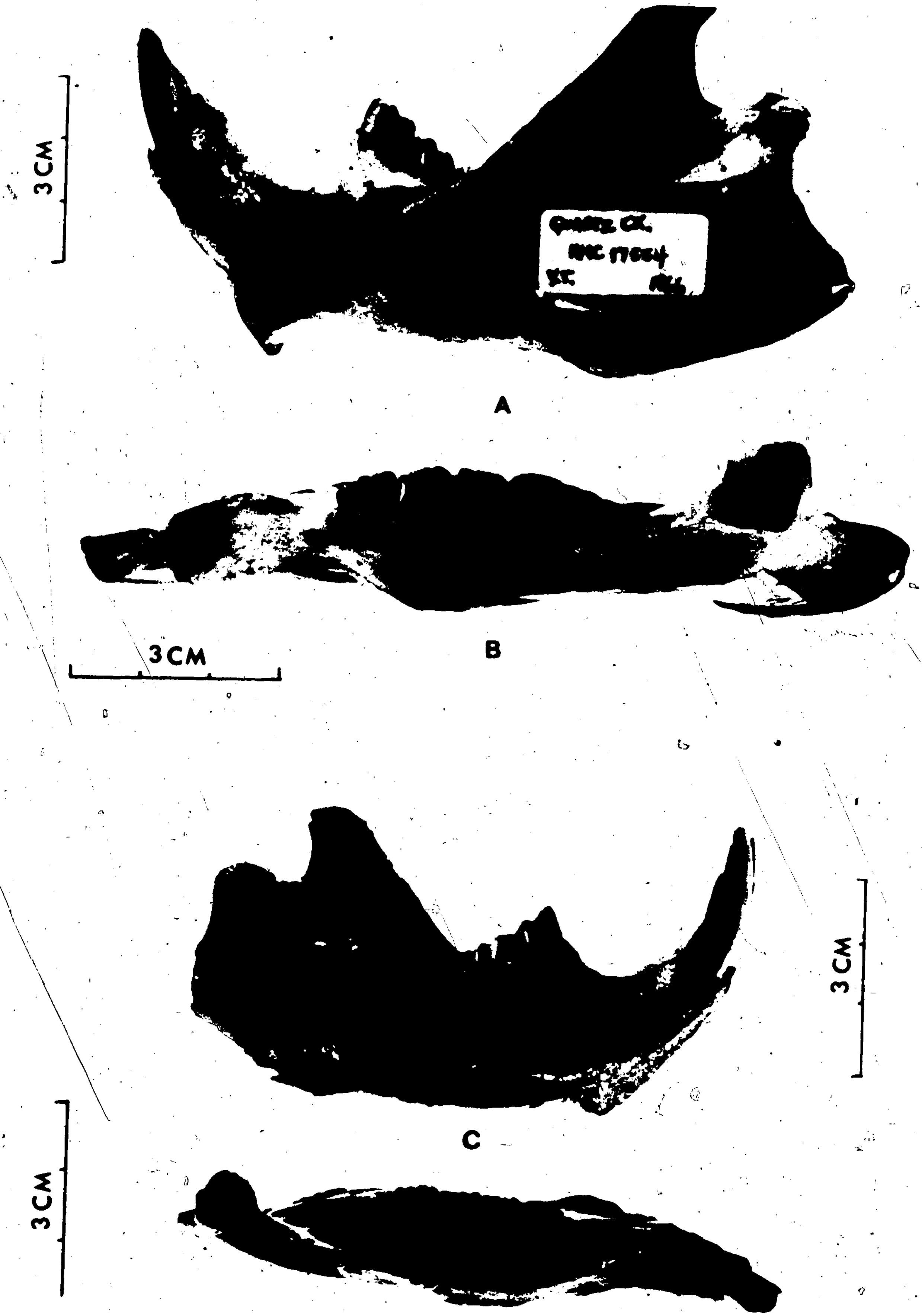

3CM
A
3CM
B
3CM
C
3CM
D

Table 20. Measurements of Pleistocene beaver (*Castor canadensis*) maxillae from the Yukon Territory compared to those of Recent beavers from the Yukon.

SPECIMENS	SEX	MEASUREMENTS (mm)* 1	2	3	4	5
Castor canadensis. Pleistocene, Old Crow, Y.T.						
NMC 13588 Loc. 11A	-	27.2	8.2	8.0	7.5	7.6
NMC 26671 Loc. 15	-	26.9	8.8**	8.4**	6.6+	8.1
Castor canadensis. Recent, Y.T.						
NMC 31754	-	27.2	8.3	8.5	6.9	7.8
NMC 31756	-	25.5	8.2	7.1	6.2	6.3
NMC 31755	-	25.9	7.2	7.3	6.0	7.1
NMC 31295	♂	26.6	6.8	6.2	6.2	6.5
NMC 36286	♂	27.8	7.4	7.7	6.3	7.3
NMC 31298	♀	27.3	8.1	7.7	6.2	6.9
NMC 31296	♂	25.4	7.3	6.9	6.2	6.3
NMC 31297	♂	27.2	8.2	7.8	6.6	7.0
NMC 36288	♂	31.1	11.0	8.9	6.4	8.0
NMC 36291	♂	27.2	8.1	7.7	6.3	6.9
NMC 37380	-	29.4	8.8	9.1	6.5	8.2
NMC 1953	♀	23.9	6.6	7.0	5.6	6.2

* 1. Maximum width between lateral alveolar margins of P^4. 2. Length occlusal surface (anteroposterior) P^4. 3. Width P^4. 4. Length M^1. 5. Width M^1. ** Measurements taken at alveolus.

Light copy

Table 21. Measurements of Pleistocene beaver *(Castor canadensis)* mandibles from the Yukon Territory compared to t
Recent beavers from the Yukon.

SPECIMENS	SEX	MEASUREMENTS (mm) *												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Castor canadensis. Pleistocene, Yukon Territory:														
NMC 17554 Quartz Creek Dawson Area.	–	102.4	93.4	23.3	33.6	25.0	17.7	8.7	7.0	9.1	7.4	7.6	8.5	7.9
NMC 19255 Old Crow Loc. 14	–	–	108.2	25.7	39.8	28.9	20.4	9.7	8.1	11.1	8.7	9.3	9.8	8.4
NMC 16302 Old Crow Loc. 60	–	–	95.0	23.7	33.9	25.9	21.0	–	–	8.5	7.2	8.2	8.2	7.3
NMC 16407 Old Crow Loc. 71	–	–	74.9	20.3	28.9	21.5	16.9	6.6	6.0	6.6	5.9	6.4	6.2	6.2
NMC 20729 Old Crow Loc. 22	–	–	–	22.5	36.6	24.4+	20.1	–	–	9.1	6.9	7.7	8.3	7.9
NMC 16993 Old Crow Loc. 20	–	–	–	24.2	34.2	24.7	19.8	–	–	9.5	6.6	7.7	7.1	7.6
NMC 16057 Old Crow Loc. 44	–	–	–	22.1	34.4	24.9	19.3	–	–	8.9	6.8	8.3	7.3	7.4
NMC 27165 Old Crow Loc. 29	–	–	–	24.1	36.3	26.6	20.6	8.6	7.2	10.4	7.4	8.3	8.6	8.0
NMC 26678 Old Crow Loc. 20	–	–	–	23.3	35.3	27.9	19.8	–	–	9.0	7.1	7.9	8.0	7.4
NMC 27871 Old Crow Loc. 87	–	–	–	22.8	36.2	27.6	21.8	–	–	10.2	8.4	8.4	8.4	8.1
NMC 24794 Old Crow Loc. 22E	–	–	–	22.6	36.1	28.9	18.2	8.0	6.9	10.0	7.6	7.7	7.9	7.5
NMC 18701 Old Crow Loc. 29	–	–	–	20.5	34.5	25.8	20.0	–	–	9.0	7.7	8.0	8.6	7.7
NMC 18301 Old Crow Loc. 29	–	–	–	23.6	–	24.8	–	–	–	8.7	8.2	8.0	9.4	8.1
NMC 26979 Old Crow Loc. 22	–	–	–	–	–	–	22.6	–	–	–	–	7.1	7.0	7.5
NMC 20298 Old Crow Loc. 29	–	–	–	24.1	35.2	–	19.2	–	–	9.6	7.9	7.7	8.9	8.1
NMC 26975 **Old Crow Loc. 22	–	–	–	23.5	35.0	–	22.1	–	–	–	–	7.9	8.6	7.5
NMC 18300 Old Crow Loc. 29	–	–	–	–	–	–	22.2	–	–	–	–	8.0	8.4	7.7
NMC 18260 Old Crow Loc. 11A	–	–	–	–	34.5	–	20.4	–	–	7.7	5.8		6.6	7.4
NMC 28295 Old Crow Loc. 136	–	–	–	–	–	–	–	–	–	–	–	8.2	7.9	7.7
NMC 18219 Old Crow Loc. 29	–	–	–	–	–	–	–	–	–	9.5	7.4	8.8	8.6	8.4
NMC 14808 Old Crow Loc. 29	–	–	–	–	–	–	–	–	–	–	–	7.6	7.7	8.1
NMC 27192 Old Crow Loc. 29	–	–	–	–	–	–	20.8	–	–	–	–	–	–	7.9
NMC 27328 Old Crow Loc. 29	–	–	–	–	–	–	–	–	–	–	–	8.2	7.9	8.2
NMC 24678 Old Crow Loc. 45	–	–	–	–	–	22.3	–	–	–	7.9	6.2	6.9	7.4	–
NMC 15574 Old Crow Loc. 28	–	–	–	23.9	–	23.7	–	–	–	9.7	7.5	–	–	–
Castor canadensis. Recent. Y.T.														
NMC 31754	–	102.1	90.8	23.3	34.5	26.4	17.8	7.8	7.6	9.2	8.0	7.9	8.6	7.4
NMC 31756	–	93.6	81.8	22.0	31.8	26.7	17.5	7.8	6.8	8.4	6.1	6.6	6.2	6.5
NMC 31755	–	92.1	81.2	20.5	31.5	23.2	16.4	7.4	7.2	7.3	6.1	6.9	7.0	6.8
NMC 31295	♂	97.4	84.6	20.1	30.8	27.5	18.8	7.0	6.7	7.2	5.2	6.8	6.0	6.5
NMC 36286	♂	97.4	83.7	21.9	31.2	25.7	18.0	7.3	7.0	8.3	6.5	7.1	7.0	6.8
NMC 31298	♀	96.7	84.2	20.7	32.1	25.0	18.7	7.3	6.6	8.6	6.9	7.3	7.3	7.1
NMC 31296	♂	87.4	74.0	19.8	30.6	21.9	17.1	6.6	6.2	7.9	6.2	6.9	6.4	6.4
NMC 31297	♂	96.5	85.8	20.5	31.5	23.4	17.3	7.8	6.[illegible]	8.0	6.5	7.3	7.3	7.3
NMC 36288	♂	105.4	91.8	23.0	35.9	25.4	19.5	8.6	8.0	9.2	7.5	7.5	8.3	8.2
NMC 36291	♂	92.7	83.3	21.0	33.5	21.3	16.7	7.2	6.4	8.5	6.4	6.8	7.1	7.0
NMC 37380	–	98.1	88.7	22.0	33.6	24.0	18.1	7.4	7.4	9.0	6.9	7.6	7.4	7.4
NMC 1953	♀	88.1	76.0	20.0	29.8	22.6	16.2	6.2	6.4	7.4	6.3	6.6	6.0	5.7

---

* 1. Mandible length (superior alveolar margin of I_1 to posterior of angular process). 2. Mandible length (superior alveolar
– posterior of condyle). 3. Diastema depth (minimum distance across mental foramen to inferior margin posterior to symphys
* 4. Alveolar length (P_4-M_3). 5. Diastema length (superior alveolar margin of I_1 to anterior alveolar margin of P_4)
6. Mandible depth at M_3. 7. Length (anteroposterior) of I_1. 8. Width of I_1. 9. Length P_4. 10. Width P_4.
11. Length M_1. 12. Width M_1. 13. Length M_2. 14. Width M_2. 15. Length M_3. 16. Width M_3.

** Teeth are very heavily worn.

1of 1

:s of Pleistocene beaver *(Castor canadensis)* mandibles from the Yukon Territory compared to those of
/ers from the Yukon.

MEASUREMENTS (mm) *															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
102.4	93.4	23.3	33.6	25.0	17.7	8.7	7.0	9.1	7.4	7.6	8.5	7.9	7.6	7.9	6.3
–	108.2	25.7	39.8	28.9	20.4	9.7	8.1	11.1	8.7	9.3	9.8	8.4	9.2	–	–
–	95.0	23.7	33.9	25.9	21.0	–	–	8.5	7.2	8.5	8.2	7.3	7.9	8.1	6.6
–	74.9	20.3	28.9	21.5	16.9	6.6	6.0	6.6	5.9	6.4	6.2	6.2	6.0	6.6	5.5
–	–	22.5	36.6	24.4+	20.1	–	–	9.1	6.9	7.7	8.3	7.9	8.3	7.4	6.4
–	–	24.2	34.2	24.7	19.8	–	–	9.5	6.6	7.7	7.1	7.6	7.0	8.4	6.4
–	–	22.1	34.4	24.9	19.3	–	–	8.9	6.8	8.3	7.3	7.4	6.9	7.3	6.1
–	–	24.1	36.3	26.6	20.6	8.6	7.2	10.4	7.4	8.3	8.6	8.0	8.5	7.8	6.8
–	–	23.3	35.3	27.9	19.8	–	–	9.0	7.1	7.9	8.0	7.4	8.0	7.3	6.6
–	–	22.8	36.2	27.6	21.8	–	–	10.2	8.4	8.4	8.4	8.1	8.1	8.4	6.9
–	–	22.6	36.1	28.9	18.2	8.0	6.9	10.0	7.6	7.7	7.9	7.5	7.8	–	–
–	–	20.5	34.5	25.8	20.0	–	–	9.0	7.7	8.0	8.6	7.7	8.7	–	–
–	–	23.6	–	24.8	–	–	–	8.7	8.2	8.0	9.4	8.1	7.9	–	–
–	–	–	–	–	22.6	–	–	–	–	7.1	7.0	7.5	6.9	7.5	6.5
–	–	24.1	35.2	–	19.2	–	–	9.6	7.9	7.7	8.9	8.1	8.0	–	–
–	–	23.5	35.0	–	22.1	–	–	–	–	7.9	8.6	7.5	7.5	9.0	6.3
–	–	–	–	–	22.2	–	–	–	–	8.0	8.4	7.7	8.0	7.8	6.8
–	–	–	34.5	–	20.4	–	–	7.7	5.8	7.0	6.6	7.4	6.6	–	–
–	–	–	–	–	–	–	–	–	–	8.2	7.9	7.7	7.6	8.0	6.4
–	–	–	–	–	–	–	–	9.5	7.4	8.8	8.5	8.4	8.6	–	–
–	–	–	–	–	–	–	–	–	–	7.6	–	8.1	8.2	–	–
–	–	–	–	–	20.8	–	–	–	–	–	–	7.9	8.2	8.3	6.2
–	–	–	–	–	–	–	–	–	–	8.2	7.9	8.2	7.6	–	–
–	–	–	–	22.3	–	–	–	7.9	6.2	6.9	7.4	–	–	–	–
–	–	23.9	–	23.7	–	–	–	9.7	7.5	–	–	–	–	–	–
102.1	90.8	23.3	34.5	26.4	17.8	7.8	7.6	9.2	8.0	7.9	8.6	7.4	8.3	7.8	6.9
93.6	81.8	22.0	31.8	26.7	17.5	7.8	6.8	8.4	6.1	6.6	6.2	6.5	6.4	7.2	6.0
92.1	81.2	20.5	31.5	23.2	16.4	7.4	7.2	7.3	6.1	6.9	7.0	6.8	7.2	6.8	6.2
97.4	84.6	20.1	30.8	27.5	18.8	7.0	6.7	7.2	5.2	6.8	6.0	6.5	6.2	6.4	5.3
97.4	83.7	21.9	31.2	25.7	18.0	7.3	7.0	8.3	6.5	7.1	7.0	6.8	7.0	6.5	6.1
96.7	84.2	20.7	32.1	25.0	18.7	7.3	6.6	8.6	6.9	7.3	7.3	7.1	7.4	7.3	6.0
87.4	74.0	19.8	30.6	21.9	17.1	6.6	6.2	7.9	6.2	6.9	6.4	6.4	5.8	6.4	5.3
96.5	85.8	20.5	31.5	23.4	17.3	7.8	6.8	8.0	6.5	7.3	7.3	7.3	7.1	7.2	5.9
105.4	91.8	23.0	35.9	25.4	19.5	8.6	8.0	9.2	7.5	7.5	8.3	8.2	7.6	7.8	6.5
92.7	83.3	21.0	33.5	21.3	16.7	7.2	6.4	8.5	6.4	6.8	7.1	7.0	7.0	7.6	6.1
98.1	88.7	22.0	33.6	24.0	18.1	7.4	7.4	9.0	6.9	7.6	7.4	7.4	7.3	7.6	6.1
88.1	76.0	20.0	29.8	22.6	16.2	6.2	6.4	7.4	6.3	6.6	6.0	5.7	6.0	6.1	5.5

:olar margin of I_1 to posterior of angular process). 2. Mandible Length (superior alveolar margin of I_1 to
astema depth (minimum distance across mental foramen to inferior margin posterior to symphyseal flange).
Diastema length (superior alveolar margin of I_1 to anterior alveolar margin of P_4)
:ngth (anteroposterior) of I_1. 8. Width of I_1. 9. Length P_4. 10. Width P_4.
13. Length M_2. 14. Width M_2. 15. Length M_3. 16. Width M_3.

the more alpine nature of Dawson Area during that period, and the relatively better drainage there. Specimens are stained brown unless otherwise noted.

NMC 13588 from Old Crow Locality 11A is an anterior maxillary fragment with RP^4-RM^1 and LP^4-LM^1. NMC 26671 from Old Crow Locality 15 is a maxilla with RP^4-RM^2 and LP^4-LM^2. Of these teeth, all are broken off at the alveolar margins except LM^1, which is nearly complete.

NMC 17554 from Dawson Locality 7 is a complete left mandible with all teeth. It is lighter in color than all other specimens described, being manila with patches of reddish brown and black - possibly due to iron and manganese staining respectively. The enamel surface on the anterior of the incisor is black rather than orange as in Recent specimens. The remaining specimens are from the Old Crow Area. NMC 19255 from Old Crow Locality 14 is a complete right mandible except that it lacks M_3 (the alveolus is present), the posterior margin of the angular process, and the tip of the coronoid process. Enamel on the anterior surface of the incisor is stained olive green. NMC 16302 from Old Crow Locality 60 is a left mandible with LP_4-LM_3 lacking the incisor. NMC 16407 from Old Crow Locality 71 on Johnson Creek is a complete right mandible with all teeth except that the inferior and posterior (angular process) margins of the mandible are eroded. The small size of the specimen and the roughened surface of the condyle suggest the specimen represents an immature individual. A slight perforation on the lateral surface of the mandible exposes part of the base of RM_3- another indication that the specimen is from an immature beaver. NMC 20729 from Old Crow Locality 22 is a left mandible with LP_4-LM_3 and part of the incisor. NMC 16993 from Old Crow Locality 20 is a right mandible with RP_4-RM_3 and a broken incisor. NMC 16057 is a left mandible with LP_3-LM_3 and a broken incisor. It was excavated at Old Crow Locality 44 and may be of Sangamon interglacial age. NMC 27165 from Old Crow Locality 29 is a left mandible with LP_4-LM_3 and the incisor. NMC 26678 from Old Crow Locality 20 is a left mandible with LP_4-LM_3 and the alveolus for the incisor. NMC 27871 from Old Crow Locality 87 is a right mandible with RP_4-RM_3 and a broken incisor. NMC 24794 from Old Crow Locality 22E is a left mandible with LP_4-LM_2, the alveolus for M_3 and the incisor. The wear on the incisor is unusual in that its apex occurs on a ridge approximately 3 mm posterior to the enamel, rather than on the tip of the enamel surface itself. Both posterior and anterior-facing facets show signs of wear. Presumably this phenomenon resulted from a change in the bite of the jaws. NMC 18701 from Old Crow Locality 29 is a left mandible with LP_4-LM_2, the alveolus for LM_3 and a broken incisor. NMC 18301 from Old Crow Locality 29 is a right mandible with RP_4-RM_2 and a broken incisor. The anteromedial part of LM_1 is missing. NMC 26979 from the sand bar opposite to Old Crow Locality 22 is a left mandible with LM_1-LM_3. The condyle is present. The surface of the fossil suggests that it had been buried in heavily oxidized matrix. NMC 20298 from Old Crow Locality 29 is a left mandible with LP_4-LM_2 and the alveolus for LM_3 NMC 26975 from the sand bar opposite to Old Crow Locality 22 is a left mandible with LM_1-LM_3 and the alveolus for LP_4. The incisor is broken. The cheek teeth are so heavily worn that the flexids which usually appear are worn away, particularly on the posterior part of LM_3 and on the lingual margin of LM_1. NMC 18300 from Old Crow Locality 29 is a left mandible with LM_1-LM_3 and a partial alveolus for LP_4. Part of the incisor is within the mandible below the cheek teeth. NMC 18260 from Old Crow Locality 11A is a right mandible with RP_4-RM_2. The alveolus for RM_3 is barely discernible, being nearly obscured by oxidized sand. A fragment of the incisor lies beneath the cheek teeth. The teeth are high above the alveolar margin and are relatively narrow, suggesting that the individual represented may be rather young. NMC 28295 from Old Crow Locality 136 is a right mandible fragment with RM_1-RM_3. NMC 14808 from

Old Crow Locality 29 is a posterior fragment of a left mandible with LM_1-LM_2 and a partial alveolus for LM_3. Highly oxidized sandy matrix is seen on the exposed surface of the alveolus for the incisor. NMC 27192 from Old Crow Locality 29 is a posterior fragment of a right mandible with RM_2-RM_3. NMC 27328 from Old Crow Locality 29 is a right mandible fragment with RM_1-RM_2 and the alveolus for RM_3. NMC 24678 from Old Crow Locality 45 is an anterior left mandible fragment with LP_4-LM_1 and part of the incisor. Matrix adhering to the surface is oxidized sand. The specimen was collected *in situ* from a fine gray sandy gravel overlying the basal clay unit about 30 feet (9.1 m) above river level. I correlate this unit with Unit 2 at Old Crow Locality 44 and suggest that this specimen is of Sangamon age. NMC 15574 from Old Crow Locality 28 is an anterior fragment of a right mandible with RP_4 and part of the alveolus for the incisor.

Discussion

Evidently beavers (Castoridae) were present in the Old Crow Area from ?Yarmouth interglacial or earlier times to the present. The earliest evidence is from a basal unit of oxidized grit at Porcupine Locality 100 where many beaver-cut sticks - possibly the remains of a dam - were found. A beaver-cut stick was collected *in situ* from the basal clay at a point 15 feet (4.6 m) above the level of the Old Crow River at Locality 96. I suggest that this specimen is of

Illinoian age. In this connection, it is interesting to note that beaver dams and beaver-cut wood have been found in redeposited loess of Illinoian age in the valley of Sheep Creek near Fairbanks, Alaska (Péwé and Hopkins 1967, p. 268). Although beaver-cut sticks have been collected at many other localities in the Old Crow Basin, few were found in place and none has been radiocarbon dated. A well preserved mandible, NMC 16057, collected *in situ* from Unit 2 at Old Crow Locality 44, and another mandible, NMC 24678, from what I consider to be a correlative unit just upstream at Old Crow Locality 45, are of ?Sangamon interglacial age. Specimens of *Castor canadensis* other than NMC 16057 have been excavated from Unit 2 at Old Crow Locality 44. The mandible (NMC 17554) from Dawson Locality 7 is probably of late Wisconsin age. Sticks, almost certainly cut by *Castor canadensis*, from organic sediments near Arctic Red River, Northwest Territories yielded a radiocarbon date of 9,500 ± 90 years B.P. (GSC-1814). The species has also been described from the fauna at Acasta Lake somewhat farther east. That fauna has been radiocarbon dated at approximately 7,000 years B.P. (Noble 1971). Beaver-gnawed wood radiocarbon dated between approximately 9,000 and 4,000 years ago has been recorded from Cook Inlet, Tofty and Kotzebue areas in Alaska. Beavers presently occupy most of the Yukon Territory except for the arctic coastal region (Youngman 1975, p. 77).

The genus *Castor* had its origin in the early Pliocene of Eurasia (Kurtén 1971, p. 147). The earliest North American record is of *Castor* sp. from Hemphillian deposits (Repenning 1967, p. 291). Presumably beavers like *Castor accessor* or *C. californicus* from Blancan deposits in western United States could have given rise to *C. canadensis* during the early Pleistocene. Both were approximately 10% larger than the living North American beaver, but were similar in gross characteristics of dentition and skeleton (Shotwell 1970, p. 30). A mandible of the modern beaver (*Castor* cf. *canadensis*) from sediments of probable Kansan age near Medicine Hat, Alberta is the earliest record for Canada (Stalker and Churcher 1971, p. 114). Hibbard (1970, p. 423) reports *C. canadensis* from Illinoian deposits of Kansas. This appears to be the earliest record from the Great Plains of the United States. *Castor canadensis* has been reported in Wisconsin age faunas from Cherokee Cave, Missouri and Samwel Cave, California, among others (Hibbard 1958, p. 15).

All European Pleistocene beavers of the genus *Castor* seem to be referable to *Castor fiber*. This species is recorded from Villafranchian to postglacial time there -

indeed, it has survived in parts of Scandinavia, in the Rhône and Elbe rivers and in eastern Europe. In Asia its range extends to Siberia and Mongolia. Although *C. fiber* and *C. canadensis* are closely related, Lavrov and Orlov (1973) showed karyotypical and craniological differences between the two species.

The beaver is Canada's largest and perhaps most distinctive rodent. Its characteristic morphological features are adaptations for swimming and feeding on woody vegetation. It is found throughout North America where there are wooded waterways such as lakes and slow-flowing streams where aspen and other suitable food occurs. Occasionally beavers can live where only shrub willows, alders or water plants provide food. In order to maintain a fairly constant water level around the lodge or bank den, a dam made of brush, cut trees and mud is constructed across a stream. Beavers are colonial. Most colonies consist of an adult pair, the new-born young and the young of the previous year, bringing the family to about 10 by autumn. Food consists mainly of the bark and twigs of trees, although many other plants are eaten, especially in summer. Bear, wolf, coyote, fisher, wolverine, otter and lynx prey on beavers. Man is also a most important predator, desiring pelts for clothing.

Castoroides ohioensis (giant beaver)

A few hundred teeth and largely fragmentary postcranial bones of the giant beaver have been collected from the Old Crow Basin. Cheek teeth and astragali are generally best preserved due to their toughness and compactness. Incisors break readily but even very small pieces of the ribbed enamel can be recognized. Of the specimens collected only two mandibles with teeth, a mandibular fragment and a few of the more substantial incisor fragments are described (Figures 16-18, Table 22). The patterns of lophids and flexids (Martin 1969, p. 1035) seen on the occlusal surfaces of the lower cheek teeth from the Old Crow Area have the "S" shape and the large size characteristic of *Castoroides*. A specimen of *Castoroides ohioensis* from postglacial deposits of Minnesota compares closely in morphology with mandibles from the Porcupine and Old Crow rivers and lies between them in size. Therefore, the Yukon Pleistocene specimens are referred to *Castoroides ohioensis*.

Referred specimens

NMC 29418 is an upper incisor fragment as indicated by the robustness relative to lower incisors and the central depression running the length of the ribbed outer surface that characterize these teeth. Its maximum length and width are 25.8 mm and 26.2 mm respectively. It was excavated

Figure 16. Right mandible with $RP_4 - RM_2$ and incisor of a Pleistocene giant beaver (*Castoroides ohioensis*) (NMC 16587, Porcupine Locality 100).

A. Lateral view.

B. Occlusal view.

C. Medial view.

A

C

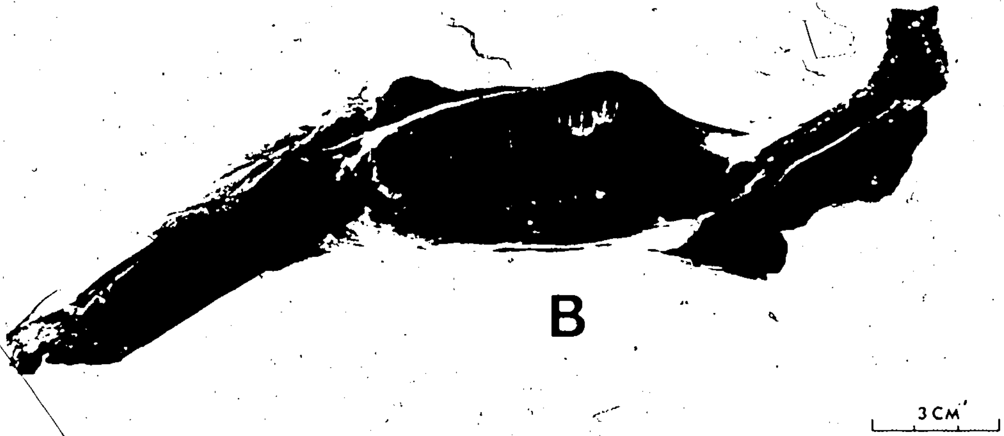
Figure 17. Left mandible with all teeth of a Pleistocene giant beaver (*Castoroides ohioensis*) (NMC 15333, Old Crow Locality 22).

A. Lateral view.

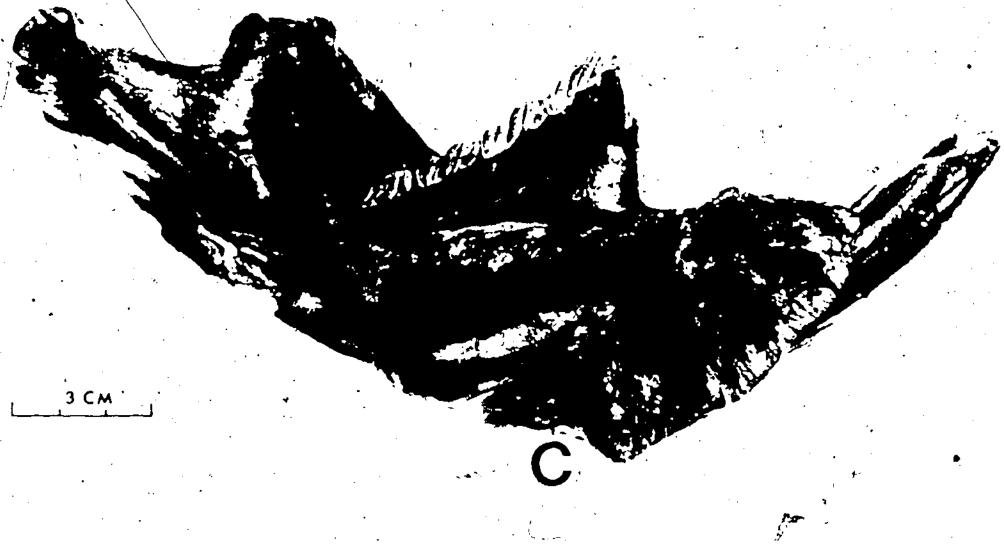
B. Occlusal view.

C. Medial view.

A



B



C

Figure 18.- A. Restoration of a giant beaver (*Castoroides ohioensis*) as it may have appeared in its natural habitat in the Old Crow Basin during the late Pleistocene. In adulthood these animals reached over 7 feet (2.1 m) long and may have weighed as much as 480 pounds (218 kg). Note muskrat-like tail. Ink sketch by Charles Douglas. B. Detailed restoration of the head and forepart of the body of a giant beaver (*Castoroides ohioensis*). Note the deep skull and ribbed cutting teeth. Ink sketch by Bonnie Dalzell.

A

B

Table 22. Measurements of Pleistocene giant beaver (*Castoroides ohioensis*) mandibles from the Yukon Territory compared to those of Pleistocene giant beavers from the United States.

SPECIMENS	MEASUREMENTS (mm) *															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Castoroides ohioensis, Old Crow, Y.T.																
NMC 16587 Porcupine Loc. 100	200.6	63.4	71.3	54.6	32.2	22.0	24.4	127.0	18.0	14.8	16.7	15.0	16.7	14.9	-	-
NMC 15333 Old Crow Loc. 22	181.8	52.6	64.3	53.6	-	20.7	20.4	41.0	18.3	13.8	15.4	13.4	14.4	12.6	13.3	12.6
NMC 14745 Old Crow Loc. 29	-	-	-	47.2	-	-	-	-	18.1	14.7	-	-	-	-	-	-
Castoroides ohioensis																
NMC 17691 (cast) Minnesota (left mandible)	178.7	56.4	70.4	52.8	27.1	22.0	21.2	107.0	18.3	13.6	16.7	13.9	15.7	13.3	** 14.2	** 12.6
Castoroides ohioensis dilophidus (Martin 1969, p. 1037). Florida																
Adult - Mean width of 18 incisors	-	-	-	-	-	-	24.8	-	-	-	-	-	-	-	-	-
Young - Mean width of 4 incisors	-	-	-	-	-	-	11.5	-	-	-	-	-	-	-	-	-
Castoroides ohioensis (Barbour 1931, p. 183)																
Indiana (Earlham College specimen).	-	-	-	-	-	-	-	-	20.0	12.0	17.0	13.0	17.0	13.0	16.0	12.0
Nebraska (No. 20-9-30)	-	-	-	-	-	25.0	20.0	-	19.0	16.0	16.0	16.0	17.0	15.0	-	-

* 1. Mandible length (superior alveolar margin of I_1 to posterior of condyle).
2. Diastema depth (minimum distance across mental foramen to inferior margin posterior to symphyseal flange).
3. Alveolar length (P_4-M_3).
4. Diastema length (superior alveolar margin of I_1 to anterior alveolar margin of P_4).
5. Mandible depth at constriction just posterior to M_3.
6. Length (anteroposterior) of I_1.
7. Width of I_1.
8. Inside length of I_1 from alveolar margin to tip.
9. Length P_4.
10. Width P_4.
11. Length M_1.
12. Width M_1.
13. Length M_2.
14. Width M_2.
15. Length M_3.
16. Width M_3.

** Right mandible.

Light copy

from oxidized organic sand overlying the basal clay unit at Old Crow Locality 29. NMC 13599 from Old Crow Locality 11A is a similar upper incisor fragment. Its maximum length and width are 24.5 mm and 26.7 mm respectively.

The most impressive specimen, which is now on display in the National Museum of Natural Sciences, is a right mandible (NMC 16587) with RP_4-RM_2, the alveolus for RM_3 and the complete incisor. The incisor is slightly cracked and warped. The thin bone of the posterior extremity of the angular process is missing. The specimen is stained blackish brown. I found the fossil on a narrow shelf at the base of the high bluffs at Porcupine Locality 100. It lay about 2 feet (0.6 m) above river level. In attempting to locate its source, directly above the site approximately 12 feet (3.7 m) above stream level, I found a black organic layer consisting of vegetative litter exposed just below some slumped surface material. Although I suspect that the mandible was derived from this organic layer, there is no way to prove it. Except in its larger size, the mandible differs in no important respect from a cast of a *Castoroides ohioensis* mandible (NMC 17691) from Hennepin County, Minnesota. B.R. Erickson, who kindly donated this cast to the National Museums of Canada, estimates that the original specimen (SMVP P69.21.1) is about

8,000 years old. The size of NMC 16587 and the fact that the occlusal surfaces of the cheek teeth show complete flexids, indicate that it represents an adult.

NMC 15333 from Old Crow Locality 22 is a left mandible with all teeth. Most of the coronoid process and the angular portion of the jaw are missing. The incisor is split and slightly warped. NMC 15333 is noticeably smaller than NMC 16587, but its most striking feature is the short incisor, which is 32% of the length of the Porcupine specimen and 38% of the length of the Minnesota fossil. Despite its relatively small size, the fact that the flexids are complete and the cheek teeth are greater than 12.5 mm in occlusal length indicates that NMC 15333 represents an adult. Furthermore, young *Castoroides'* incisors are approximately half the width of adult incisors (Martin 1969, p. 1036), whereas the Old Crow specimen is closest to the width of adults. I cannot account for the unusual shortness of the incisor, but speculate that it has undergone extremely heavy wear. The cutting facet is normal in every respect: there is no indication that the tooth had been broken. The mandible is stained dark brown.

NMC 14746 from Old Crow Locality 29 is an anterior portion of a left mandible with LP_4, the top of which has been broken off near the alveolar margin. It is more robust than the corresponding part of NMC 15333, and the LP_4 is wider. In these respects it is closer to the large mandible from the Porcupine River. It is dark brown.

Discussion

The specimens from Old Crow Basin constitute the most northerly record of *Castoroides ohioensis* in North America. Fossils of this species have not been found elsewhere in the Yukon Territory or in Alaska. Although the Porcupine River specimen could be older, fossils (e.g. an incisor tooth NMC 16056) excavated from Old Crow Locality 44 indicate that giant beavers occupied the Old Crow Basin prior to 54,000 years ago - possibly during the Sangamon interglacial. *Castor canadensis* fossils were found in the same stratigraphic unit at Old Crow Locality 44, indicating that giant and modern beavers lived in the same region and were approximately contemporaneous. To explain their co-existence, I postulate that giant beavers occupied large lakes and ponds, while the modern beavers dammed slow-flowing streams in the region. The fact that all *Castoroides* specimens recovered so far are deeply stained suggests that the species became extinct in Eastern Beringia prior to the late Wisconsin. Could the relative coolness and dryness of the environment during the peak of the Wisconsin have resulted in their withdrawal from the region or in their local extinction?

The only other Canadian fossil of *Castoroides ohioensis* is an incisor tooth from the Don Formation of Sangamon interglacial age in Toronto. Perhaps giant beavers were able to disperse rather rapidly northward into the Yukon from the southern part of North America through chains of lakes which evidently tend to form along the southern margin of the Canadian Shield during interglacial phases (e.g. the present interglacial). I suggest that the most likely time of this northward radiation would have been at the beginning of the Sangamon interglacial when the Illinoian ice sheet was melting back.

Two beavers that are of great importance when considering the ancestry of *Castoroides* are *Dipoides* and *Procastoroides*. *Dipoides* is known from the Pliocene of Eurasia and the middle Pliocene and Pleistocene of North America, while *Procastoroides sweeti* from the Rexroad fauna (early Blancan) of Kansas is intermediate between *Dipoides* and *Castoroides* in morphology of the cheek teeth and size, but it lacks the ribbed incisors characteristic of the latter genus. However, Shotwell (1970, p. 36) supplies a critical piece of information in his description of a new species, *Procastoroides idahoensis*, from the Grand View fauna

(Blancan) of Idaho: "The new species differs from *P. sweeti* primarily in the numerous longitudinal grooves (= ribs), on the incisors much like those in *Castoroides*." This observation breaks down many objections to the *Procastoroides* - *Castoroides* sequence of evolution. I wish to stress the steady increase in size from *Dipoides* to *Castoroides*, and to put forward the hypothesis that as the incisors lengthen, they reach a point where extra structural support is necessary. I see this transition occurring between the *Procastoroides sweeti* and *P. idahoensis* stages, and taking the form of ribbing on the anterior surface of the incisors of the latter species and *Castoroides* providing extra support to those very important teeth. Indeed, this may have been one of the slight advantages that allowed *Castoroides* to replace *Procastoroides* in late Blancan time. In summary, I concur with Shotwell (1970, p. 39) that the phyletic line *Dipoides* - *Procastoroides* - *Castoroides* is the most probable sequence. It is interesting to note in this regard that Martin's (1969, p. 1040) study of *Castoroides* material from Florida showed stages of dental ontogeny suggesting a succession from a *Dipoides*-like molar pattern to that of adult *Castoroides* teeth in which the flexids are complete. Other possible origins for *Castoroides* are discussed by Woodburne (1961).

Although Eurasian giant beavers (*Trogontherium*) are known from Villafranchian to middle Pleistocene time in Asia, and from the Villafranchian to the Holstein (?Yarmouth) interglacial in Europe (Kurtén 1968, p. 198), Dechaseaux (1967) concluded that *Trogontherium* and *Castoroides* are at extreme ends of two markedly different branches of evolution. The Eurasian giant beaver, despite some similarities to *Castoroides* and the fact that it may have filled a similar ecological niche in relation to *Castor*, was only slightly larger than the modern beaver.

Castoroides was confined to North America. *Castoroides ohioensis* had become well established by Illinoian time and has been reported from late Pleistocene deposits from Florida to Ontario and New York to the Yukon Territory. During the retreat of the Wisconsin ice, many giant beavers lived in moist habitat south of the Great Lakes, particularly in the region covered by the present states of Indiana, Ohio and Illinois. *Castoroides ohioensis* evidently became extinct in postglacial time. Bone from a skeleton from Ramsay County, Minnesota yielded a radiocarbon date of 10,320 ± 250 years B.P. (Erickson 1967, p. 2).

Giant beavers reached the size of black bears - 7 feet (2.1 m) or more in total length, compared to approximately

3 feet (0.9 m) in the modern beaver, *Castor canadensis*. They may have weighed as much as 480 pounds (218 kg), compared to about 60 pounds (27 kg) for the modern beaver (Stirton 1965, p. 273). Unlike modern beavers, giant beavers had long incisors with ribbed anterior enamel surfaces. Stirton (1965, p. 274) remarks: "The construction of their incisors and the length that they extended beyond the alveolar borders, however, do not support the idea that these giant beavers felled larger trees or built dams." Although they may not have been able to build dams, I see no reason why giant beavers were unable to cut wood efficiently. I think the deeply ribbed enamel on the outer surface of the incisors would have acted as girdering. If they merely used their teeth for rooting out soft marsh plants, then why the massive size of the cutting teeth, why the deepened mandible with larger rather heavily ridged cheek teeth, and above all, why the relatively deeper masseteric fossa implying greater chewing and biting power? The extremely heavy wear on the incisor of NMC 15333 is worth considering again. Most likely the heavy wear was a result of cutting wood rather than feeding on softer aquatic plants. Nor does Stirton's observation that the tips of the giant beaver incisors are more rounded when seen from behind, compared to the flatter, chisel-like edge of modern beaver incisors, convince me that the former could not have filled

the combined role of wood cutters and gougers.

According to comparative studies of caudal vertebrae (Hay 1914), giant beavers had roundish, muskrat-like tails. This suggests that they were unable to use their tails to give alarm by slapping the water as modern beavers do. Perhaps they did not need an alarm signal! Although the hind limbs of *Castoroides* were well adapted for swimming, they are relatively short compared to *Castor* (Erickson 1962, p. 12), and considering the great weight of the animals, their ability to disperse overland, as some modern beavers do, would have been reduced (Cahn 1932, p. 238).

A possible giant beaver "lodge" was discovered by Williamson (1912) near New Knoxville, Ohio. Evidently a cranium of *Castoroides* and the den were in a peaty layer surrounded by humus. The den was said to be about 4 feet (1.2 m) high and 8 feet (2.4 m) square. It was made of willow poles approximately 3 inches (7.6 cm) in diameter.

Giant beavers evidently preferred lakes and ponds bordered by swamps as their habitat, for their remains have so often been found in ancient swamp deposits (Barbour 1931, pp. 172-174). The eventual reduction of these environments, perhaps linked with the inability to build dams like those of *Castor canadensis* and the inability to disperse readily overland to new drainage systems when drought occurred, may have resulted in their extinction and the ultimate dominance of the smaller modern beaver in North America. Likewise, the Eurasian giant beaver *Trogontherium* gave way to *Castor fiber*, but earlier. It is unusual that there is no evidence that giant beavers were hunted by man. Evidently they co-existed. Surely a *Castoroides* pelt would have made an excellent coat or sleeping robe!

Family Cricetidae

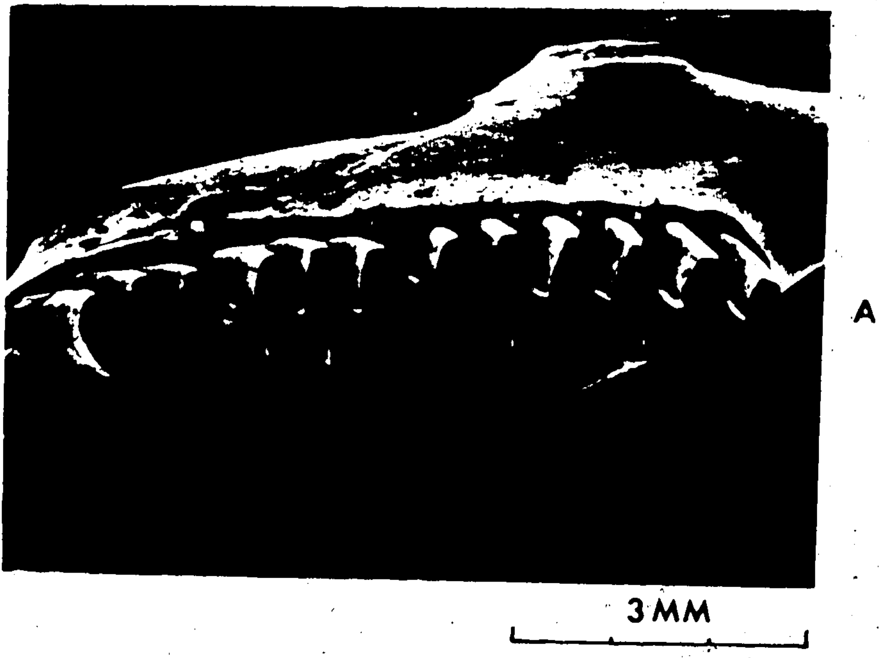
Dicrostonyx cf. *henseli* (Hensel's lemming)

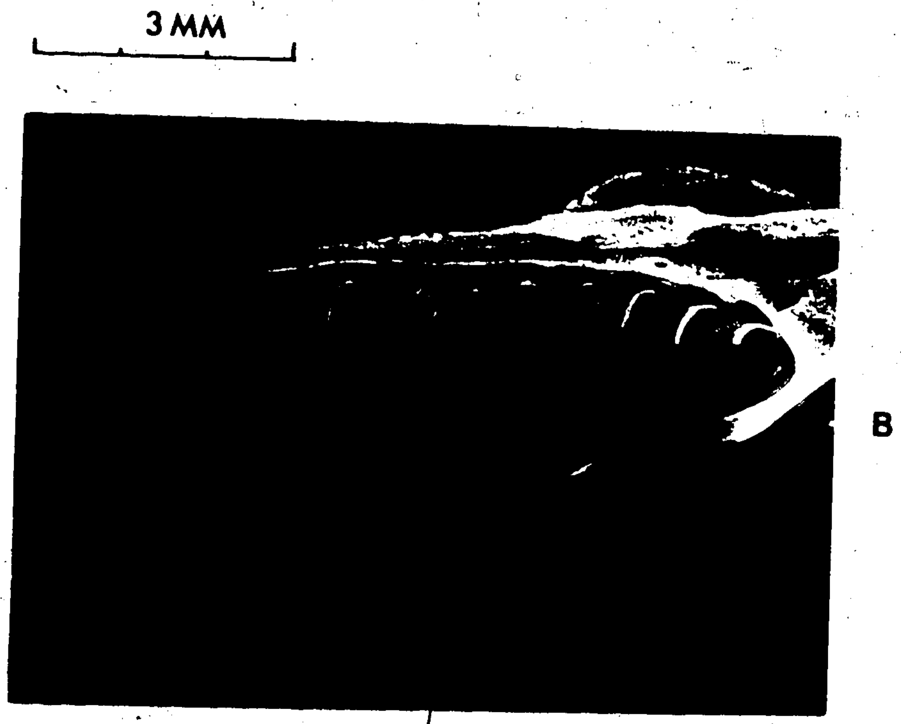
A maxillary fragment and several mandibles with teeth (Figure 19A) from localities in the Old Crow Basin appear to be best referred to *Dicrostonyx* cf. *henseli*, which has a less complex tooth crown pattern than the collared lemming, *D. torquatus* (Hinton 1926). The point of greatest diagnostic importance in separating these specimens from fossils of the more common collared lemming is the lack of an anterior labial bud on M_3. Thus, *D. henseli* has a posterior loop and four salient angles in addition to an anterior lingual bud, as figured in Guthrie and Matthews (1971, p. 486). However, identification is not necessarily clear-cut because of the degree of variability in *Dicrostonyx*

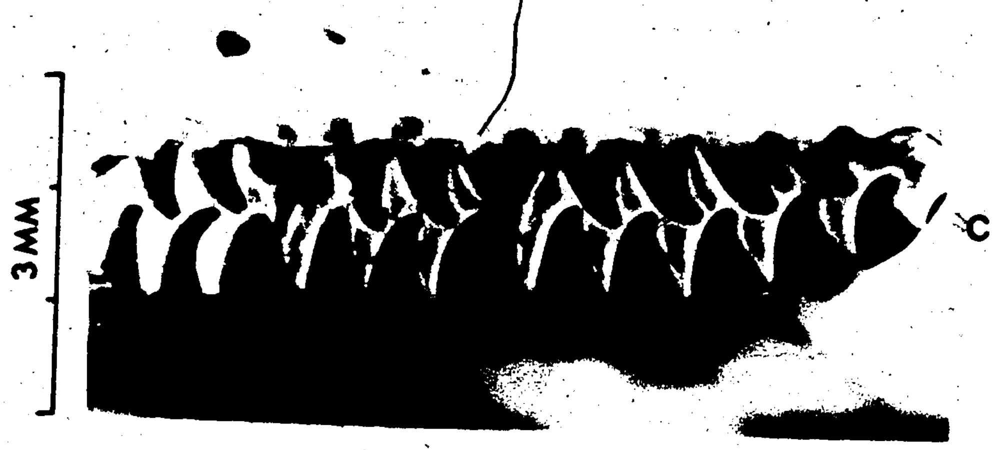
Figure 19. A. Occlusal view of RM_1-RM_3 in a right mandible (NMC 22219, Old Crow Locality 27W) of a Pleistocene Hensel's lemming (*Dicrostonyx* cf. *henseli*). SEM photograph.

B. Occlusal view of RM_1-RM_3 in a right mandible (NMC 18561, Old Crow Locality 29) of a Pleistocene collared lemming (*Dicrostonyx torquatus*). SEM photograph.

C. Occlusal view of LM_1-LM_3 in a left mandible (NMC 37802) of a Recent collared lemming (*Dicrostonyx torquatus*) from northern Canada. Note apparent lack of an anterior labial bud on M_3, as in *Dicrostonyx henseli*, suggesting the plasticity of what has been considered a "diagnostic" character of the latter species.


A
3 MM


3 MM
B


3 MM
C

tooth patterns (Guilday 1968, p. 66; Agadzhanyan 1973, p. 339), and the problem must be investigated in detail - particularly in living *D. torquatus*. This problem is brought sharply into focus in observing a left mandible with incisor and LM_1-LM_3 of *Dicrostonyx* sp. from Old Crow Locality 27W which has an anterior loop of LM_1 like that of *D. torquatus*, whereas LM_2 and LM_3 are most like *D. simplicior* or *Predicrostonyx hopkinsi*, as illustrated by Guthrie and Matthews (1971, p. 486). All specimens are stained dark brown.

S[illegible]ies based on comparative measurements of most of the cricetid rodents are deferred until suitably detailed statistical analyses of the large masses of data available can be made.

Referred specimens

NMC 15638 from Old Crow Locality 28 is a maxilla with LM^1-LM^2 and RM^1-RM^2 and palate. M^1s have posterior buds (small folds) on the labial side like those of *Dicrostonyx henseli* or *D. hudsonius* (the living Ungava lemming), while M^2s lack posterior buds entirely, consisting only of anterior loops and four triangles, being closest in this feature to *Predicrostonyx hopkinsi* (Guthrie and Matthews, p. 486). Unfortunately, M^3s are lacking so the pattern of the posterior trefoil or loop which is of diagnostic importance cannot be used to more precisely identify the specimen. Pending further evidence, I refer this specimen to *D.* cf. *henseli*, and suggest that the lack of posterior buds on M^2s is an aberrant situation indicating a substantial degree of genetic plasticity.

NMC 22219 from Old Crow Locality 27W is a right mandible with the incisor and RM_1-RM_3. The ascending ramus is lacking. NMC 24411 from Old Crow Locality 11A is a left mandible with the incisor and LM_1-LM_3. NMC 22093 from Old Crow Locality 27W is a left mandible with the incisor, LM_3 and alveoli for LM_1-LM_2.

Discussion

The dark staining of the Old Crow fossils suggest a pre- late Wisconsin age, but beyond that nothing can be said, for they were not found *in situ* in one of the thicker sections along Old Crow River. In North America, this species has been reported previously only from the Deering Formation at Cape Deceit, Alaska. Guthrie and Matthews (1971, p. 501) consider that the sediments containing *D. henseli* were laid down during early Illinoian time. Hensel's lemming is known from many European Pleistocene localities and is closely related to the living Ungava lemming (*Dicrostonyx hudsonius*) of North America, which is restricted to tundra east of

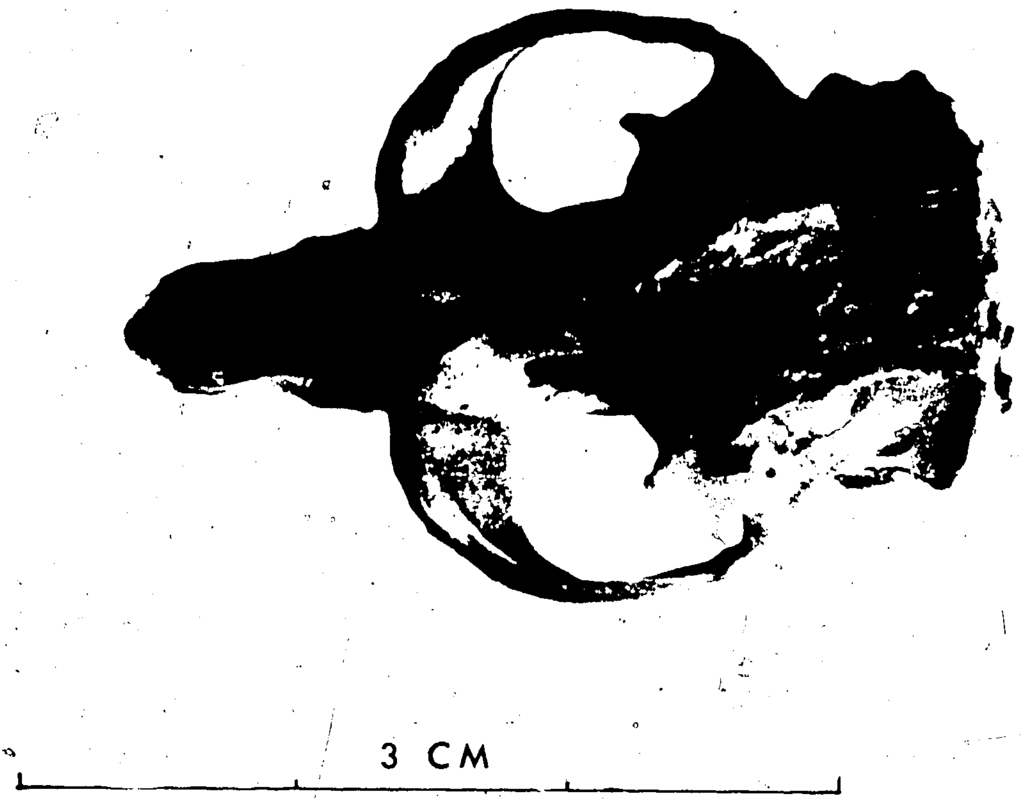
Hudson Bay. Indeed, I am not sure how the two species can be distinguished! It appears that lemmings of the *D. henseli-hudsonius* type were widespread in Eurasia and North America before they were replaced everywhere except Ungava by the more complex-toothed collared lemming.

Perhaps the appearance and habits of *D. henseli* can be loosely compared to the living Ungava lemming, which is white in winter, and in summer is brownish to grayish above with a dark gray dorsal stripe. Like the collared lemming, it occupies tundra and fluctuates rather dramatically in population size, which in turn affects vitally its many predators such as the arctic fox and Snowy Owl.

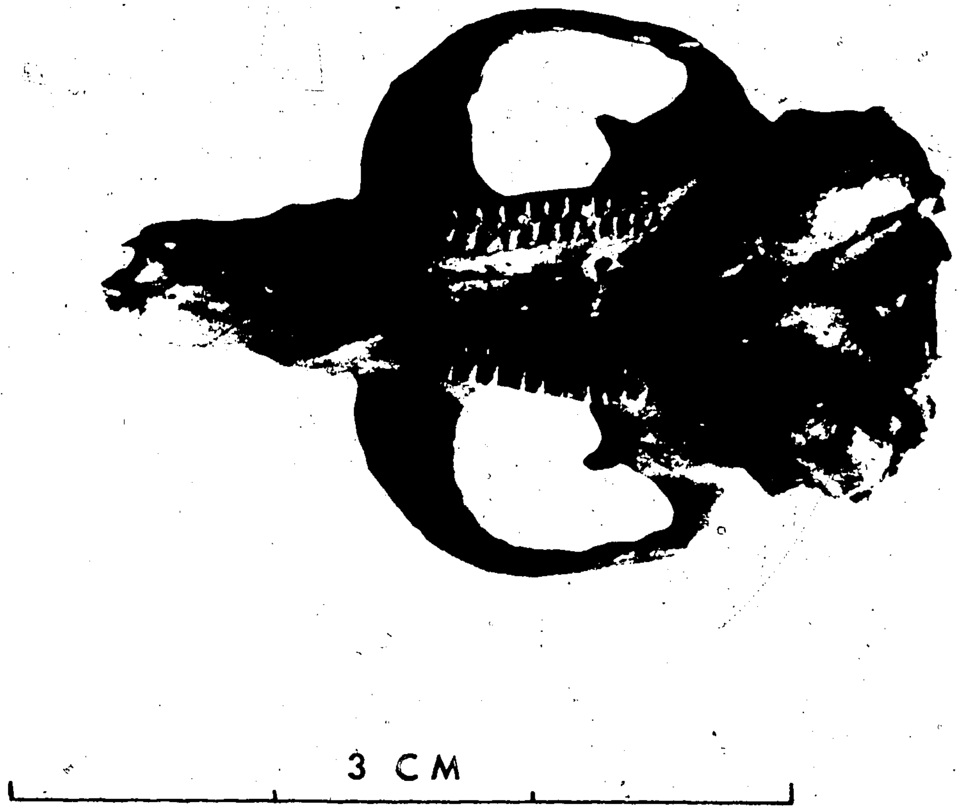
Dicrostonyx torquatus (collared lemming)

A well preserved cranium from the Sixtymile Area and many mandibles with teeth (Figure 19B-C, 20A-B) from the Pleistocene deposits of the Old Crow Basin have been collected. These specimens generally fit the occlusal pattern for the collared lemming illustrated by Guthrie and Matthews (1971, p. 486) and Banfield (1974, p. 182). Not only skeletal elements but also fecal pellets of lemmings have been found in Yukon Pleistocene deposits. One large sample from frozen muck was excavated *in situ* 16 feet

Figure 20. Cranium (NMC 12062, Sixtymile Locality 1) of a Pleistocene collared lemming (*Dicrostonyx torquatus*). A. Dorsal view. B. Ventral view showing occlusal pattern of upper molar teeth.



A



B

(4.9 m) above the surface of the gold-bearing gravel in the Dawson Area. A lens of ground ice was situated below these droppings. I intend to have the pellets examined by paleobotanists in order to find out about the diet of late Pleistocene collared or brown lemmings.

Referred specimens

NMC 12062 is a complete cranium which was collected *in situ* at a mining cut at the mouth of Miller Creek where it enters the Sixtymile River (Sixtymile Locality 1). The muck layer at the locality was from 8 to 12 m thick overlying gold-bearing gravel. The rodent burrows from which the specimen came were exposed on the muck face 3 to 6 m below the surface. Several of the chambers contained remains of a nest, fecal pellets, and seeds. Skulls and skeletons of the rodents were found in some of the chambers. The specimen is estimated to be at least 10,000 years old (Porsild *et al.* 1967, p. 113).

NMC 18561 from Old Crow Locality 29 is a right mandible with RM_1-RM_3, the complete diastema and a large part of the ascending ramus. It is stained reddish brown. The following specimens are left mandibles with RM_1-RM_3: NMC 28640 (Old Crow Locality 65), NMC 22182 (Old Crow Locality 27W), NMC 24819 (Old Crow Locality 20), NMC 24680 (Old Crow Locality 11A). NMC 15714 from Old Crow Locality

28 has the incisor and RM_1-RM_3. NMC 19243 is a left mandible with LM_1-LM_3. It was excavated from the fossiliferous layer of Unit 2 at Old Crow Locality 44, which may be of Sangamon interglacial age. NMC 24419 from Old Crow Locality 11A is a left mandible with LM_1-LM_3. NMC 18841 from Old Crow Locality 20 is a left mandible with the incisor and LM_1-LM_2. NMC 28729 from Locality 27 is a left mandible with incisor and LM_1-LM_2. The following specimens are left mandibles with LM_1-LM_2: NMC 25275 (Old Crow Locality 27W), NMC 25070 (Old Crow Locality 20). NMC 25495 is a left mandible with LM_1-LM_2. It was screened from matrix excavated from Unit 2 at Old Crow Locality 44 and consequently may be of Sangamon age. NMC 25490, a left mandible with LM_1 and a fragment of LM_2, was also excavated from Old Crow Locality 44. Also excavated from that site is NMC 15840, which consists of a right mandible with RM_1-RM_2. NMC 25017 from Old Crow Locality 11A is a right mandible with RM_1-RM_2. Most of the diastema is present.

NMC 24813 from Old Crow Locality 20 is a right mandible with RM_1-RM_2. NMC 22190 from Old Crow Locality 27W is a right mandible with the incisor just projecting through its alveolar margin and RM_1-RM_2. The relatively small size of the specimen and the spindly incisor development indicate it represents an immature individual. The deep reentrant on the lingual side of the anterior loop of RM_1 is unusual compared to the more normal condition seen in the fossil NMC 24704. The following specimens are right mandibles with RM_1-RM_2: NMC 25304 (Old Crow Locality 27W), NMC 18877 (Old Crow Locality 20), NMC 28817 (Old Crow Locality 20). NMC 22412 from Old Crow Locality 11A is a right mandible with a damaged RM_1 and complete RM_2. NMC 18648 from Old Crow Locality 27 is a right mandible with RM_1-RM_2 and the alveolus for RM_3. It is stained reddish brown. NMC 25086 is a right mandible with RM_1-RM_2. It was excavated from organic silts lying in a basin on the surface of the basal clay at Old Crow Locality 64, which I correlate with Unit 2 at Old Crow Locality 44. NMC 24413 from Old Crow Locality 11A has RM_1 and RM_3. Most of the diastema is present. NMC 15635 from Old Crow Locality 28 is a right mandible with long incisor and RM_1. NMC 19172 from Old Crow Locality 28 is a right mandible with long incisor and RM_1. NMC 19172 from Old Crow Locality 28 is a right mandible with RM_1, the alveolus for RM_2 and a damaged RM_3. NMC 18873 from Old Crow Locality 20 is a left mandible with LM_1 and the anterior half of LM_2. NMC 22070 from Old Crow Locality 27W is a small left mandible with LM_1-LM_2. It is stained black and the anterior loop of LM_1 is slightly damaged.

NMC 24704 from Old Crow Locality 11A is a right mandible with the incisor and RM_1. NMC 19253 is a right mandible with RM_1. It was excavated from Old Crow Locality 44 and may be of Sangamon interglacial age. NMC 22185 from Old Crow Locality 27W is a right mandible with RM_1. NMC 22067 from the same site is a right mandible with RM_1. NMC 24686 from Old Crow Locality 11A is a right mandible fragment with RM_1. NMC 25025 from Old Crow Locality 11A is a right mandible with RM_1. NMC 16169, a left mandible with LM_2, was excavated from organic silts overlying the basal clay at Old Crow Locality 45 which are probably correlative with Unit 2 at Old Crow Locality 44. NMC 22175 from Old Crow Locality 27W is a left mandible with the incisor and LM_1. The following specimens are left mandibles with LM_1: NMC 22091 (Old Crow Locality 27W), NMC 19174 (Old Crow Locality 28), NMC 28826 (Old Crow Locality 20), NMC 25019 (Old Crow Locality 11A). NMC 18572 from the sand bar at Old Crow Locality 29 is a left mandible with LM_1 and alveoli for LM_2-LM_3. NMC 25023 from Old Crow Locality 11A is a left mandible with LM_2 and part of the ascending ramus. NMC 22146, 22217 and 22287 from Old Crow Locality 27W are left mandibles with LM_1. Based on its very small size, the last represents a juvenile.

Discussion

Several mandibles excavated from organic deposits overlying the basal clay unit at Localities 44, 45 and 64 indicate that collared lemmings may have lived in the Old Crow Basin as early as the Sangamon interglacial. The cranium from Miller Creek is probably of late Wisconsin age. The only other specimens from Canada are from postglacial deposits on the northern coast of Ellesmere Island, Northwest Territories (Fielden and DeRance 1873; Harington 1971a).

In Alaska, *Dicrostonyx torquatus* seems to occur earlier than anywhere else, although the specific identification of material from interglacial (?Yarmouth) deposits laid down prior to the Illinoian glaciation in the Kotzebue Sound area should be checked (Péwé 1975a, p. 96). Fossils of this species are also known from Illinoian and Wisconsin deposits near Fairbanks (Guthrie 1968, p. 232), and from probable Illinoian sediments at Cape Deceit (Guthrie and Matthews 1971). Collared lemming fossils from Tofty are probably of Wisconsin age (Repenning *et al.* 1964, p. 196).

The relatively simple, generalized molar patterns of *Predicrostonyx hopkinsi* indicate that it is ancestral to *Dicrostonyx*. In addition, it has many incipient dental features that are emphasized in *Dicrostonyx* (Guthrie and

Matthews 1971, p. 488), and it is known from geological deposits that are sufficiently early (?Nebraskan) to allow evolution towards *Dicrostonyx*. *Dicrostonyx simplicior* appears to be the most primitive member of the genus. It lived during the cold phase of the Mindel (?Kansan) in central Czechoslovakia. The next stage, in which dental patterns are more complex, is the *D. henseli-hudsonius* phase. Lemmings in this group are known from Riss (Illinoian) or pre- Riss deposits near Cologne, Germany (Fejfar 1966), and from the beginning of the Dnepr (early Illinoian) at the Likhvin sections near Tula and Yaroslov in the Soviet Union (Agadzhanyan 1973, p. 333). The records from the Deering Formation at Cape Deceit, Alaska and from the Old Crow Basin, Yukon Territory have been mentioned previously: they are probably of Illinoian and pre- late Wisconsin age, respectively. It is most interesting to note the presence of two types of *Dicrostonyx*, one like *D. torquatus* (called *D. gulielmi*) and the other like *D. henseli* from Würm (Wisconsin) sediments in the Carpathian Basin. Although Janossy (1954) considers them to be extreme varieties of *D. torquatus*, I suggest that they mark the change from the *D. henseli-hudsonius* phase to the more advanced *D. torquatus* phase in this particular region. This change evidently occurred earlier in Beringia, as might be expected if the main evolution and radiation of the group took place there. What happened in western Beringia?

Two types of *Dicrostonyx* have been recorded from the Olyor Suite of ?Kansan age in the Kolyma Lowland (Sher 1971). *D. torquatus* did not become the dominant collared lemming in northeastern Siberia until the Illinoian (e.g. the Utka Beds of the Kolyma Lowland and the Aldan River second terrace deposits described by Sher (1971) and Vangengeim (1961) respectively). *D. torquatus* has also been recorded from Illinoian to Wisconsin age deposits on southern Bolshoi Lyakhov Island (Vangengeim 1961) and from the early Wisconsin Iedoma Suite of the Kolyma Lowland (Sher 1971).

The late Pleistocene zoogeography of *Dicrostonyx* in North America has been discussed at length by Guilday (1963, 1968). Apparently the Ungava lemming, *D. hudsonius*, is a survivor of a formerly widespread Palaearctic *D. henseli-hudsonius* form occurring in a rather isolated tundra zone in eastern North America. Presumably it arrived there during Illinoian time, but its earliest record is from late Wisconsin cave deposits in Pennsylvania. Probably the ice salient in the Great Lakes region during the last glaciation, and Hudson Bay itself during interglacial (Sangamon and present) times helped to maintain the isolation of this relatively primitive group. *D. torquatus* survived the late Wisconsin glaciation in refuges in the unglaciated Yukon-Alaska region and in northwestern United States, where it has been reported from Little Box Elder Cave in Wyoming.

In summary, the evolution of the collared lemming took place rather rapidly during the Pleistocene. The trend was from larger animals with relatively simple molar structure to smaller ones with complicated molar structure (Agadzhanyan 1973, p. 352). The most probable phyletic line is *Predicrostonyx hopkinsi* — *Dicrostonyx simplicior* — *D. henseli-hudsonius* — *D. torquatus*. The major dispersal centre of the group appears to have been Beringia.

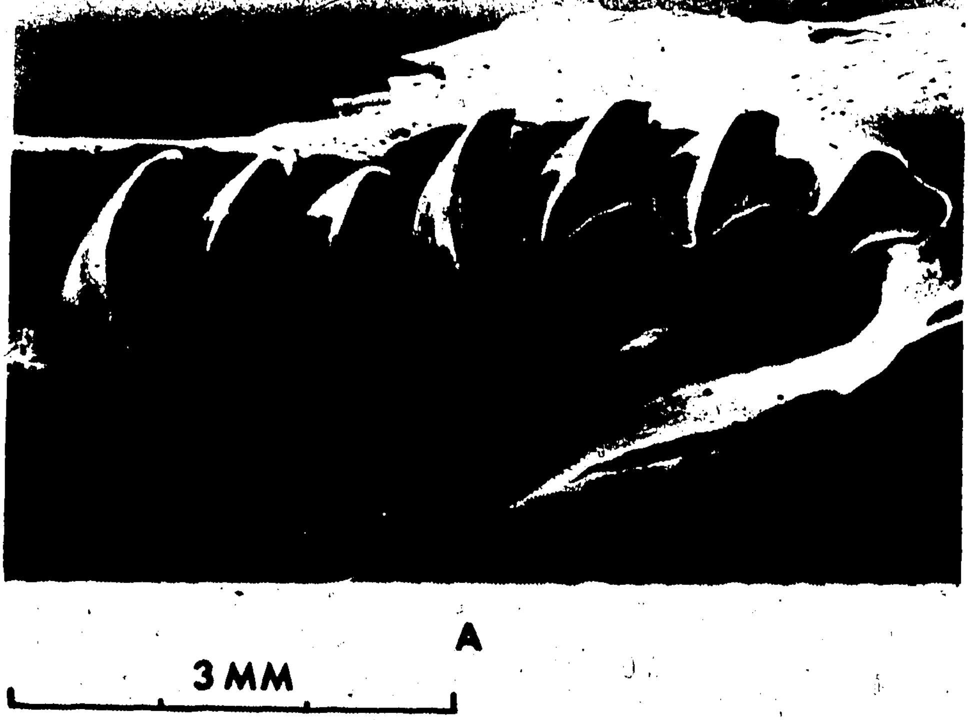
Collared lemming fossils are good indicators of tundra conditions in the past, for the species is presently confined to arctic and alpine tundra throughout the Holarctic region from the White Sea in the west to Greenland in the east. In the Yukon there is a northern population *D. t. kilangmiutak* and an isolated grayish form in the Ogilvie Mountains of the central Yukon (Youngman 1975, p. 115).

The collared lemming turns white in winter. Many morphological features including short tail and heavy fur enable it to survive in the relatively severe tundra environment. In winter the third and fourth digits of the foreclaws expa[illegible]rden to the point where they are well adapted to [illegible]g through wind-packed snow. Temperatures are [illegible]h warmer under the snow, where they spend most of their time. They are colonial, but perhaps less so than the brown lemmings. Their populations fluctuate dramatically with a periodicity varying between two and five years. In the summer, collared lemmings occupy shallow burrows below the tundra surface, which lead to resting and defecation areas and to nest chambers lined with dry grasses situated above the permafrost. Their winter nests are constructed on the surface of the tundra beneath snowbanks. Summer food consists of sedges, cottongrass, and grasses. In winter they eat willow buds, twigs and bark. Important predators are ermine, arctic fox, wolf, wolverine, owls, hawks, gulls and jaegers, all of which are known from the Pleistocene deposits of the Yukon Territory.

Lemmus sibiricus (brown lemming)

Fossils of brown lemmings (Figures 21A-B, 22A-C)

Figure 21. A. Occlusal view of RM_1-RM_2 in a right mandible (NMC 24899, Old Crow Locality 11A) of a Pleistocene brown lemming *(Lemmus sibiricus)*. SEM photograph. B. Occlusal view of LM_1-LM_3 in a left mandible (NMC 33757) of a Recent brown lemming *(Lemmus sibiricus)* from northern Canada.


A
3 MM

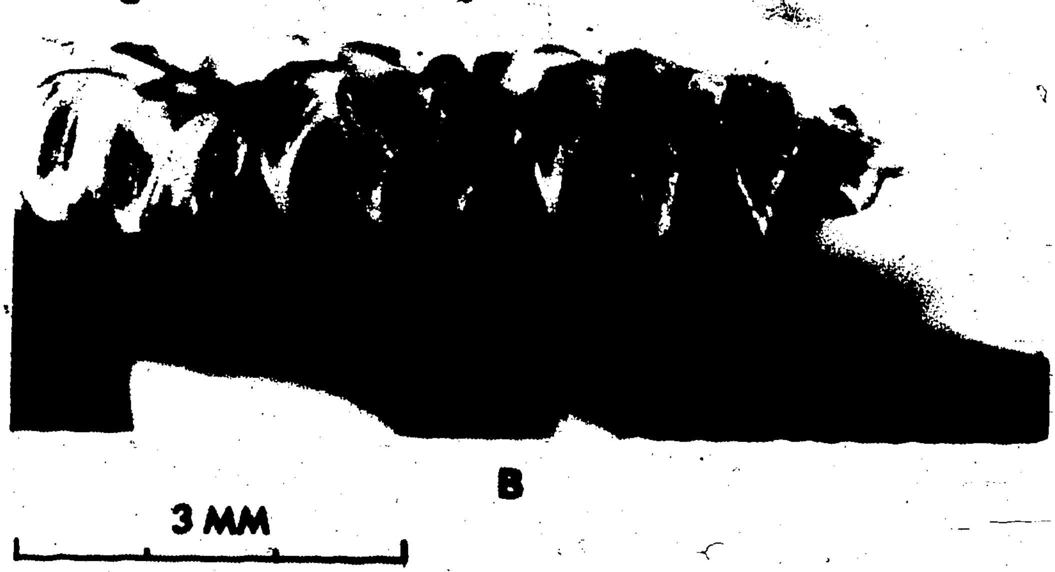
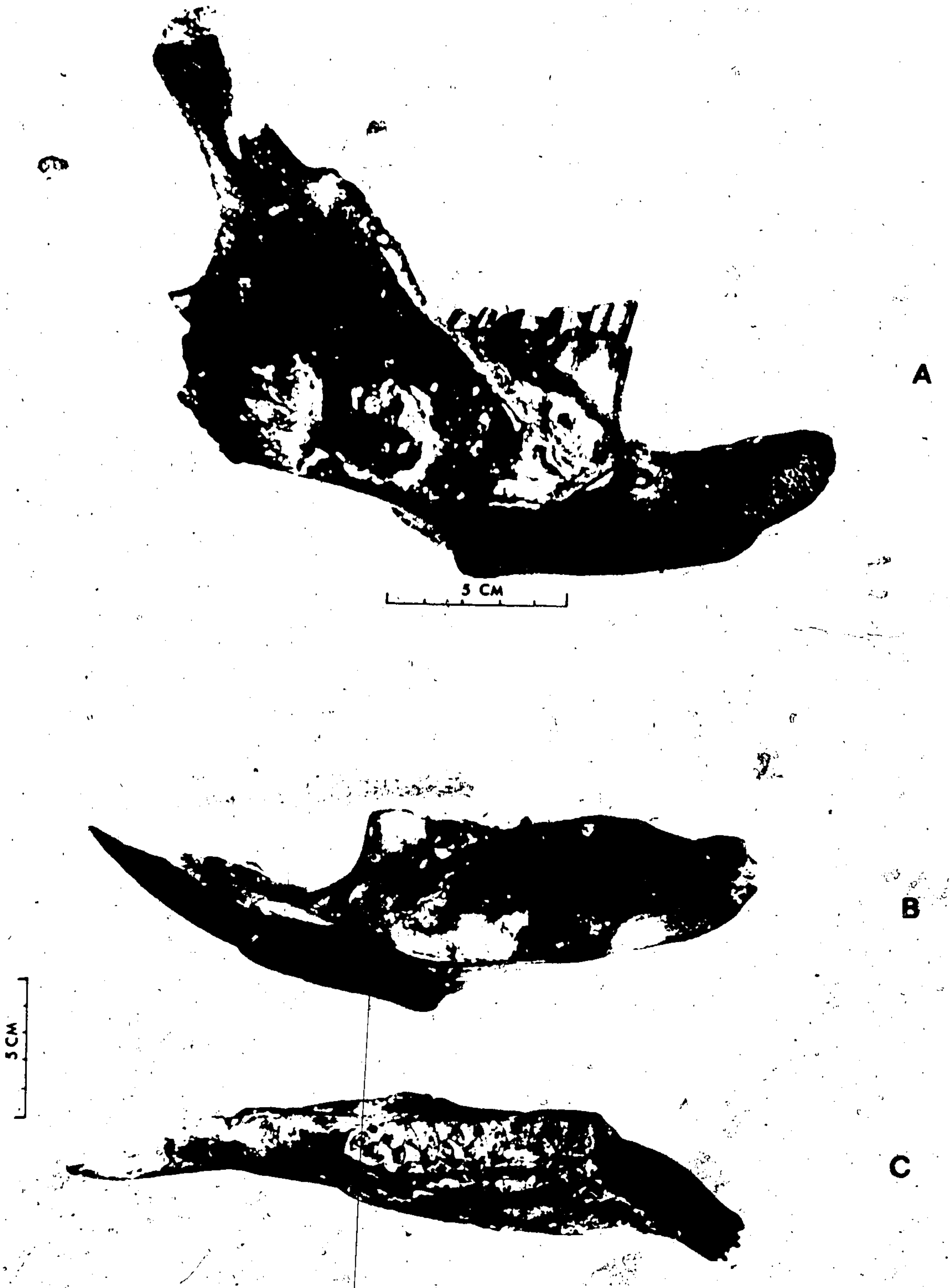

B
3 MM

Figure 22. A. Lateral view of a right mandibular fragment with RM_1-RM_2 (NMC 24597, Old Crow Locality 11A) of a Pleistocene brown lemming *(Lemmus sibiricus)*. B. Lateral view of left mandible with all teeth (NMC 28711, Old Crow Locality 27) of a Pleistocene brown lemming *(Lemmus sibiricus)*. C. Occlusal view of NMC 28711.


A
5 CM
B
5CM
C

are more commonly found than those of any other species of rodent in the Old Crow Pleistocene deposits, except muskrats. Apart from some postcranial material not described here, only mandibles have been recovered so far, and few have all teeth. No fossils have been found in the Dawson Area, but teeth have been screened from an organic sandy silt layer with freshwater mollusc shells (*Pisidium idahoense - Cytherissa lacustris* zone) at Porcupine Locality 100, which has been radiocarbon dated at 32,400 ± 770 years B.P. (McAllister and Harington 1969, p. 1188). Most of the specimens are stained dark brown to black. Dental patterns are similar to those of Recent brown lemmings from northern Canada, and all of the Old Crow fossils are referred to *Lemmus sibiricus*.

Referred specimens

NMC 28711 from Old Crow Locality 27 is a left mandible with the incisor and LM_1-LM_3. The following left mandibles have the incisor and LM_1-LM_2: NMC 28717 (Old Crow Locality 27), 28769 (Old Crow Locality 104), 28770 (Old Crow Locality 104), 22096 (Old Crow Locality 27W), 18641 (Old Crow Locality 27), 22087 (Old Crow Locality 27W), 19322 (Old Crow Locality 20), 18574 (Old Crow Locality 29), 18647 (Old Crow Locality 27), 18570 from the sand bar at Old Crow Locality 29; 28772 (Old Crow Locality 104), 19169 (Old Crow Locality 28). The following right mandibles have the incisor and RM_1-RM_2: NMC 19337 (Old Crow Locality 20), 24548 (Old Crow Locality 11A), 22172 (Old Crow Locality 27W), 22183 (Old Crow Locality 27W), 24409 (Old Crow Locality 11A), 2489 [illegible] Crow Locality 11A) and 25007 (Old Crow Locality 11A). The following right mandibular fragments have RM_1-RM_2: NMC 24597 (Old Crow Locality 11A), 15839, which was excavated from the fossiliferous zone at Old Crow Locality 44 which may be of Sangamon interglacial age, 18638 (Old Crow Locality 27), 25272 (Old Crow Locality 27W), 25011 (Old Crow Locality 11A), 15634 (Old Crow Locality 28), 25033 (Old Crow Locality 11A), 18899 (Old Crow Locality 20), 18838 (Old Crow Locality 20), 19176 (Old Crow Locality 28), 18417 (Old Crow Locality 11A), and 24544 (Old Crow Locality 11A) which is stained reddish brown. The following left mandibles have LM_1-LM_2: NMC 28774 (Old Crow Locality 104) has heavily worn teeth; 22202 (Old Crow Locality 27W), 15640 (Old Crow Locality 28), 18562 (Old Crow Locality 29), 22100 (Old Crow Locality 27W), 28828 (Old Crow Locality 20).

The following right mandibles have RM_1: NMC 18583 (Old Crow Locality 29), 24676 (Old Crow Locality 22), 19315 (Old Crow Locality 20), 25301 (Old Crow Locality 27W), 18569 (Old Crow Locality 29), 22216 (Old Crow Locality 27W), 25090 (Old Crow Locality 64), which was excavated from an organic layer overlying the basal clay unit that I correlate with the fossiliferous zone at Old Crow Locality 44, therefore it may be of Sangamon age; 22188 (Old Crow Locality 27W), 18644 (Old Crow Locality 27), 18806 (Old Crow Locality 20), 19335 (Old Crow Locality 20), 18585 (Old Crow Locality 29), 22210 (Old Crow Locality 27W), 25485 (Old Crow Locality 44), which may be of Sangamon interglacial age; 28727 (Old Crow Locality 27). The following left mandibles have the incisor and LM_1: NMC 28776 (Old Crow Locality 104), 22195 (Old Crow Locality 27W), 22076 (Old Crow Locality 27W) which is missing the posterior loop on LM_1; 25494 (Old Crow Locality 44, which is possibly of Sangamon age; 25098 (Old Crow Locality 64), which was excavated from organic sediments overlying the basal clay and, like NMC 25090, may be of Sangamon age; 24814 (Old Crow Locality 20), 25013 (Old Crow Locality 11A), 25089 (Old Crow Locality 64), which was excavated from silt overlying the basal clay and may be of Sangamon age; 25274 (Old Crow Locality 27W). The following left mandibles have LM_1: NMC 19219 (Old Crow Locality 22), 25273 (Old Crow Locality 27W), 25280 (Old Crow Locality 27W), 18584 (Old Crow Locality 29), 22115 (Old Crow Locality 27W), 28833 (Old Crow Locality 20), 22199 (Old Crow Locality 27W), 24815 (Old Crow Locality 20), 19173 (Old Crow Locality 28), 18901 (Old Crow Locality 20), 19164 (Old Crow Locality 28). NMC 28771 from Old Crow Locality 104 is a left mandible with the incisor and LM_2. NMC 24563 from Old Crow Locality 11A is a left mandible with a damaged LM_2. The following right mandibles have RM_2: NMC 18583 (Old Crow Locality 29), 24676 (Old Crow Locality 22), 28710 (Old Crow Locality 27), 15064 (Old Crow Locality 69), 22134 (Old Crow Locality 27W), 18579 (Old Crow Locality 29), 28715 (Old Crow Locality 27), 18576 (Old Crow Locality 29), 18894 (Old Crow Locality 20), which has a mottled surface; 18641A (Old Crow Locality 27).

Discussion

Mandibles of the brown lemming found *in situ* in organic sediments overlying the basal clay at Old Crow Localities 44 and 64 indicate that *Lemmus sibiricus* may have lived in the Old Crow Basin as early as the Sangamon interglacial. Teeth from mid- Wisconsin organic deposits at Porcupine Locality 100 suggest that brown lemmings lived in wet meadow habitat, with some spruce trees in the vicinity, near the margin of a cool, shallow lake (McAllister and Harington 1969, p. 1189). This species has not been recorded from Pleistocene deposits in other parts of Canada.

The earliest record from Alaska is of *Lemmus* cf. *sibiricus* from the Cape Deceit Formation (?Nebraskan) near Kotzebue Sound (Guthrie and Matthews 1971, p. 492). Teeth have also been screened from organic matrix in deposits considered to be of Illinoian and Wisconsin age near Fairbanks (Guthrie 1969, p. 232; Péwé 1975, p. 96). Although few brown lemming fossils were collected by Guthrie (1968, p. 231), he notes that more occurred in the middle of zones thought to have been deposited during a full glacial stage. In this regard, the only indications of the presence of brown lemmings in the Old Crow Area are during the ?Sangamon interglacial and mid- Wisconsin interstadial, so possibly they were most abundant during the warmer, wetter phases of the Pleistocene.

I concur with Rausch (1953) and Rausch and Rausch (1975, p. 25) that the Nearctic brown lemming is conspecific with the Ob lemming of Siberia *("Lemmus obensis")*, in which case *Lemmus* cf. *sibiricus* is first recorded in abundance from the northeastern Siberian Olyor deposits of ?Kansan age (Sher 1971, p. 93). *Lemmus sibiricus* is also known from the second terrace deposits on the Aldan River, which seem to be of Illinoian age (Vangengeim 1961); from the Utka Beds of late Illinoian age in the Kolyma Lowland (Sher 1971); from late Pleistocene deposits (Illinoian to Wisconsin?) near the southern tip of Bolshoi Lyakhov Island in the New Siberian Islands (Vangengeim 1961); and from the early Wisconsin Iedoma Suite in the Kolyma Lowland (Sher 1971). Thus, brown lemmings seem to have occupied various parts of northeastern Siberia from at least ?Kansan time to the present.

Another closely related species, the Scandinavian lemming *(Lemmus lemmus)* (Rausch and Rausch 1975, p. 25), a fairly large animal found mostly in alpine birch woods and the zone just above the treeline, occurred in Europe as early as the late Günz (late ?Nebraskan) glaciation (Kurtén 1968, p. 220). As the Cape Deceit record of *Lemmus* may predate this one, perhaps the genus evolved in and radiated from Beringia about the time of the first Quaternary continental glaciation of major proportions in the Northern Hemisphere. The ancestry of *Lemmus* is poorly known, although probably it was derived from the same stock that gave rise to the smaller wood lemming of Eurasia *Myopus schisticolor*. A remarkable fact about the brown lemming is the lack of change in its dental patterns throughout the Pleistocene. Presumably its initial adaptations were quite successful, and it could be argued on this basis that its habits and habitat have changed little since the early Pleistocene.

Brown lemmings prefer moist tundra with abundant grasses and sedges, so their fossils are good indicators of those conditions. The fossils usually indicate proximity to tundra, but the animals themselves are not presently restricted to that type of environment. Brown lemmings occur along the northern coasts from the White Sea to

Baffin Island - a similar distribution to the collared lemming *Dicrostonyx torquatus*, except that the former do not occupy the northern Canadian Arctic Islands, or Greenland, and they extend southward from the Yukon into northern British Columbia. Brown lemmings are found now throughout most of the Yukon Territory except its extreme southwest corner (Youngman 1975, p. 107). The northern Yukon subspecies *Lemmus sibiricus trimucronatus* probably survived the Wisconsin glaciation in the Beringian refugium, while *L. s. helvolus* may have differentiated in a more southerly refugium (Macpherson 1965, p. 169). Rausch and Rausch (1975, p. 27) object to the latter view, stating that the group was derived from the north in postglacial time, but have not provided a good reason for their conclusion.

Brown lemmings have specialized lateral foreclaws for digging. Their coats are chestnut brown on the lower back and buffy gray on the head, shoulders and belly. Their winter coats are longer and grayer. These lemmings are colonial and are active all winter under the snow. Spring and autumn are critical periods for their survival: melting snow in spring exposes their nests and tunnels, and autumn blizzards may catch them before protective snow cover accumulates. Like collared lemmings, they fluctuate in numbers with a periodicity of 2 to 10 years. They feed mainly on grass shoots and the bases of grass and sedge leaves. They occasionally eat bark and twigs of willows and dwarf birch in winter. Brown lemmings cut hay for winter use, but do not make food caches. They have the same predators as collared lemmings (Banfield 1974, pp. 185-187).

Clethrionomys cf. *rutilus* (northern red-backed vole)

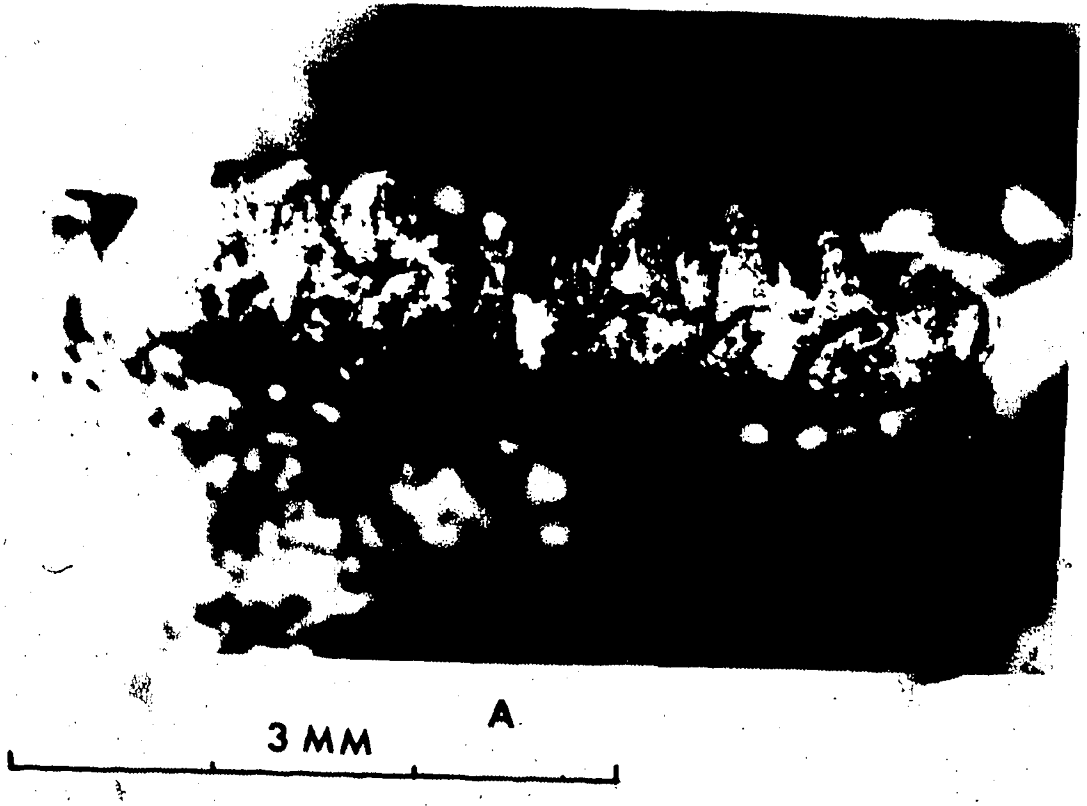
Fossils of this species are rarely found Pleistocene deposits of the Old Crow Basin. Only six mandibles (Figure 23A-B) have been recovered. None has been found near Dawson. These specimens have dental patterns like Recent northern red-backed voles and are referred to *Clethrionomys* cf. *rutilus* because of their northerly geographic position and because that species occupies the same area during the present interglacial. However, it should be noted that no method is presently available for separating *C. rutilus* from the more southerly *C. gapperi* on the basis of skeletal remains alone. Therefore, comments on the dispersal history of red-backed voles are highly speculative.

<u>Referred specimens</u>

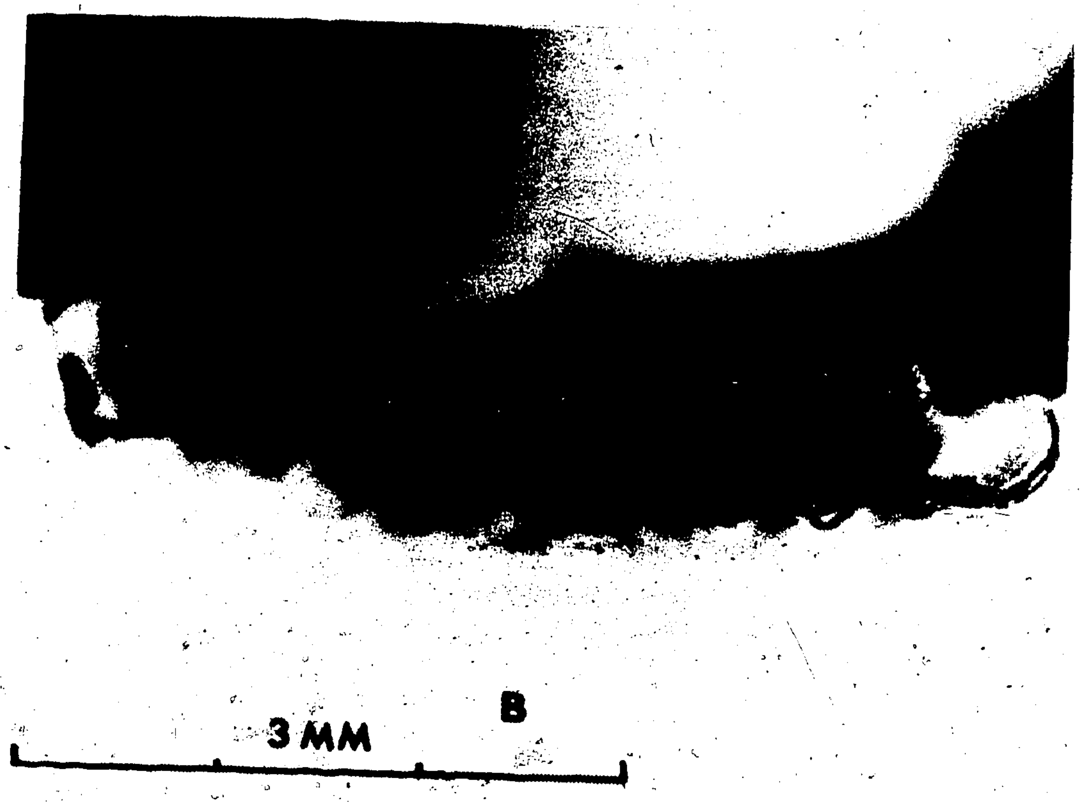
NMC 19323 from Old Crow Locality 20 is a right mandible with the incisor and RM_1-RM_2. It is stained brown

Figure 23. A. Occlusal view of RM_1-RM_2 in a right mandible (NMC 19323, Old Crow Locality 20) of a Pleistocene northern red-backed vole *(Clethrionomys* cf. *rutilus)*.

B. Occlusal view of RM_1-RM_3 in a right mandible (NMC 34917) of a Recent northern red-backed vole *(Clethrionomys rutilus)* from northern Canada.



A



B

and is mottled with yellowish specks. Much of the ascending ramus is preserved. NMC 25496 is a right mandible with RM_1-RM_2. Only the bone surrounding the teeth is preserved. It was excavated from the fossiliferous zone overlying the basal clay at Old Crow Locality 44 and may be of Sangamon interglacial age. NMC 25092 is a badly fragmented left mandible with the incisor and LM_1. It was excavated from sediments overlying the basal clay in a [illegible] bluff section at Old Crow Locality 64, and may be of Sangamon age also. NMC 25497, a left mandible with LM_1, was excavated at Old Crow Locality 44, NMC 25300 from Old Crow Locality 27W is a right mandible with RM_1. NMC 28841 from Old Crow Locality 20 is a left mandible with LM_1.

Discussion

Of the six specimens described, three were derived from deposits of ?Sangamon age, and possibly the others were reworked from those deposits, suggesting that red-backed voles were most common in the Old Crow Basin during late Pleistocene interglacials. But various difficulties arise in presenting ideas of this nature, an important one being that, during glacial maxima, evidently large lakes occurred in the central parts of the basin where most fossil localities are exposed, and the possibility exists that red-backed voles were common on the basin margins at those times. The northern red-backed vole has not been reported previously from Pleistocene deposits in Canada.

The only other report of the [illegible]-backed vole from sedimentary deposits in Eastern Beringia is of *Clethrionomys* sp. from the Tofty fauna, Alaska (Repenning *et al.* 1964). It is difficult to interpret this fauna in paleoenvironmental terms. Fossils from units A and B at Tofty represent a mixture of forest (as indicated by the presence of rooted spruce stumps, beaver-gnawed wood and remains of the red-backed vole) and steppe-tundra forms (the remainder of the fauna). Presumably the steppe-tundra mammals were concentrated from Wisconsin age sediments of unit C, while the moist forest element lived in spruce woodland that existed in the area during postglacial time. If this conjecture is correct, then the red-backed vole remains would be of postglacial age.

An early record of this genus from North America is *Clethrionomys* cf. *gapperi* from deposits of probable Illinoian age at Cumberland Cave, Maryland, where it is part of a relatively minor "northern" faunal component (Guilday 1971, p. 236). Guilday (1971, p. 249) observes that *C. gapperi* and other woodland species increase greatly at the expense of grassland species from bottom to top of stratified sediments in the sinkhole at New Paris No. 4, Pennsylvania. This deposit probably ranges in age from late Wisconsin to postglacial. *C. gapperi* has also been reported from Wisconsin deposits at Frankstown Cave, Pennsylvania (Hibbard 1958, p. 17), from Robinson Cave, Tennessee and from two other late Pleistocene cave deposits in the Midwest, Mayer Cave, Illinois and Crankshaft Pit, Missouri (Guilday *et al.* 1969, p. 54).

The relationship between *C. rutilus* and *C. gapperi* is not very clear. Rausch and Rausch (1975, p. 169) state that cytogenetic and zoogeographical evidence, including the affinities of the respective species of fleas of *C. rutilus* and *C. gapperi*, are indicative of diverse distributional histories, implying that the latter species survived in the southern refugium and the former occupied the Beringian refugium - the latter spreading northward to meet the former as the Wisconsin ice retreated. Youngman (1975, p. 85) considers *C. rutilus* to be conspecific with *C. gapperi*, but produces no evidence to support his contention.

Clethrionomys is known from early middle Pleistocene (?Kansan) deposits of China (Kurtén 1968, p. 213). In northeastern Siberia fossils of *Clethrionomys* sp. have been collected from the Olyor Suite of ?Kansan age (Sher 1971), while *C. rutilus* has been reported from Illinoian deposits on the second terrace of the Aldan River (Vangengeim 1961).

In Europe, Astian and Villafranchian fossils of this kind have been tentatively referred to the Eurasian bank vole *(Clethrionomys glareolus)*. This medium-sized vole, which prefers open woodlands, is also known from the early middle Pleistocene of Europe. During the late Pleistocene it occurred in many places from England to Poland and the Soviet Union. The species now ranges throughout Europe (excluding Ireland), northernmost Scandinavia, the Mediterranean peninsulas and eastward to Lake Baikal in Asia. Rausch and Rausch (1975, p. 169) state: ..."the relationship between *C.* [illegible] and *C. glareolus* would seem to be no closer [illegible] that between other species-pairs, such as *C. gapperi* and *C. rutilus*, of which the members also fall into different karyotypic groups."

In summary, *Clethrionomys* seems to have originated in Europe in late Pliocene (Astian) time. The bank vole *C. glareolus* occupied parts of Eurasia throughout the Pleistocene and still lives there. It may have given rise to the North American red-backed voles, including *C. rutilus*, about Illinoian time. Perhaps the northern red-backed vole diverged from its ancestral stock in Beringia. Although the earliest known occurrence of *C. rutilus* in the Nearctic is in ?Sangamon time, obviously *Clethrionomys* had reached North

America during or prior to the early part of the Illinoian glaciation, for remains identified as *Clethrionomys* cf. *gapperi* have been reported from Cumberland Cave, Maryland.

The northern red-backed vole is a relatively small, slender and brightly colored Holarctic species that is distributed from northern Scandinavia through northern Asia, most of Alaska and the northern Canadian mainland to Hudson Bay. It is active all winter and constructs tunnels under the snow. Winter nests are built on the ground surface, while summer nests are in short underground burrows or beneath rocks or large roots. Although the species has been collected at elevations up to 6,000 feet (1830 m) above sea level in habitats varying from dry arctic tundra to floating bogs, it is most common in willow, alder and dwarf birch, or in overgrown talus (Youngman 1975, p. 86). Presumably the fossils from the Old Crow Basin indicate the presence of northern shrub habitat there during the ?Sangamon interglacial. This vole eats leaves, buds, twigs and fruits of shrubs such as those mentioned previously. Corbet (1966) notes that *Clethrionomys* tends to eat more fruit and seeds than other microtines.

Ondatra zibethicus (muskrat)

Hundreds of muskrat fossils have been recovered from Pleistocene deposits in the Old Crow Basin. Except for most of a cranium, only a series of mandibles (Figures 24A-C, 25A-C, Tables 23-24) that contain at least the diagnostic M_1 will be described. Most of these fossils are stained dark brown, but a few are a lighter reddish brown.

In 1966 Semken reported that measurements of fossil muskrat teeth showed an increase in size and an increase in dentine tract height as geological time progressed. These data were reassessed by Nelson and Semken (1970) using more material (particularly Recent specimens) and the results correlated well with those previously obtained by Semken. They (Nelson and Semken 1970, p. 3733) also found that living southern forms have a significantly lower M_1 length to width ratio than living northern forms and suggested that the difference noted in living populations may be applicable to fossil populations, indicating that specimens regarded as of interglacial age would have lower ratios than those considered to be of glacial age. Martin and Tedesco (1974 MS, p.8) generally support the conclusions of Nelson and Semken, but emphasize that

Figure 24. A. Dorsal view of a partial cranium (NMC 28781, Old Crow Locality 101) of a Pleistocene muskrat *(Ondatra zibethicus)*. B. Occlusal view of a right mandible (NMC 29403, Old Crow Locality 14N) of a Pleistocene muskrat *(Ondatra zibethicus)*. C. Occlusal view of a complete left mandible (NMC 28689, Old Crow Locality 27) of a Pleistocene muskrat *(Ondatra zibethicus)*.


28781
A
3 CM
B
C

Figure 25. Compare with Figure 24.

A. Ventral view of NMC 28781.

B. Lateral view of NMC 29463.

C. Lateral view of NMC 28689.

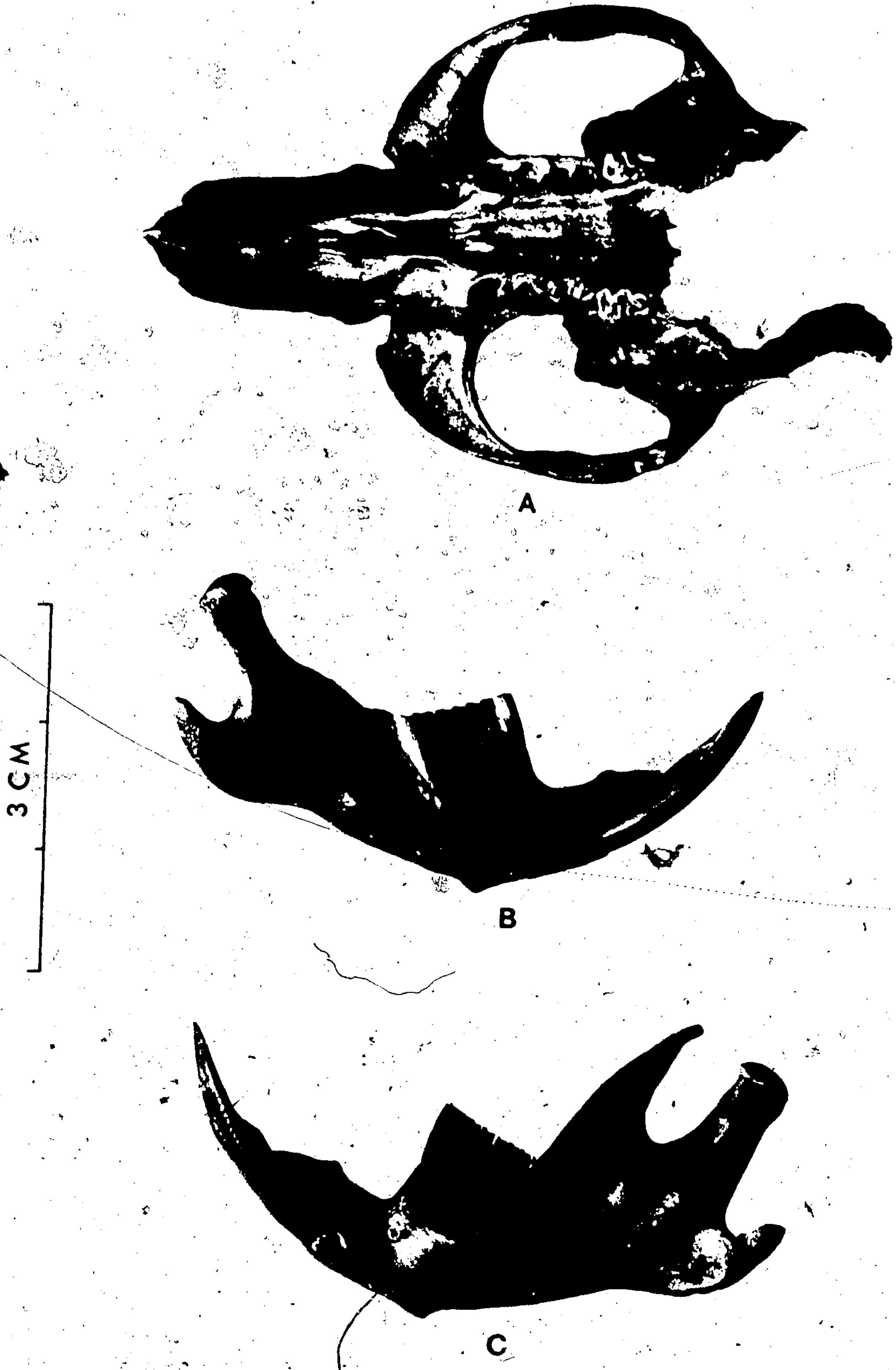

A
3 CM
B
C

Table 23. Measurements of a Pleistocene muskrat (*Ondatra zibethicus*) cranium from the Yukon Territory compared to those of Recent muskrats from the Yukon Territory.

SPECIMENS	SEX	MEASUREMENTS (mm)*			
		1	2	3	4
Ondatra zibethicus. Pleistocene, Y.T.					
NMC 28781 Old Crow Loc. 101	–	38.3	13.2	6.3	14.2
Ondatra zibethicus. Recent, Old Crow, Y.T. (Youngman 1975, p. 105)					
M	4♂ 2♀	37.6	12.9	5.9	14.3
OR		37.2 - 38.7	12.6 - 13.1	5.5 - 6.2	13.4 - 14.1
N		6	6	6	6
SD		0.43	0.19	0.29	0.53
SE		0.22	0.07	0.12	0.22
Ondatra zibethicus. Recent. Southern Yukon (Youngman 1975, p. 105)					
M	14♂ 3♀	39.5	13.6	5.9	15.1
OR		38.3 - 40.9	12.5 - 14.7	4.4 - 6.5	14.4 - 15.8
N		17	17	17	17
SD		1.28	0.65	0.47	0.43
SE		0.31	0.16	0.11	0.10

* 1. Zygomatic breadth. 2. Rostral breadth. 3. Least interorbital width. 4. Alveolar length of maxillary tooth row.

Table 24. Measurements of Pleistocene muskrat (*Ondatra zibethicus*) mandibles from the Yukon Territory compared to those of Recent muskrats from the Yukon Territory.

SPECIMENS	SEX	MEASUREMENTS (mm)*				
		1	2	3	4	5
Ondatra zibethicus, Pleistocene, Old Crow, Y.T.						
NMC 15319 Loc. 22	-	6.3	2.6	12.9	11.7	7.5
NMC 16873 Loc. 14N	-	6.6	2.6	[illegible]	10.9	8.9
NMC 29403 Loc. 14N	-	6.9	2.7	14.0	11.3	9.4
NMC 27233 Loc. 29	-	7.1	2.8	14.6	10.2	8.5
NMC 18634 Loc. 27	-	6.6	2.5	13.4	10.6	8.6
NMC 19198 Loc. 22	-	6.7	2.8	13.9	11.6	8.5
NMC 24614 Loc. 22	-	6.7	2.8	13.9	10.5	8.9
NMC 24365 Loc. 11A	-	6.5	2.7	13.5	-	-
NMC 25054 Loc. 22	-	6.2	2.4	12.1	-	-
NMC 24648 Loc. 67	-	6.3	2.5	13.6	-	8.8
NMC 28797 Loc. 20	-	6.0	2.7	13.0	-	-
NMC 28624 Loc. 65	-	6.7	2.8	13.7	-	10.7
NMC 24666 Loc. 22	-	6.4	2.6	13.6	-	9.2
NMC 16879 Loc. 14N	-	6.2	2.6	13.0	-	8.5
NMC 24367 Loc. 11A	-	6.2	2.5	13.2	-	8.4
NMC 25052 Loc. 22	-	6.9	2.5	13.6	-	-
NMC 28703 Loc. 27	-	6.4	2.6	13.5	-	-
NMC 15712 Loc. 28	-	5.9	2.3	12.6	-	8.4
NMC 18508 Loc. 29	-	6.8	2.8	-	13.2	9.3
NMC 15824 Loc. 44	-	6.1	2.6	-	-	-
NMC 15822 Loc. 44	-	6.6	2.6	-	-	5.6
NMC 15821 Loc. 44	-	6.5	2.5	-	10.7	[illegible]
NMC 24357 Loc. 11A	-	6.7	2.7	-	12.9	9.9
NMC 24359 Loc. 11A	-	6.7	2.8	-	9.8	8.5
NMC 15818 Loc. 44	-	6.6	2.6	-	-	7.9
NMC 15817 Loc. 44	-	6.1	2.5	-	9.6	-
NMC 28669 Loc. 27	-	6.1	2.4	-	-	7.9
NMC 26996 Loc. 28	-	6.2	2.5	-	11.0	-
NMC 26668 Loc. 15	-	6.3	2.6	-	-	7.2
NMC 28860 Loc. 66	-	6.9	2.8	-	-	9.3
NMC 24452 Loc. 11A	-	6.6	2.4	-	-	-
NMC 15710 Loc. 28	-	6.5	2.6	-	-	-
NMC 18739 Loc. 20	-	6.3	2.4	-	-	-
NMC 27043 Loc. 32E	-	6.9	2.7	-	-	-
NMC 22263 Loc. 27W	-	6.2	2.5	-	10.9	-
NMC 14903 Loc. 31	-	6.3	2.5	-	-	7.9
NMC 19242 Loc. 44	-	6.4	2.6	-	-	-
NMC 28701 Loc. 27	-	6.7	2.4	-	-	-
NMC 28689 Loc. 27	-	6.9	2.8	14.1	12.1	9.7
NMC 22251 Loc. 27W	-	6.7	2.7	-	-	9.4
NMC 15820 Loc. 44	-	6.8	2.7	-	-	9.1
NMC 15249 Loc. 22	-	7.1	3.0	-	-	9.8
NMC 24807 Loc. 20	-	7.0	2.8	-	-	9.0
NMC 22051 Loc. 27	-	6.4	2.6	-	-	8.8
NMC 19197 Loc. [illegible]	-	7.1	2.8	-	-	9.7
NMC 24859 Loc. 11A	-	6.6	2.5	-	-	9.4
NMC 15567 Loc. 20	-	6.1	2.4	-	-	-
NMC 25312 Loc. 27W	-	6.6	2.6	-	-	-
NMC 22260 Loc. 27W	-	6.7	2.6	-	-	-
NMC 25051 Loc. 22	-	6.2	2.4	-	-	7.9
NMC 28636 Loc. 65	-	6.6	2.6	-	-	-
NMC 15827 Loc. 44	-	6.0	2.4	-	-	-
NMC 19195 Loc. 28	-	6.4	2.3	-	-	-
NMC 22045 Loc. 27W	-	6.9	2.9	-	-	-
NMC 15636 Loc. 28	-	6.1	2.3	-	-	-
NMC 22050 Loc. 27W	-	6.4	2.5	-	8.5	-
NMC 28600 Loc. 103	-	6.4	2.7	-	-	-
NMC 25050 Loc. 22	-	6.3	2.7	-	-	-
NMC 15828 Loc. 44	-	6.1	2.6	-	-	-
NMC 15823 Loc. 44	-	6.2	2.4	-	-	-
NMC 22164 Loc. 27W	-	6.8	2.5	-	-	-

NMC 28703	Loc. 27	-	6.4	2.6	13.5	-	-
NMC 15712	Loc. 28	-	5.9	2.3	12.6	-	8.4
NMC 18508	Loc. 29	-	6.8	2.8	-	13.2	9.3
NMC 15824	Loc. 44	-	6.1	2.6		-	-
NMC 15822	Loc. 44	-	6.6	2.6		-	5.6
NMC 15821	Loc. 44	-	6.5	2.5		10.7	7.4
NMC 24357	Loc. 11A	-	6.7	2.7	-	12.9	9.9
NMC 24359	Loc. 11A	-	6.7	2.8		9.8	8.5
NMC 15818	Loc. 44	-	6.6	2.6	-	-	7.9
NMC 15817	Loc. 44	-	6.1	2.5	-	9.6	-
NMC 28669	Loc. 27	-	6.1	2.4	-	-	7.9
NMC 26996	Loc. 28	-	6.2	2.5	-	11.0	-
NMC 26668	Loc. 15	-	6.3	2.6	-	-	7.2
NMC 28860	Loc. 66	-	6.9	2.8	-	-	9.3
NMC 24452	Loc. 11A	-	6.6	2.4	-	-	-
NMC 15710	Loc. 28	-	6.5	2.6	-	-	-
NMC 18739	Loc. 20	-	6.3	2.4	-	-	-
NMC 27043	Loc. 32E	-	6.9	2.7	-	-	-
NMC 22263	Loc. 27W	-	6.2	2.5	-	10.9	-
NMC 14903	Loc. 31	-	6.3	2.5	-	-	7.9
NMC 19242	Loc. 44	-	6.4	2.6	-	-	-
NMC 28701	Loc. 27	-	6.7	2.4	-	-	-
NMC 28689	Loc. 27	-	6.9	2.8	14.1	12.1	9.7
NMC 22251	Loc. 27W	-	6.7	2.7	-	-	9.4
NMC 15820	Loc. 44	-	6.8	2.7	-	-	9.1
NMC 15249	Loc. 22	-	7.1	3.0	-	-	9.8
NMC 24807	Loc. 20	-	7.0	2.8	-	-	9.0
NMC 22051	Loc. 27	-	6.4	2.6	-	-	8.8
NMC 19197	Loc. 22	-	7.1	2.8	-	-	9.7
NMC 24859	Loc. 11A	-	6.6	2.5	-	-	9.4
NMC 15567	Loc. 20	-	6.1	2.4	-	-	-
NMC 25312	Loc. 27W	-	6.6	2.6	-	-	-
NMC 22260	Loc. 27W	-	6.4	2.6	-	-	-
NMC 25051	Loc. 22	-	6.2	2.4	-	-	7.9
NMC 28636	Loc. 65	-	6.6	2.6	-	-	-
NMC 15827	Loc. 44	-	6.0	2.4	-	-	-
NMC 19195	Loc. 28	-	6.4	2.3	-	-	-
NMC 22045	Loc. 27W	-	6.9	2.9	-	-	-
NMC 15636	Loc. 28	-	6.1	2.3	-	-	-
NMC 22050	Loc. 27W	-	6.4	2.5	-	8.5	-
NMC 28600	Loc. 103	-	6.4	2.7	-	-	-
NMC 25050	Loc. 22	-	6.3	2.7	-	-	-
NMC 15828	Loc. 44	-	6.1	2.6	-	-	-
NMC 15823	Loc. 44	-	6.2	2.4	-	-	-
NMC 22164	Loc. 27W	-	6.8	2.5	-	-	-
NMC 22261	Loc. 27W	-	6.1	2.5	-	-	-
NMC 20750	Loc. 20	-	6.3	2.8	-	-	-
Ondatra zibethicus. Recent, Y.T.							
NMC 2229		♀	6.6	2.6	14.2	10.5	8.8
NMC 2226		♂	7.3	3.1	14.0	12.5	10.2
NMC 2228		♂	6.7	2.6	14.7	11.4	9.3
NMC 2225		♂	6.6	2.7	13.6	11.3	10.1
NMC 2230		♀	7.2	3.0	13.8	13.3	10.8
NMC 2227		♂	6.7	2.9	14.1	11.2	8.7
NMC 29897		♀	6.7	2.9	14.0	11.4	9.1
NMC 20898		♂	7.1	2.9	14.2	11.8	9.0
NMC 29899		♂	7.0	2.9	14.1	12.2	9.5
NMC 29900		♀	6.6	2.6	13.8	11.5	9.2
NMC 31501		♀	7.0	2.7	14.5	11.8	9.0
NMC 31502		♂	7.4	2.9	14.0	13.3	9.3

---

* 1. M_1 length. 2. M_1 width. 3. Alveolar length M_1-M_3. 4. Diastema length anterior alveolar margin of M_1 to posterior alveolar margin of I_1. 5. Mandible depth below centre of M_1 (lingual side).

specimens must be of Sangamon (possibly Illinoian?) age or younger, which makes the ability to distinguish glacial and interglacial fossils of limited value.

A preliminary study of a smaller sample than that provided here of Pleistocene muskrat mandibles from the Old Crow Basin was undertaken by Marla L. Weston (1975 MS). Her evidence tended to support the hypothesis that the ratio of increase of tooth width relative to length decreases with time. She also notes that: (a) where western Canadian Recent muskrats are concerned, statistical analysis of M_1 length/width ratios with respect to latitude only provides significant results if means rather than individual values are used;[1] (b) living southern forms show significantly larger alveolar length and mandible depth means than northern ones, indicating that there is a trend toward increasing size from north to south (Youngman 1975, p. 106 also mentions the possibility of a north - south cline existing in the Yukon); (c) Semken's (1966) proposal that lingual dentine tract height on M_1 increases with time is not acceptable on the basis of the data she (Weston) sampled (therefore it is not measured here); (d) generally, muskrat fossils are useful in solving biostratigraphic problems only if large numbers are available so that means can be compared. In the last respect, the Old Crow sample seems adequate, but relatively few specimens were found *in situ*. Also the effect on the sample of possible north - south clines operating in the past is difficult to estimate. But, as little geochronological control is available for the Old Crow fossils, their M_1 dimensions were plotted on Nelson and Semken's chronocline in the hope of obtaining a very approximate indication of their geological age.

Except for their generally smaller size, the Old Crow Pleistocene bones are very similar to those of Recent muskrats, and until the opportunity arises to carry out detailed comparisons with *Ondatra nebracensis*, which has been recorded from the early Illinoian of Kansas (Hibbard 1970, p. 423), they are referred to *Ondatra zibethicus*.

Referred specimens

NMC 28781 from Old Crow Locality 101 is a cranium lacking the posterior part, the nasals and all teeth except M^3s. It is stained dark reddish brown. The following right mandibles have all teeth: NMC 15319 (Old Crow Locality 22), 16873 and 29403 (Old Crow Locality 14N), 27233 (Old Crow Locality 29), 18634 (Old Crow Locality 27). The following left mandibles have all teeth: NMC 28689 (Locality 27), 19198 (Old Crow Locality 22), which has unusually whitish teeth relative to the brown staining of the mandibular bone, 24614 (Old Crow Locality 22), 24648 (Old Crow

Locality 67), 18797 (Old Crow Locality 20), which is mottled with yellowish specks. The following right mandibles have RM_1-RM_3: NMC 28624 (Old Crow Locality 65), 24666 (Old Crow Locality 22), 16979 (Old Crow Locality 14N), 15824, 15822 and 15821, which were excavated from the fossiliferous zone overlying the basal clay unit at Old Crow Locality 44 and may be of Sangamon interglacial age, 24357 (Old Crow Locality 11A), which has ivory colored teeth while the mandibular bone is reddish brown, 15818 and 15817, which were excavated from organic deposits overlying the basal clay unit at Old Crow Locality 44 and may be Sangamon age, 28669 (Old Crow Locality 27).

The following right mandibles have RM_1-RM_2: NMC 26668 (Old Crow Locality 15), 28860 (Old Crow Locality 66), 24452 (Old Crow Locality 11A), 18739 (Old Crow Locality 20), 27043 (Old Crow Locality 32E), 22263 (Old Crow Locality 27W), 14903 (Old Crow Locality 31), 19242, which was excavated from fossiliferous sediments overlying the basal clay unit at Old Crow Locality 44 and may be of Sangamon interglacial age; 28701 (Old Crow Locality 27), which has an abnormally bevelled, highly polished anterior loop on RM_1. The following left mandibles have LM_1-LM_2: NMC 22251 (Old Crow Locality 27W), 15820, which was excavated from Old Crow Locality 44 and may be of Sangamon age, 15249 (Old Crow Locality 22), 24807 (Old Crow Locality 20), 22051 (Old Crow Locality 27), 19197 (Old Crow Locality 22), 24859 (Old Crow Locality 11A), 15567 (Old Crow Locality 20), 25312 and 22260 (Old Crow Locality 27W), 25051 (Old Crow Locality 22), 28636 (Old Crow Locality 65), 15827, which was excavated from organic sediments overlying the basal clay unit at Old Crow Locality 44 and may be of Sangamon age, 19195 (Old Crow Locality 28), 22045 (Old Crow Locality 27W), 15636 (Old Crow Locality 28). NMC 22050 from Old Crow Locality 27W is a left mandible with the incisor and LM_1.

The following left mandibles have LM_1: NMC 28600 (Old Crow Locality 103), 25050 (Old Crow Locality 22), 15828, which was excavated from Old Crow Locality 44 and may be of Sangamon interglacial age. The following specimens are right mandibles with RM_1: NMC 15823, which was excavated from the fossiliferous zone overlying the basal clay unit at Old Crow Locality 44 and may be of Sangamon interglacial age, 22164 and 22261 (Old Crow Locality 27W), 20750 (Old Crow Locality 20).

Discussion

Several fossils from Locality 44 indicate that muskrats occupied the Old Crow Basin as early as the ?Sangamon interglacial. The relatively small sizes of the M_1s in the Yukon fossils places them within the zone of Illinoian specimens in Nelson and Semken's (1970, p. 3734,

Figure 1) scattergram of M_1 length versus width in fossil and Recent *Ondatra*. Accounting for a possible cline of decreasing size from south to north, it is reasonable that the Yukon fossils could be interpreted as being of Sangamon interglacial age (Nelson and Semken 1970, Figure 5). The only other Quaternary records of *Ondatra zibethicus* in Canada are from Sangamon interglacial deposits at Medicine Hat, Alberta (Stalker and Churcher 1970) and from post-glacial beds near Hamilton, Ontario (Wetmore 1958).

A nearly complete specimen from bedded sand and silt abutting on an end moraine of Illinoian age near Kotzebue is the earliest record of the muskrat *O. zibethicus* from Alaska (Péwé and Hopkins 1967, p. 268). It may be of late Illinoian or possibly Sangamon age.

The North American ancestry of the muskrat (*Ondatra* sp.) is clear. The probable phyletic line leads from an early member of the *Ogmodontomys* stock to *Pliopotamys minor*, *Pliopotamys meadensis*, *Ondatra idahoensis* (or *Pliopotamys idahoensis* according to Shotwell 1970, p. 68). *Ondatra annectens*, *Ondatra nebracensis*, and finally to the living *Ondatra zibethicus*. Similarity of palatal and dental characters suggests that *Pliopotamys* could have been derived from a primitive *Ogmodontomys* during the late

Pliocene (Zakrzewski 1969, p. 27). Hibbard and Zakrzewski (1967) considered *Pliopotamys* as ancestral to *Ondatra*, and Zakrzewski's (1969, p. 27) later findings tended to support that hypothesis. Zakrzewski noticed that by plotting *Pliopotamys* M_1 lengths against widths that Semken's size cline for *Ondatra* could be carried back in time through the former genus (Nelson and Semken 1970, p. 3734 figure [illegible]). *Pliopotamys* occurred in the late Pliocene of to [illegible] the early Pleistocene of Kansas and Nebraska. [illegible] in the reentrant angles of the teeth may have been acquired during the transition from *Pliopotamys meadensis* to *Ondatra idahoensis* according to Chaline (1975, p. 35). Muskrat remains are abundant and widespread in late Kansan and post- Kansan deposits of North America. In the Great Plains of the United States, *Ondatra annectens* was dominant during Kansan time, giving way to *O. nebracensis* in the early Illinoian (Hibbard 1970). *Ondatra zibethicus* first appears widely in the Sangamon interglacial, and it is during this phase that the species probably reached Eastern Beringia. Evidently muskrats flourished in the Old Crow Basin during the ?Sangamon interglacial, according to the number of fossils recovered, and the situation appears to be similar during the present interglacial, for the Old Crow Basin is among the foremost sources in the world for commercial muskrat pelts.

The muskrat occurs throughout most of North America with the exception of parts of the arid southwest and most of the arctic tundra. It is a large rodent weighing approximately 3 pounds (1.3 kg) and measuring about 2 feet (0.6 m) long. It is well adapted to aquatic life with partially webbed feet and waterproof fur. Its greatest value as a paleoenvironmental indicator is to suggest the presence of large areas of permanent water. Muskrats prefer lakes, rivers, ponds and marshes where the water is between 4 and 12 feet (1.2 and 2.7 m) deep, so that it will not freeze to the bottom, yet will allow growth of submerged vegetation. Indeed, muskrats spend most of their time in the water, where they use their hind feet as propellers and their tails as rudders. They commonly build houses of marsh plants and also use bank dens if there is any firm ground around their ponds. In winter they pull up submerged vegetation through the ice, creating "push-ups", or domes of frozen vegetation that protect their plunge-holes. In summer muskrats feed mainly on emergent plants such as cattail, bulrush, sedges, and waterlilies. Mink and men are among its most serious predators. On land muskrats are attacked by foxes, coyotes, wolves and birds of prey.

Microtus (Stenocranius) miurus (singing vole)

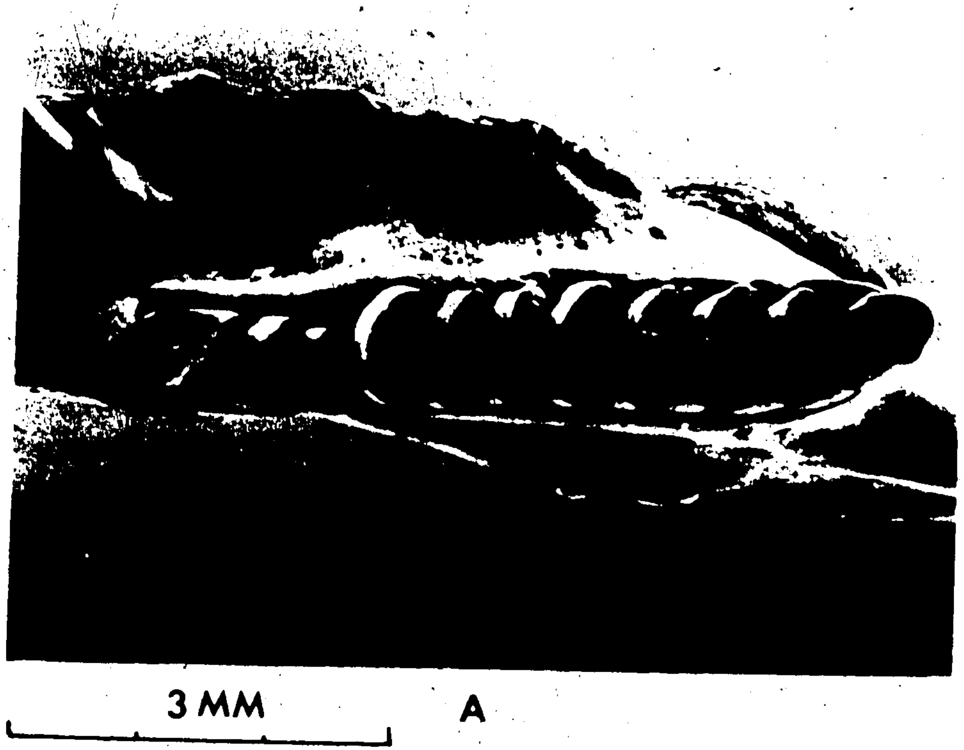
Mandibles of singing voles are less commonly found than those of chestnut-cheeked voles (*Microtus xanthognathus*) in the Pleistocene deposits of the Old Crow Basin. Fifteen mandibles (Figure 26A-B) are described that have tooth patterns most closely matching those of Recent singing voles. The specimens are stained dark brown to black.

Referred specimens

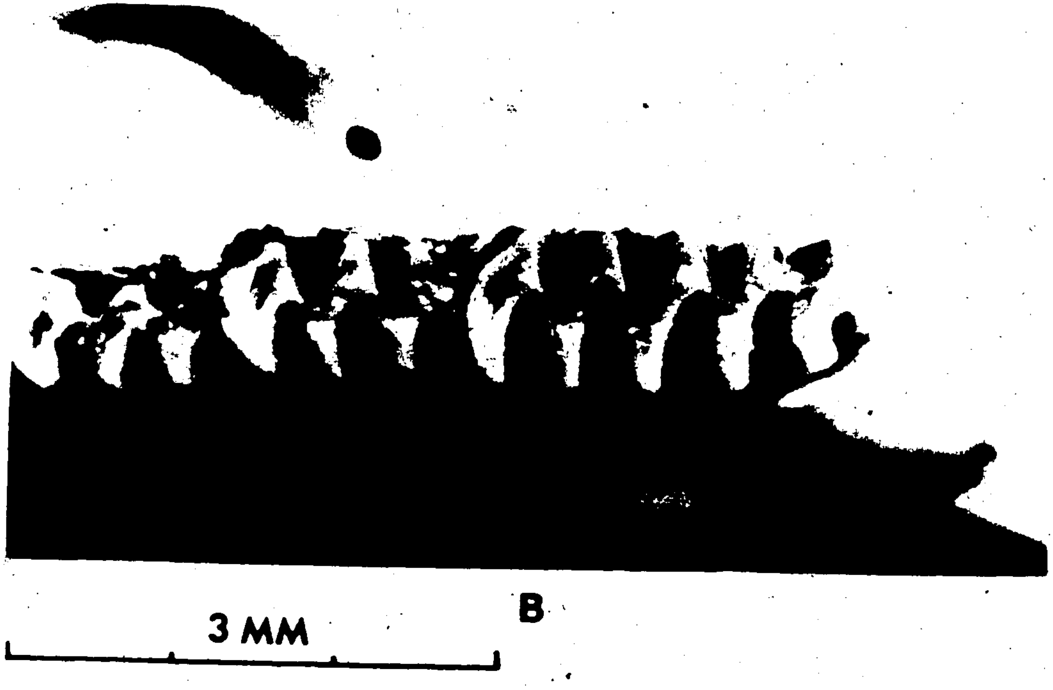
NMC 24566 is a left mandible with the incisor and LM_1-LM_3. It was collected at Old Crow Locality 11A. The following left mandibles have the incisor and LM_1-LM_2: NMC 22180 (Old Crow Locality 27W), 25091 and 25117 which were excavated from the organic silt zone overlying the basal clay unit at Old Crow Locality 64 and which may be of Sangamon interglacial age. The following are right mandibles with the incisor and RM_1-RM_2: NMC 15003 (Old Crow Locality 69), 22170, 22201 and 22079 (Old Crow Locality 27W), and 25096, which was excavated from organic silts overlying the basal clay at Old Crow Locality 64 and may be of Sangamon age. NMC 25292 from Old Crow Locality 27W is a right mandible with RM_1-RM_2, as is NMC 18640 from Old Crow Locality 27. The anterior loop of RM_1 is open in the latter specimen - a variation from the usual condition as shown in Banfield

Figure 26. A. Occlusal view of a left mandible showing LM_1-LM_3 (NMC 24566, Old Crow Locality 11A) of a Pleistocene singing vole *(Microtus (Stenocranius) miurus)*. SEM photograph.

B. Occlusal view of a left mandible showing LM_1-LM_3 (NMC 30458) of a Recent singing vole *(Microtus (Stenocranius) miurus)* from northern Canada.



A



B

(1974, p. 182). The following left mandibles have LM_1-LM_2: NMC 22081 (Old Crow Locality 27W), 25122 and 25094 (Old Crow Locality 64), which were excavated from organic silt overlying the basal clay unit and may be of Sangamon age. NMC 25288 from Old Crow Locality 27W is a right mandible with RM_1.

Discussion

The fossils from Locality 64 indicate the presence of singing voles in the Old Crow Basin as early as the ?Sangamon interglacial. The only other Pleistocene *Microtus* records from Canada are: *Microtus* sp. from deposits considered to be of Sangamon interglacial and mid-Wisconsin interstadial ages at Medicine Hat, Alberta (Stalker and Churcher 1970); *Microtus pennsylvanicus* from postglacial deposits at Scarborough Bluffs, Toronto, Ontario (Churcher and Karrow 1963); and *M. pennsylvanicus* and *M. pinetorum* from postglacial deposits near Hamilton, Ontario (Wetmore 1958).

The earliest record of *Microtus* in Eastern Beringia is from Alaska, where *M. deceitensis* specimens have been excavated from the Cape Deceit Formation (?Nebraskan). *M. deceitensis* has characteristics that are more primitive than *paroperarius* of the late Kansan Cudahy fauna. *Microtus* sp. has also been reported from the Inmachuk (?Kansan) and Deering (?Illinoian to postglacial) Formations at Cape

Deceit (Guthrie and Matthews 1971). Near Fairbanks in central Alaska, *M. miurus* is the most commonly found small mammal fossil, and it covers the greatest stratigraphic range from Illinoian to late Wisconsin time (Guthrie 1968a, p. 231). It has also been reported from deposits of probably Wisconsin age at Tofty, Alaska, where it was more numerous than all other rodents recovered (Repenning *et al.* 1964, p. 196).

The earliest Eurasian record of *Microtus* is from late Günz (late ?Nebraskan) deposits (Kurtén 1968, p. 217). By the middle Pleistocene, *Microtus* became abundant and widespread in Europe. It is interesting to note that *M. (Stenocranius) gregalis*, the gregarious vole of Eurasia, is the closest relative of *M. miurus* (it was considered to be conspecific with the singing vole until Fedyk (1970) showed that *M. gregalis major* from Siberia had a diploid number of 54 chromosomes compared to 72 for *M. miurus* (Rausch 1964)), and first occurs during the Mindel (?Kansan) glaciation of Europe. Evidently it was most common there during glacial phases. Würm (Wisconsin) records are known from England, Germany, Switzerland, Czechoslovakia, Hungary and Poland (Kurtén 1968, p. 219).

The earliest *Microtus* record from northeastern

Siberia is *M.* cf. *(Stenocranius) gregalis*, from sediments of the Olyor Suite (?Kansan) (Sher 1971). *M. gregalis* has also been reported from the second terrace deposits (Illinoian) of the Aldan River (Vangengeim 1961). *M. (Stenocranius)* sp. is present in the mammalian fauna from the Iedoma Suite of early Wisconsin age in the Kolyma Lowland (Sher 1971).

Mimomys newtoni and *Allophaiomys pliocaenicus*, voles of the Villafranchian and early middle Pleistocene of Europe, appear to be the immediate ancestors of *Microtus* (Chaline 1974, p. 441). *Microtus* seems to have evolved by Nebraskan time and *M. deceitensis* is the earliest record, suggesting a Beringian dispersal centre for the genus (Guthrie and Matthews 1971, p. 499). *M. paroperarius*, which was likely derived from *M. deceitensis*, had reached the southern part of North America by late Kansan time. *M. (Stenocranius) gregalis* first appears in Eurasia during the Mindel (?Kansan) glaciation and survives there to the present day, where, like the singing vole, it prefers well-drained habitat. Voles of this narrow-skulled stock had reached Alaska by Illinoian time, the species *M. (Stenocranius) miurus* having evolved in Eastern Beringia. Two subspecies, *M. m. muriei* and *M. m. cantator*, are found in the northern and southern parts of the Yukon Territory, respectively (Youngman 1975; p. 102).

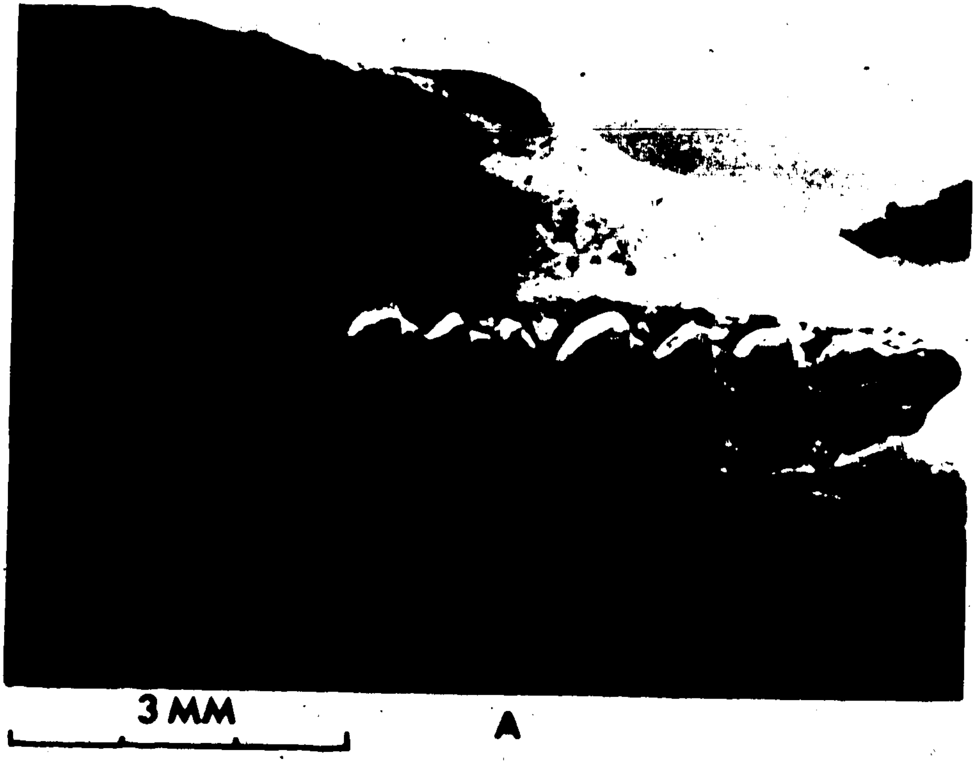
The singing vole is of medium size and is found throughout most of Alaska (excepting the central part) and the Yukon Territory and the westernmost mainland of the Northwest Territories. It is tawny gray to grayish brown and lives in colonies. It prefers dry alpine tundra, and the fossils probably indicate this type of paleoenvironmental niche. Singing voles dig short, shallow burrows that lead to relatively large nesting and storage areas. They feed on forbs, such as lupine, arctic locoweed, horsetails, and leaves and twigs of arctic willow. In autumn they cache large amounts of food for winter use and cut stacks of willow leaves and green forbs, which are left as outside supplies. Their predators include Gray Jays, jaegers, owls, weasels, wolves and foxes.

Microtus xanthognathus (chestnut-cheeked vole)

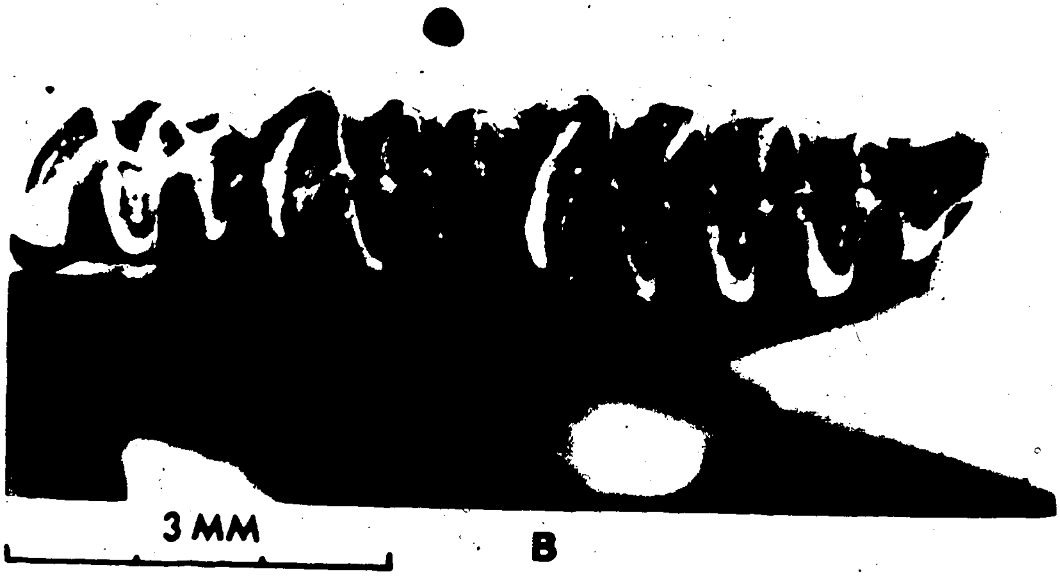
Twenty mandibles (Figure 27A-B) are described from Pleistocene deposits of the Old Crow Basin. The mandibles are generally larger than those of the singing vole *(Microtus (Stenocranius) miurus)* fossils from the same region and their dental patterns compare most closely with those of Recent chestnut-cheeked voles. Most of the specimens are stained dark brown to black.

Figure 27. A. Occlusal view of a left mandible showing LM$_1$-LM$_3$ (NMC 18839, Old Crow Locality 20) of a Pleistocene chestnut-cheeked vole (*Microtus xanthognathus*). SEM photograph.

B. Occlusal view of a left mandible showing LM$_1$-LM$_3$ (NMC 35087) of a Recent chestnut-cheeked vole (*Microtus xanthognathus*) from northern Canada.



A



B

Referred Specimens

NMC 18839 from Old Crow Locality 2 is a left mandible with all teeth. The following left mandibles have the incisor and LM_1-LM_2: NMC 22211, 22107, 22[illegible]77 (Old Crow Locality 27W), 18870, 19339 (Old Crow Locality 20), 24415 (Old Crow Locality 11A), 18645 (Old Crow Locality 27). The following right mandibles have the incisor and RM_1-RM_2: NMC 22222 (Old Crow Locality 27W), 18840 and 19332 (Old Crow Locality 20). The following right mandibles have RM_1-RM_2: NMC 25119 was excavated from organic silt overlying the basal clay unit in the high bluff exposure at Old Crow Locality 64, indicating that it may be of Sangamon interglacial age; 22080 (Old Crow Locality 27W), 19175 and 19178 (Old Crow Locality 28). The following left mandibles have LM_1-LM_2: NMC 25116 was excavated from organic silt overlying the basal clay unit at Old Crow Locality 64 and may be of Sangamon age; 22109 and 22203 (Old Crow Locality 27W), 28773 and 28775 (Old Crow Locality 104).

Discussion

The fossils excavated from Locality 64 indicate that chestnut-cheeked voles occupied the Old Crow Basin during the ?Sangamon interglacial. Evidently they were contemporaneous with the singing voles, which probably lived in drier more open habitat. Other *Microtus* fossils from Canada are reviewed in the section on *M. miurus*.

There are three late Pleistocene to postglacial records of the chestnut-cheeked vole from Alaska. The most remarkable of these is a mummified specimen from permafrost at Chicken Creek near the Canada-Alaska border (Guilday and Bender 1960; Youngman 1975, p. 98). I suspect that this specimen is of Wisconsin age, for Péwé (1975b) notes that the best preserved carcasses of Pleistocene mammals in the Fairbanks area have been derived from the Goldstream Formation, which he considers to be of Wisconsin age. In addition, radiocarbon analyses of bison and horse bone from Lost Chicken Creek, which is near the *M. xanthognathus* locality, have yielded dates of 26,760 ± 300 years B.P. (SI-355) and 10,370 ± 160 years B.P. (I-8582), respectively (Harington 1976 MS, p. 78). A single molar was collected from deposits of possible postglacial age at Ready Boullion Bench near Fairbanks (Guthrie 1968a, p. 232). Another single molar from the Tofty area probably is referable to *M. xanthognathus*. It was derived from unit B, which evidently contains a mixture of specimens of Wisconsin and postglacial age (Repenning *et al.* [illegible], p. 196).

M. xanthognathus has been recorded from 11 Pleistocene localities in the eastern United States (Hallberg *et al.* 1974, p. 641). Most of these localities are in the states of Pennsylvania, Virginia, West Virginia, Kentucky, Illinois, Missouri, Arkansas, and Iowa. Radiocarbon dates on associated material from two sites suggest that the specimens are of late Wisconsin age. The authors mentioned put forward a cogent argument that chestnut-cheeked vole fossils from these localities are indicative of a type of parkland with no modern analog, but with affinities to the southern boreal forest. It is interesting to note that this apparent parkland region was one in which extinct musk-oxen (*Symbos cavifrons* and *Bootherium sargenti*) were most heavily concentrated in the southern refugium.

The origins of the chestnut-cheeked vole are not very clear. Chaline (1974, p. 448-449) considers that *M. xanthognathus*, *M. chrotorrhinus* and *M. pennsylvanicus* belong to a North American group that is part of the subgenus *Arvalomys*, and that was derived from a European *M. agrestis*-like stock toward the end of the Kansan glaciation. He indicates that the meadow vole *M. pennsylvanicus* diverged from the ancestral line leading to *M. xanthognathus* and the rock vole *M. chrotorrhinus* about Illinoian time. The latter two species, he suggests, differentiated from a common ancestor near the close of the Wisconsin glaciation, which is difficult to understand in view of the fact that (a) *M. xanthognathus* has been recorded from ?Sangamon (<54,000 years B.P.) deposits in the Yukon; (b) clearly identifiable specimens of *M. xanthognathus* and *M. chrotorrhinus* were associated in cave deposits at New Paris No. 4, Pennsylvania that are approximately 11,300 years old (Guilday *et al.* 1964, p. 135; (c) *M. xanthognathus* and *M. chrotorrhinus* differ considerably cytogenetically, morphologically, ecologically and ethologically (Youngman 1975, p. 98).

It is difficult to explain the present distribution pattern of *M. xanthognathus* - particularly as no subspecies have been identified. Youngman (1975, p. 99) suggests that the species had a southern origin and closely followed the retreating glaciers northward. That is possible if he means that it had a southern origin before the Wisconsin glaciation. The possibility that one or two of the Alaskan Pleistocene fossils are of Wisconsin age also casts doubt on this rather straightforward analysis involving a northwestern movement toward Beringia from the southern refugium as the Wisconsin ice retreated.

The chestnut-cheeked vole is a large microtine found only in North America from the northern prairie provinces of Canada to central Alaska. It is dark brown above and has a grayish belly. The prominent rusty yellow patch on the nose is characteristic. This species lives mainly in boreal forest regions, but also occurs in sphagnum bogs. It is colonial and digs deep burrows in the crumbly forest earth. Chestnut-cheeked voles sometimes make nests of dried sedges, and feed on horsetails, willows, lichens, mosses, mushrooms and berries.

Order Cetacea

Family indeterminate

Genus and species indeterminate (large whale)

Referred specimen

In the summer of 1970 M. Bouchard, an assistant of V. Rampton then of the Geological Survey of Canada, collected at Herschel Island Locality 2 a heavily permineralized fragment (NMC 17611) of what appears to be whale bone according to its cellular structure. Its maximum dimensions are approximately 360 mm long x 70 mm across x 7 mm deep. The bone was *in situ* in what Bouchard considered to be "preglacial marine sands" with a few bands of organic-rich silt. Peaty material and at least two water-rounded stones fill a canal 15 mm in diameter near the natural surface of the bone. Rampton (personal communication 1976) suggests that this specimen is of pre- early Wisconsin age.

Discussion

Although I cannot definitely identify the specimen, it is reminiscent of part of a bowhead whale *(Balaena mysticetus)* mandible. In summer these large whales pass through Bering Strait and are occasionally sighted in the Beaufort Sea, where they were much more common prior to the early incursions of whalers, which began at Herschel Island in 1888 (Youngman 1975, p. 123).

Order Carnivora

Family Canidae

Canis lupus (wolf)

Pleistocene wolf specimens (Figure 28, Tables 25-26) have been found in both Old Crow and Dawson areas. They are often fragmentary. Although many postcranial specimens that are probably referable to wolf have been collected, only some of the more complete cranial material is described. These specimens are mainly separated from those of dholes *(Cuon* sp.*)*, dogs *(Canis familiaris)* and coyotes *(Canis latrans)* on the basis of their larger size - particularly tooth size. Where specimens are sufficiently complete, they usually have M_3s or traces of alveoli for M_3, whereas that tooth is absent in *Cuon*. They have low foreheads, widely spaced cheek-teeth, relatively long carnassials (P^4s) and wide M^1s and broad, highly inflated auditory bullae, features which help to separate them from *C. familiaris*. Harrison's (1973, p. 188, Figure 1) observation

Figure 28. Partial cranium (NMC 9929, Dawson Locality 2) of a Pleistocene wolf *(Canis lupus)*.

A. Dorsal view. B. Left lateral view.

C. Ventral view.

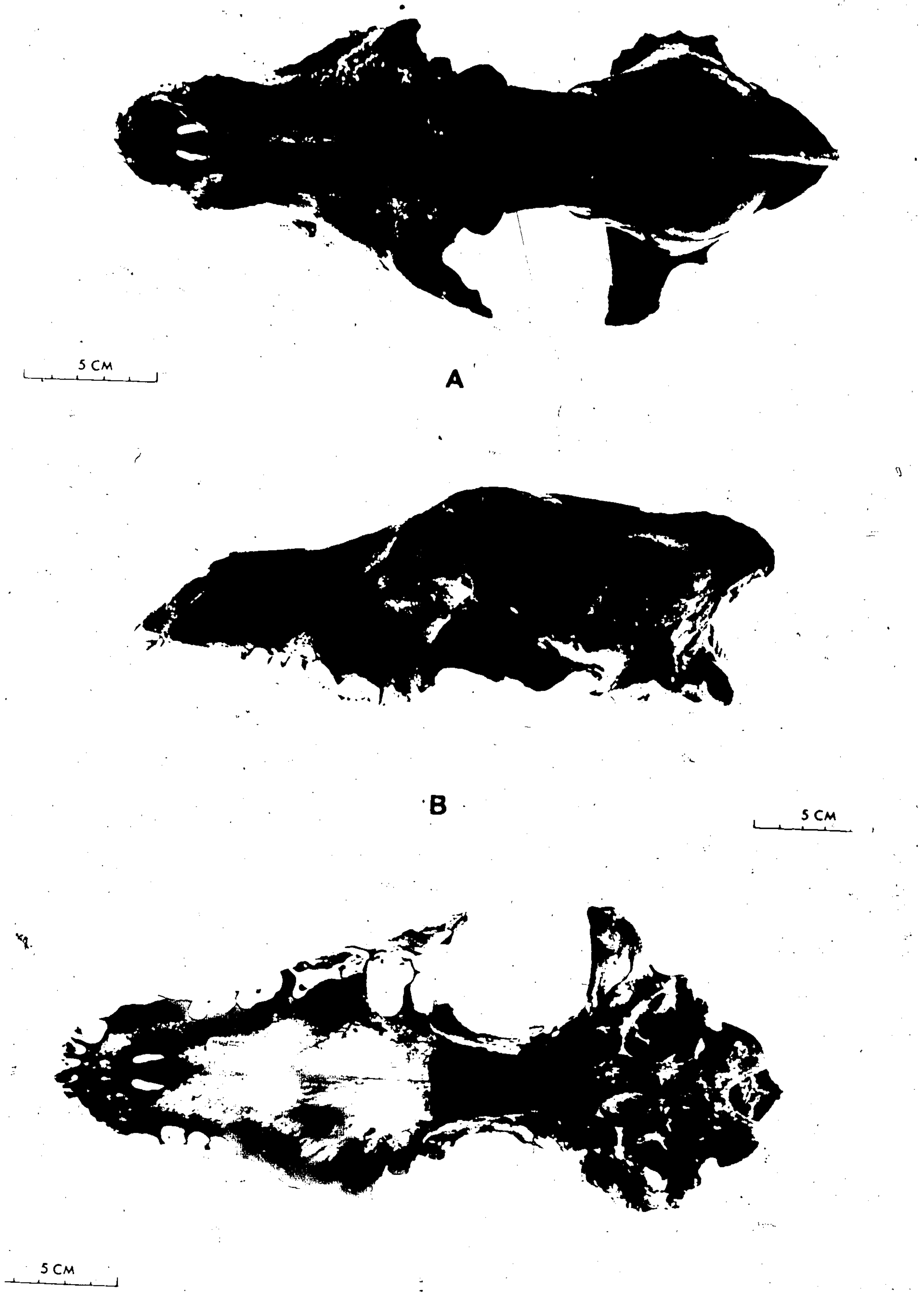

5 CM
A
B
5 CM
5 CM

Table 25. Measurements of Pleistocene wolf *(Canis lupus)* crania from the Yukon Territory compared to those of Recent wolves the Yukon Territory.

SPECIMENS	SEX	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Canis lupus. Pleistocene, Y.T.															
NMC 9929 Dawson Loc. 2	-	253.6	241.9	124.8	102.8	36.9	66.6	80.8	18.8	50.4	46.9	39.9	108.2	18.1	-
Uncataloged. Old Crow, near mouth of Johnson Creek.	-	-	-	127.5	-	-	-	-	-	-	49.0	45.5	109.1	17.5	-
NMC 17377 Dawson Loc. 25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NMC 20863 Old Crow Loc. 74	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NMC 24939 Old Crow Loc. 11A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NMC 19476 Old Crow Loc. 65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NMC 24955 Old Crow Loc. 11A	-	-	-	-	-	-	-	-	-	-	-	-	-	16.9	-
NMC 17311 Dawson Loc. 7	-	-	-	122.6e	-	34.4e	-	-	-	-	47.0e	-	103 ?	17.4	9.3
Canis lupus. Recent, Y.T.															
NMC 34690	♂	271.1	254.3	130.8	107.4	35.3	64.9	83.3	19.0	49.8	48.5	44.7	109.8	17.4	9.6
NMC 30924	♀	241.7	234.9	122.1	98.9	31.3	64.8	76.0	16.5	48.3	43.3	40.7	104.6	14.8	9.1
NMC 30923	♀	238.3	230.2	119.7	95.2	30.3	60.8	77.3	16.6	46.2	44.8	43.8	102.4	15.0	8.9
NMC 34691	♂	275.7	256.5	133.0	108.1	34.9	65.7	89.5	20.8	51.9	47.7	43.8	109.6	17.1	10.3
NMC 31760	♀	253.3	239.8	119.7	103.0	31.6	67.2	79.1	19.5	49.5	40.7	39.6	105.4	15.6	9.5
NMC 18133	?♂	268.9	253.6	126.2	110.5	35.3	68.6	85.9	16.5	54.2	50.4	45.6	112.8	17.7	10.0

Measuremen

* 1 - Greatest length.

2 - Condylobasal length

3 - Palatal length (anterior of premaxilla to posterior of palate)

4 - Postpalatal length (posterior of palate to inferior margin of foramen magnum)

5 - Palatal breadth inside P^2s (minimum)

6 - Width between postglenoid foramina

7 - Postzygomatic width (across squamosal ridges at level of auditory meati)

8 - Basioccipital width (minimum width between auditory bullae).

9 - Width across occipital condyles

10 - Minimum interorbita

11 - Minimum width of br

12 - Alveolar length C^1-

13 - C^1 length (at alveo

14 - C^1 width (at alveol

15 - P^1 length

16 - P^1 width

17 - P^2 length

18 - P^2 width

itory compared to those of Recent wolves from

Measurements (mm)*																	
9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
50.4	46.9	39.9	108.2	18.1	-	8.5	6.3	16.9	7.4	17.6	8.1	31.9	14.9	16.5	23.0	9.0	13.7
-	49.0	45.5	109.1	17.5	-	-	-	15.1	6.1	16.4	7.0	27.2	14.8	16.4	20.9	9.8	14.5
-	-	-	-	-	-	-	-	-	-	-	-	28.3	14.7	17.4	20.6	8.8	11.5
-	-	-	-	-	-	-	-	14.3	6.3	15.8	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	23.5	11.6	16.4	17.9	-	-
-	-	-	-	16.9	-	-	-	-	-	-	-	27.2	16.1	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	25.9	14.0	-	-	-	-
-	47.0e	-	103.2	17.4	9.3	7.9	5.5	14.9	5.9	16.9	6.8	27.4	15.3	16.7	20.3	9.3	13.2
49.8	48.5	44.7	109.8	17.4	9.6	9.2	5.8	15.3	6.6	16.6	7.3	26.1	14.6	17.0	21.7	9.4	13.8
48.3	43.3	40.7	104.6	14.8	9.1	7.3	5.0	13.5	5.9	15.1	6.9	24.5	14.2	16.5	20.6	9.3	14.1
46.2	44.8	43.8	102.4	15.0	8.9	8.2	5.5	14.4	6.5	15.9	7.4	25.8	13.9	16.2	21.5	8.9	14.5
51.9	47.7	43.8	109.6	17.1	10.3	8.7	5.7	14.9	6.8	17.4	7.7	27.8	15.9	17.6	20.9	9.9	14.4
49.5	40.7	39.6	105.4	15.6	9.5	8.9	5.6	15.0	5.9	16.2	6.6	27.1	15.4	17.2	21.8	9.8	14.8
54.2	50.4	45.6	112.8	17.7	10.0	7.5	5.5	12.8	6.0	15.1	6.5	25.4	13.8	17.4	21.9	9.3	13.4

10 - Minimum interorbital width
11 - Minimum width of braincase
12 - Alveolar length C^1-M^2
13 - C^1 length (at alveolus)
14 - C^1 width (at alveolus)
15 - P^1 length
16 - P^1 width
17 - P^2 length
18 - P^2 width

19 - P^3 length
20 - P^3 width
21 - P^4 length
22 - P^4 width
23 - M^1 length
24 - M^1 width
25 - M^2 length
25 - M^2 width

Table 26. Measurements of Pleistocene wolf (*Canis lupus*) mandibles from the Yukon Territory compared to those of the Yukon Territory.

SPECIMENS	SEX	MEASUREMENTS (mm) * 1	2	3	4	5	6	7	8	9	10	11	12	13
Canis lupus. Pleistocene, Y.T.														
NMC 25954 **Dawson Loc. 16	–	36.5	15.7	29.3	13.5	–	–	14.0	6.7	$14.7^{\dagger}$	7.3	16.7	8.3	31.0
NMC 25228 Dawson Loc. 32	–	37.5	15.8	–	–	–	–	–	–	–	–	–	–	33.5
NMC 28862 Old Crow Loc. 66	–	27.4	11.5	22.5	10.6	–	–	–	–	14.6	6.2	16.0	7.4	26.7
NMC 13595 Old Crow Loc. 11A	–	27.8	11.9	23.2	9.6	–	–	–	–	–	–	–	–	$25.3^{\dagger}$
NMC 28866 Old Crow Loc. 66	–	27.3	12.1	21.8	10.3	–	–	–	–	–	–	–	–	25.2
OCR 9262 Old Crow Loc. 11A	–	–	–	–	10.2	5.2	4.0	11.5	5.2	12.1	5.4	13.4	6.2	–
NMC 18335 Old Crow Loc. 29	–	–	–	29.2	14.1	6.2	5.3	13.8	7.2	15.9	7.5	17.4	9.0	–
NMC 18716 Old Crow Loc. 29	–	–	–	28.6	12.2	6.0	5.1	13.6	6.6	15.4	7.4	17.3	$8.2^{\dagger}$	–
NMC 24902 Old Crow Loc. 11A	–	33.2	15.4	–	–	–	–	–	–	–	–	15.6	–	27.6
NMC 13579 Old Crow Loc. 11A	–	29.7	12.0	–	–	–	–	–	–	–	–	–	–	–
NMC 15902 Old Crow Loc. 44	–	–	–	22.0	10.8	–	–	13.6	5.9	–	–	–	–	–
NMC 20340 Old Crow Loc. 64	–	–	–	–	–	–	–	–	–	–	–	–	–	–
NMC 27706 Old Crow Loc. 66	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Canis lupus. Recent, Y.T.														
NMC 34690	♂	37.9	16.9	30.5	14.7	6.6	5.0	14.4	6.6	15.6	7.1	17.2	8.3	29.5
NMC 30924	♀	34.7	14.2	29.7	13.4	5.6	4.6	12.4	6.1	13.4	6.7	15.6	7.8	27.1
NMC 30923	♀	30.2	12.8	26.0	10.9	6.5	4.7	12.9	6.4	13.7	6.7	15.9	7.9	28.5
NMC 34691	♂	39.1	17.5	32.3	16.7	6.5	5.1	14.1	6.7	15.6	7.5	16.8	8.5	30.1
NMC 31760	♀	31.2	13.6	25.0	11.9	7.0	4.8	12.8	5.8	14.6	6.7	16.5	7.8	30.6
NMC 18133	♂?	38.1	15.2	26.6	14.4	6.1	4.7	12.8	5.9	14.4	6.6	15.9	7.6	29.6

* 1 - Mandible depth below centre of M_1
2 - Mandible width below centre of M_1
3 - Mandible depth below point between P_3 and P_4
4 - Mandible width below point between P_3 and P_4
5 - Length P_1
6 - Width P_1
7 - Length P_2
8 - Width P_2
9 - Length P_3
10 - Width P_3
11 - Length P_4
12 - Width P_4
13 - Length M_1
14 - Width M_1
15 - Length M_2
16 - Width M_2
17 - Length M_3
18 - Width M_3
19 - Alveolar length P_1-P_4
20 - Alveolar length M_1-M_3
21 - Alveolar length P_1-M_3
** Specimen has no M_3

f (*Canis lupus*) mandibles from the Yukon Territory compared to those of recent wolves from

MEASUREMENTS (mm) *																	
4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
13.5	--	–	14.0	6.7	14.7†	7.3	16.7	8.3	31.0	11.9	12.3	8.9	–	–	–	–	–
–	–	–	–	–	–	–	–	–	33.5	12.8	11.8	9.5	5.5	5.4	–	48.8	–
10.6	–	–	–	–	14.6	6.2	16.0	7.4	26.7	10.4	10.8	7.9	–	–	–	–	–
9.6	–	–	–	–	–	–	–	–	25.3†	9.5†	10.4	7.3	–	–	46.0	40.6	85.1
10.3	–	–	–	–	–	–	–	–	25.2	9.8	10.3	8.0	–	–	45.8	39.8	84.2
10.2	5.2	4.0	11.5	5.2	12.1	5.4	13.4	6.2	–	–	–	–	–	–	48.9	–	–
14.1	6.2	5.3	13.8	7.2	15.9	7.5	17.4	9.0	–	–	–	–	–	–	51.0	–	–
12.2	6.0	5.1	13.6	6.6	15.4	7.4	17.3	8.2†	–	–	–	–	–	–	52.1	–	–
–	–	–	–	–	–	–	15.6	–	27.6	9.5	–	–	–	–	–	44.4	–
–	–	–	–	–	–	–	–	–	–	–	12.0	7.7	–	–	–	–	–
10.8	–	–	13.6	5.9	–	–	–	–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	–	12.9	9.0	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	–	10.9	7.8	–	–	–	–	–
14.7	6.6	5.0	14.4	6.6	15.6	7.1	17.2	8.3	29.5	12.0	12.5	9.2	7.3	6.2	54.8	48.5	101.6
13.4	5.6	4.6	12.4	6.1	13.4	6.7	15.6	7.8	27.1	10.7	11.9	8.4	5.8	5.2	52.5	44.9	96.5
10.9	6.5	4.7	12.9	6.4	13.7	6.7	15.9	7.9	28.5	11.0	12.5	8.7	6.1	5.7	52.4	45.9	96.8
16.7	6.5	5.1	14.1	6.7	15.6	7.5	16.8	8.5	30.1	12.4	12.6	9.6	6.9	6.5	54.6	49.0	103.4
11.9	7.0	4.8	12.8	5.8	14.6	6.7	16.5	7.8	30.6	12.2	13.0	9.8	5.9	5.4	52.6	48.4	99.6
14.4	6.1	4.7	12.8	5.9	14.4	6.6	15.9	7.6	29.6	11.9	12.8	9.3	7.1	6.3	50.5	48.1	98.4

12 - Width P_4

13 - Length M_1

14 - Width M_1

15 - Length M_2

16 - Width M_2

17 - Length M_3

18 - Width M_3

19 - Alveolar length P_1-P_4

20 - Alveolar length M_1-M_3

21 - Alveolar length P_1-M_3

** Specimen has no M_3

that large *Canis familiaris* skulls can readily be distinguished from small *Canis lupus arabs* and *C. l. pallipes* crania from the Arabian region on the basis of the strikingly larger auditory bullae in wolves, aids in separating North American wolves and dogs in a limited cranial sample I have tested. The efficiency of this criterion for distinguishing between these canids requires further research.

Specimens NMC 28862, 28866, 15902 and 27706 possibly indicate that relatively small-jawed wolves lived in the Old Crow Basin prior to late Wisconsin time, perhaps during the late Illinoian or Sangamon. However, if further work shows the validity of this distinction, probably these wolves would only differ at the subspecific level from modern Yukon wolves. Kurtén (1969, p. 110) has observed little if any difference between wolves of Eem (Sangamon) interglacial and Würm glacial times in Europe.

The Dawson fossils are usually manila to dark tan, while the Old Crow specimens are more darkly stained.

Referred specimens

The best preserved specimen is most of a cranium (NMC 9929) from Dawson Locality 2, where it was washed by a monitor out of a thick hill of muck. The strong development of the saggital crest is suggestive of a male, whereas the heavy wear on the teeth, particularly the incisors, indicates a mature to old individual. Both zygomatic arches are broken. All teeth of the right side are lacking except for RI^1, RP^1 and RP^2. The canine (LC^1) and LP^1 are missing from the left side, and the outer face of the left carnassial has been broken off. Auditory bullae are damaged, and the tip of the left nasal is lacking. The specimen is stained yellowish brown to brown. The teeth are whitish and relatively fresh in appearance. An uncataloged specimen, collected by a member of W.N. Irving's field crew, came from a gravel bar near the mouth of Johnson Creek in the Old Crow Basin. It consists of the right side of the cranium (lacking the nasal, parietal, temporal, zygomatic arch, occipital region, RC^1 and RP^1) and the left frontal region. The cranium is approximately the same size as NMC 9929, but the teeth are slightly smaller except for LM^2. According to the degree of wear on the teeth, the age of the individual represented by this specimen is a little younger than that of the wolf represented by NMC 9929. The bone and teeth of this specimen are stained dark reddish brown. I suggest, on this basis, that it is of pre- late Wisconsin age.

NMC 17311 from Dawson Locality 7 is a right facial region with all teeth, excepting RI^2, and including anterior parts of the frontal and malar bones. Tooth wear is similar to that of NMC 9929: the fossil may represent an old individual. The RC^1 seems to have been broken and worn smooth later. The specimen is dark tan. NMC 17377 from Dawson Locality 25 is a right maxillary fragment with RP^4-RM^2 and the alveolus for RP^3. The teeth are well worn suggesting that the animal it represents was of mature to old age when it died. The fossil is tan. NMC 24939 from Old Crow Locality 11A is a right maxillary fragment with RP^4-RM^1. The teeth show virtually no wear, indicating a relatively young age at death. The specimen is stained dark brown. NMC 19476 from Old Crow Locality 65 is a right maxilla with RP^4 (the posterointernal portion is lacking) and alveoli for the remaining teeth, except for RM^1 and RM^2. The degree of wear on RP^4 indicates that the individual represented was of similar age to the wolf represented by the fossil from Johnson Creek. The RC^1-RP^4 alveolar length of NMC 19476 is 87.8 mm compared to 90.1 mm for the Johnson Creek fossil. The specimen is tan colored. NMC 24955 from Old Crow Locality 11A is a maxillary fragment with LP^4, the posterior of which is damaged. The teeth show very slight wear. The black staining of the teeth may indicate a pre- late Wisconsin age for the fossil.

Mandibles are better preserved because of their solid bone and compact shape. The most complete specimen, NMC 25954 from Dawson Locality 16, is a right mandible with RP_2-RM_2. The jaw anterior to RP_2 and the posterointernal part of M_1 are missing. RM_3 is not present, evidently a rare case, but there is no chance of mistaking it for a dhole *(Cuon)* mandible because of its large size. Teeth are heavily worn indicating that the mandible is from an old individual. The fossil is tan. NMC 25228 from Dawson Locality 32 is the posterior of a left mandible including the ascending ramus with LM_1-LM_3. The teeth are not quite so heavily worn as those in NMC 25954. The specimen is light tan.

NMC 28862 from Old Crow Locality 66 is a right mandible fragment with RP_3-RM_2. It may represent a young adult as there is little wear on the teeth. The mandible is blackish brown and the teeth are marbled gray and black. NMC 13593 from Old Crow Locality 11A is a right mandible with RM_1-RM_2. Alveoli for the remaining teeth are present. The two anterior cusps of RM_1 are badly damaged. The bone of this specimen is stained reddish brown. Cusps seen on RM_1 and RM_2 are virtually fresh, suggesting that the fossil represents an immature to young adult wolf. Regardless of the possible chronological age of the individual represented by the fossil, it may have belonged to a rather small-jawed form. It has a deeper mandible than any coyotes *(Canis latrans)* to which it was compared, and cannot be a dhole *(Cuon* sp.) because the alveolus for M_3 is present. NMC 28866 from Old Crow Locality 66 is a left mandible with LM_1-LM_2 and alveoli for the remaining teeth. The teeth show little wear.

OCR 9262 from Old Crow Locality 11A was collected in 1975 by a member of W.N. Irving's field crew. It is the anterior part of a right mandible with RP_1-RP_4 and the alveoli for the canine tooth and incisors. Cusps show moderate wear. The specimen is stained blackish brown. NMC 18335 from Old Crow Locality 29 is the anterior part of a right mandible with RP_1-RP_4 and the alveoli for the canine and incisors. The teeth are slightly worn. The mandibular bone is stained dark reddish brown, whereas the teeth are marbled gray and black. Presumably it and NMC 28862 from Old Crow Locality 66 had undergone a similar history of fossilization. NMC 18716 from the same locality is a left mandible with LP_1-LP_4. The central part of the crown of LP_4 is missing. The teeth are moderately worn, suggesting that the specimen represents an adult. The jaw is stained brown, while the teeth are lighter.

NMC 24902 from Old Crow Locality 11A is a left mandible fragment with LP$_4$-LM$_1$, the alveolus for LM$_2$ and a trace of the alveolus for LM$_3$. LP$_4$ is badly damaged. The teeth, particularly LM$_1$, are extremely heavily worn and the roots are exposed well above the alveolar margin. The wolf represented was very old at death. The mandible is stained reddish brown on the outside and dark brown on the inside. NMC 13579 from the same locality is a posterior mandible fragment with a partial LM$_1$ and a complete LM$_2$. Teeth are moderately worn. The specimen is stained blackish brown. NMC 15902 is a left mandible fragment with LP$_2$ and LP$_3$ (lacking the posterior cusp and part of the posterior root). The teeth are moderately worn. The specimen was excavated from the fossiliferous zone overlying the basal clay unit at Old Crow Locality 44 and may be of Sangamon interglacial age. It is stained grayish brown. NMC 20340 from Old Crow Locality 64 is the posterior part of a left mandible with a heavily worn LM$_2$ and the alveoli for LM$_3$ and the posterior root of LM$_1$. It is grayish brown and has a fine grayish sand matrix adhering to its inner surface. Although the specimen was found on the river bank, it probably came from the organic gray sandy silt layer above the basal clay unit, which I consider to be of possible Sangamon interglacial age. NMC 27706 from Old Crow Locality 66 is a posterior left mandible fragment with LM$_2$ and the alveolus for LM$_3$. LM$_2$ shows moderately heavy wear. The specimen is stained black.

Discussion

Specimens derived from organic deposits at Old Crow Localities 44 and 64 indicate that wolves occupied the Old Crow Basin during the ?Sangamon interglacial. Fossils from the Dawson Area are probably of late Wisconsin age (Harington and Clulow 1973, p. 699).

In Canada, beyond the Yukon Territory, specimens of wolves or wolf-like animals have been reported from various Pleistocene and postglacial sites. The earliest of these reports is of the Etruscan wolf *(Canis* cf. *etruscus)* from the Kansan fauna at Medicine Hat, Alberta (C.S. Churcher, personal communication 1975). *Canis lupus* and *Canis* sp. (probably a wolf) are known from Sangamon interglacial or mid- Wisconsin interstadial deposits at Medicine Hat and Fort Qu'Appelle, Saskatchewan, respectively (Stalker and Churcher 1970; Khan 1970, p. 13). At Medicine Hat, the dire wolf *(Canis* cf. *dirus)* has been reported from late Wisconsin deposits, while *C. lupus* fossils have come from two beds of late Wisconsin age estimated to be 15,000 and 11,000 years old (Stalker and Churcher 1970). The only other Canadian specimen attributed to the dire wolf is a canine tooth found on the surface near the head of the Castleguard River in Banff National Park, Alberta (Cowan 1954, p. 44). *Canis lupus* is also a member of the postglacial fauna (approximately 5,000 years old according to radiocarbon dates) at Oxbow Dam, Saskatchewan (Nero and McCorquodale 1958, p. 88). Thus, there appear to be no earlier records of *Canis lupus* in Canada than those of Sangamon interglacial age.

The earliest Alaskan record of a canid *(Canis* sp.), possibly a wolf, is from the Cape Deceit Formation (?Nebraskan) on Kotzebue Sound (Guthrie and Matthews 1971, p. 496). Wolf *(C. lupus)* specimens are not uncommon in muck deposits of Wisconsin age near Fairbanks, and *Canis* sp. has been collected from Illinoian beds there (Péwé 1975a, pp. 96-97). Wolf material has been identified by C.A. Repenning at a late Pleistocene site on Canyon Creek in the Big Delta area (Weber 1975, p. 67). I have not identified dire wolf fossils from the Yukon Territory, and Frick's (1930, p. 79) report of this wolf *("Aenocyon dirus alaskensis")* has not been substantiated. Apparently *Canis lupus* dominated the Beringian region in the late Pleistocene, while the dire wolf was most common in the southern refugium during that period.

In Siberia, *Canis* sp. (possibly a wolf) has been identified from the Olyor Suite (?Kansan) by Sher (1971), and *Canis lupus* is known from late Pleistocene (Illinoian to Wisconsin?) deposits on Bolshoi Lyakhov Island (Vangengeim 1961). The wolf is also known from the early Wisconsin Iedoma Suite of the Kolyma Lowland (Sher 1971). The species has a long fossil record in China too, beginning with relatively small forms in the Mindel (?Kansan) deposits of Choukoutien (Kurtén 1968, p. 110).

Canis lupus first appears in Europe during the late Günz (?late Nebraskan) and is common in the Cromer (?Aftonian) and Mindel (?Kansan) of England and Germany. These early, relatively small wolves called *C. l. mosbachensis* were replaced by a larger form during the late Pleistocene. Living wolves of northern Europe are smaller than the late Pleistocene form (Kurtén 1968, p. 110).

The Etruscan wolf *(Canis etruscus)*, of sheep dog size, seems to be the most likely ancestor for the living wolf *Canis lupus*. Etruscan wolves occupied Europe throughout the Villafranchian and may have spread to North America by ?Nebraskan (Cape Deceit) or Kansan (Medicine Hat) time. *Canis lupus* seems to have evolved in Europe during the Günz (?Nebraskan) glaciation and spread rapidly into Asia, reaching America by Illinoian time. It is interesting to speculate that the dire wolf may have arisen during the late Pleistocene from a Holarctic *etruscus*-like stock, and held sway in the southern refugium until the late Wisconsin, when its specialized prey (e.g. *Bison latifrons?*) died out, leaving the way clear for the more adaptable *C. lupus*. The only other North American wolf species, the red wolf (*Canis niger*), may have greater affinities with *C. etruscus* than *C. lupus*. Detailed comparisons of the skeletal structure of the Etruscan wolf and red wolf would be interesting.

Wolves are lanky, narrow-chested canids that have an extremely broad Holarctic distribution. They are found throughout most of Canada, including all of the Yukon Territory where no well marked subspecies occur (Youngman 1975, p. 128). Their climatic tolerance is so great that they can live in tundra, forest, steppe and desert regions. Because of its adaptability, *Canis lupus* has virtually no value as a paleoenvironmental indicator. Pups are born in dens in early May in Canada. Wolves are gregarious, and make efficient use of their strength by employing various tactics, such as co-operative pursuit of game. Moose, caribou, wapiti, mule deer, white-tailed deer, mountain sheep, bison and muskoxen are among their major prey. Hares, ground squirrels, birds, fishes and berries are less important dietary items. Wolf populations appear to be regulated by abundance of prey, and occasionally by diseases. During the last few hundred years man has become an important predator of the wolf.

Canis familiaris (domestic dog)

Two specimens (Figure 29A-B, Tables 27-28) possibly derived from Yukon Pleistocene deposits are referred to the domestic dog. Both represent a relatively small-toothed, short-snouted canid that can be distinguished from other members of the Canidae reported from Pleistocene deposits of Eastern Beringia, such as the wolf *(Canis lupus)*, the coyote *(Canis latrans)* and the dhole *(Cuon* sp.*)*. This could indicate the presence of people on the arctic coast of the Yukon in pre- Wisconsin time, and in the Dawson Area during the late Wisconsin glaciation, but the geological age of the specimens must remain conjectural until an adequate method can be found to date them.

Referred specimens

NMC 29047A from Dawson Locality 29 is a cranium with LI^1-LI^3, LP^3-LM^2; RI^2, RP^4-RM^2 and alveoli for the remaining teeth. The slight tooth wear and the degree of suture fusion suggest that the dog represented by the skull died in early maturity. Zygomatic arches are slightly eroded and the sagittal crest is damaged. The surface of the specimen is stained brown to dark brown suggesting a

Figure 29. Right mandible (NMC 10489, Herschel Island Locality 6) of a ?Pleistocene domestic dog *(Canis familiaris)*. A. Lateral view. B. Occlusal view.

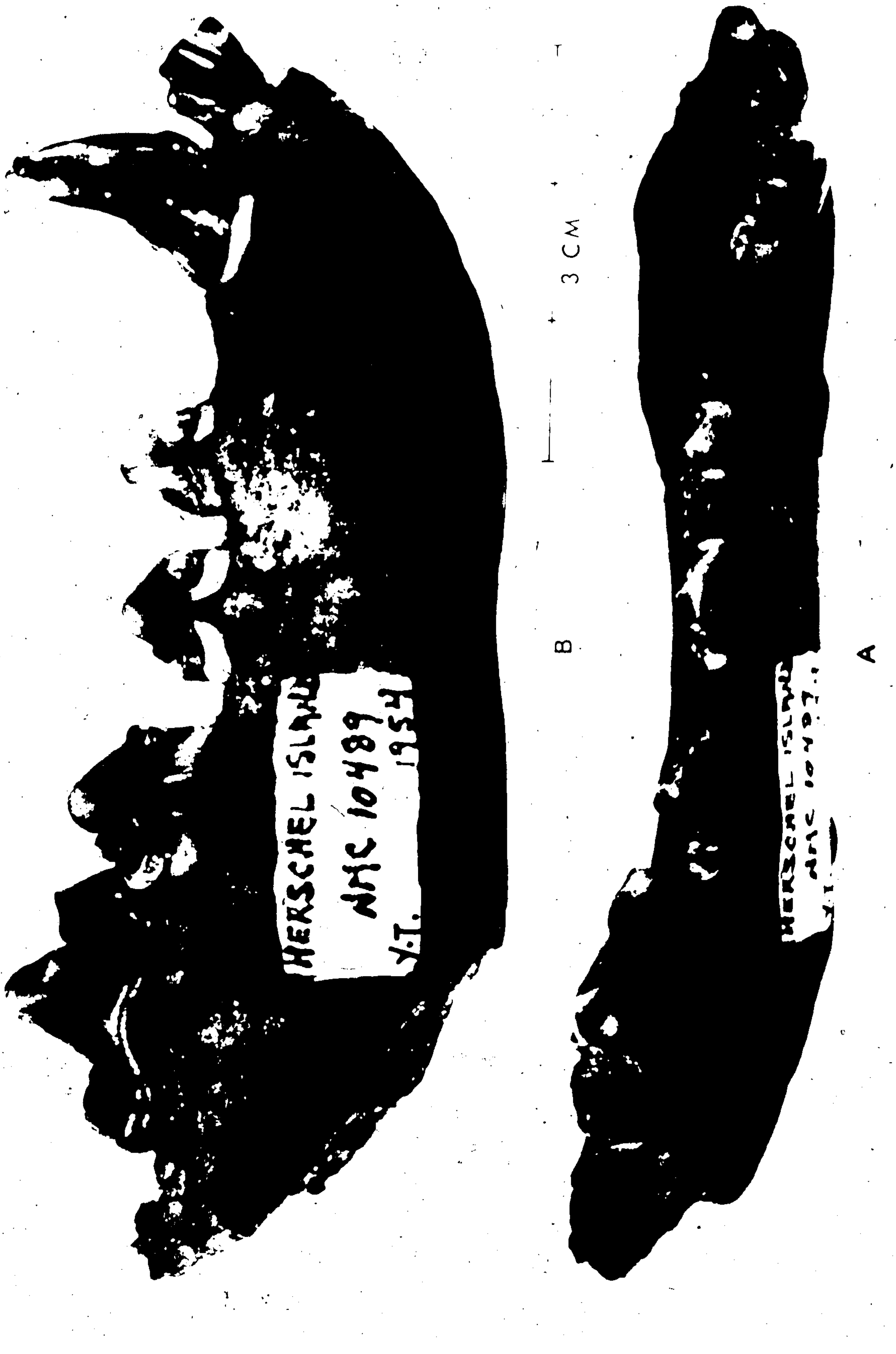

3 CM
B
A
HERSCHEL ISLAND
NMC 10489
Y.T.
1954
HERSCHEL ISLAND
Y.T.

Table 27. Measurements of a ?Pleistocene domestic dog *(Canis familiaris)* cranium from the Yukon Territory compared to crania of Recent domestic dogs from northern Canada and Greenland.

SPECIMEN	SEX	AGE (yrs.)	MEASUREMENTS (mm) * 1	2	3	4	5	6	7	8	9	10	11	12	13
Canis familiaris. ?Pleistocene, Y.T.															
NMC 29047A Dawson Loc. 29	-	-	208.1	201.5	102.8	87.9	30.5	59.8	73.8	18.5	43.4	36.6	32.9	86.3	14.3
Canis familiaris. Recent															
NMC 36085 Ellesmere I., N.W.T.	♂	-	211.9	216.5	112.3	91.8	38.7	62.7	76.9	21.6	46.0	41.3	41.2	93.7	15.0
NMC 36086 Ellesmere I., N.W.T.	-	4	237.7	230.6	122.9	93.3	39.0	70.5	92.9	20.0	49.3	49.1	44.9	102.7	16.2
NMC 36088 Ellesmere I., N.W.T.	♂	7	207.4	204.2	102.9	88.2	-	59.1	75.5	17.6	42.7	37.4	38.8	89.5	14.2
NMC 35222 Ellesmere I., N.W.T.	♂	8	226.0	221.5	114.4	93.9	36.0	61.3	78.8	18.7	46.0	44.9	39.6	95.9	13.4
NMC 35221 Ellesmere I., N.W.T.	♂	2	230.0	224.3	113.1	93.8	37.6	63.9	83.3	18.0	48.2	44.8	42.2	97.3	15.6
NMC 35223 Ellesmere I., N.W.T.	♂	6	235.7	222.4	112.2	94.3	38.3	64.0	79.3	20.4	47.7	40.7	41.2	97.5	15.3
NMC 35220 Ellesmere I., N.W.T.	♂	8	226.4	226.0	119.0	93.9	36.8	60.8	77.9	18.3	43.6	47.8	43.2	98.9	13.3
NMC 35219 Greenland	♂	-	228.6	213.0	110.8	89.3	35.0	61.6	78.5	17.3	45.1	42.1	43.4	91.8	14.1
NMC 9536 Greenland	-	-	-	216.8	111.0	92.4	36.3	61.3	77.1	20.7	45.1	39.7	40.9	92.5	12.5
NMC 19820 Y.T.	-	-	200.9	195.4	101.4	85.0	31.5	57.2	70.6	18.3	41.5	39.3	40.1	85.4	12.2
NMC 31817 N.W.T.	♀	-	176.5	178.9	89.7	76.6	27.0	56.2	68.9	16.9	41.8	32.4	31.9	78.1	11.8
NMC 31818 N.W.T.	♂	-	217.3	214.9	109.2	93.3	31.4	62.0	79.4	18.9	45.4	43.1	38.9	90.9	14.7

* 1. Greatest length. 2. Condylobasal length. 3. Palatal length (anterior of premaxilla to posterior of palate). 4. Postpalatal length (posterior of palate to inferior margin of foramen magnum). 5. Palatal breadth inside P^2s (minimum). 6. Width between postglenoid foramina. 7. Postzygomatic width (across squamosal ridges at level of auditory meati). 8. Basioccipital width (minimum width between auditory bullae). 9. Width across occipital condyles. 10. Minimum interorbital width. 11. Minimum width of braincase. 12. Alveolar length C^1-M^2. 13. C^1 length (at alveolus). 14. C^1 width (at alveolus). 15. P^1 length. 16. P^1 width. 17. P^2 length. 18. P^2 width. 19. P^3 length. 20. P^3 width. 21. P^4 length. 22. P^4 width. 23. M^1 length. 24. M^1 width. 25. M^2 length. 26. M^2 width.

10f

itory compared

MEASUREMENTS (mm) *																		
8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
8.5	43.4	36.6	32.9	86.3	14.3	8.0	-	-	-	-	13.7	5.7	20.0	10.9	14.0	16.6	8.1	11.6
1.6	46.0	41.3	41.2	93.7	15.0	9.2	6.5	4.9	13.7	5.9	15.3	6.8	22.0	13.1	13.9	18.9	7.8	12.0
0.0	49.3	49.1	44.9	102.7	16.2	9.9	6.3	4.5	12.0	5.7	13.9	7.3	22.2	13.9	14.2	20.0	8.4	12.9
7.6	42.7	37.4	38.8	89.5	14.2	9.1	5.0	4.4	10.6	4.5	12.9	5.9	20.8	11.8	13.0	17.9	7.2	11.8
8.7	46.0	44.9	39.6	95.9	13.4	8.8	5.5	4.2	11.9	5.0	13.4	5.7	22.0	11.7	13.3	18.6	8.2	11.9
8.0	48.2	44.8	42.2	97.3	15.6	9.0	6.2	4.6	12.7	5.7	14.7	7.3	21.6	13.6	13.2	18.1	7.6	12.7
0.4	47.7	40.7	41.2	97.5	15.3	8.8	6.2	4.5	12.1	5.6	14.5	6.9	22.2	12.7	13.9	18.8	7.5	11.4
8.3	43.6	47.8	43.2	98.9	13.3	8.3	5.8	4.6	13.3	5.4	14.8	6.4	21.6	12.0	13.7	18.7	8.8	12.4
7.3	45.1	42.1	43.4	91.8	14.1	8.2	6.5	4.2	12.8	5.3	14.7	6.3	-	-	13.9	19.8	8.6	12.7
0.7	45.1	39.7	40.9	92.5	12.5	8.5	6.4	4.5	10.8	5.2	13.5	5.8	-	-	14.3	18.5	8.1	12.3
8.3	41.5	39.3	40.1	85.4	12.2	7.9	5.7	3.6	10.9	4.7	12.9	5.4	19.9	10.2	13.3	16.2	7.7	10.4
6.9	41.8	32.4	31.9	78.1	11.8	7.7	6.2	4.3	10.4	4.9	12.6	6.8	20.9	11.2	13.3	17.1	8.1	11.1
8.9	45.4	43.1	38.9	90.9	14.7	8.7	-	-	11.4	5.0	13.9	5.9	20.4	10.8	13.6	17.5	8.0	11.2

. Postpalatal length

een postglenoid foramina.

between auditory bullae).

ength C^1-M^2.

. 19. P^3 length.

Table 28. Measurements of a ?Pleistocene domestic dog (*Canis familiaris*) mandible from the Yukon Territory compared to mandibles of Recent domestic dogs from northern Canada and Greenland.

SPECIMENS	SEX	AGE (yrs.)	MEASUREMENTS (mm) *													
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
Canis familiaris.?Pleistocene, Yukon Territory																
NMC 10489	-		-	11.4	19.8	9.8	-	-	8.6	4.3	9.9	5.0	11.8	6.1	21.4	8.9
Canis familiaris.Recent																
NMC 36085 Ellesmere I. N.W.T.	♂		30.3	15.0	27.0	12.7	4.8	4.8	11.5	5.8	13.8	6.8	14.3	8.0	36.2	11.3
NMC 36066 Ellesmere I. N.W.T.	-	4	36.0	14.8	28.7	14.2	5.6	3.9	9.6	4.5	11.6	6.2	13.0	7.5	26.0	11.2
NMC 36088 Ellesmere I. N.W.T.	♂	7	29.6	13.2	24.5	11.4	5.0	4.0	8.6	4.6	11.2	5.5	12.8	6.9	23.6	10.1
NMC 3[illegible]22 Ellesmere I. N.W.T.	♂	8	33.2	15.1	25.0	13.5	-	-	10.0	4.8	12.4	5.9	12.5	6.7	24.9	10.5
NMC 35221 Ellesmere I. N.W.T.	♂	2	32.5	14.5	27.9	12.7	5.2	4.1	10.2	5.4	12.3	6.4	14.2	8.0	25.4	11.4
NMC 35223 Ellesmere I. N.W.T.	♂	6	32.6	14.3	27.6	12.6	4.7	3.5	11.1	5.4	12.6	5.2	13.8	7.8	24.7	10.6
NMC 35220 Ellesmere I. N.W.T.	♂	8	32.4	15.3	28.2	12.7	4.9	4.0	11.2	5.2	12.0	7.3	13.8	7.1	24.4	10.8
NMC 35219 Greenland	♂	-	30.7	13.3	26.3	11.9	5.0	3.6	11.5	5.1	12.2	5.8	14.2	7.0	24.5	10.2
NMC 9536 Greenland	-	-	30.5	12.8	26.2	11.3	4.7	3.7	9.1	4.5	12.1	6.1	12.8	6.2	24.7	9.6
NMC 19820 Y.T.	-	-	26.5	12.0	23.8	11.2	4.6	3.4	8.7	4.9	10.8	5.3	12.5	6.2	22.5	9.3
NMC 31817 N.W.T.	♀	-	24.1	11.2	19.2	10.3	-	-	9.3	4.7	10.8	5.5	12.8	6.3	22.3	9.0
NMC 31818 N.W.T.	♂	-	28.6	13.5	22.8	12.0	4.1	3.8	9.6	4.8	11.8	5.6	13.3	7.0	24.2	9.9

* 1. Mandible depth below centre of M_1. 2. Mandible width below centre of M_1. 3. Mandible depth below point between P_3 and P_4. 4. Mandible width below point between P_3 and P_4. 5. Length P_1. 6. Width P_1. 7. Length P_2. 8. Width P_2. 9. Length P_3. 10. Width P_3. 11. Length P_4. 12. Width P_4. 13. Length M_1. 14. Width M_1. 15. Length M_2. 16. Width M_2. 17. Length M_3. 18. Width M_3. 19. Alveolar length P_1-P_4. 20. Alveolar length M_1-M_3. 21. Alveolar length P_1-M_3.

familiaris) mandible from the Yukon Territory compared to mandibles
reenland.

MEASUREMENTS (mm) *																	
4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
8	–	–	8.6	4.3	9.9	5.0	11.8	6.1	21.4	8.9	–	–	–	–	–	–	–
7	4.8	4.8	11.5	5.8	13.8	6.8	14.3	8.0	26.2	11.3	9.4	8.0	4.6	4.3	48.2	39.7	86.2
2	5.6	3.9	9.6	4.5	11.6	6.2	13.0	7.5	26.0	11.2	10.8	7.6	4.6	4.4	51.9	40.3	91.4
4	5.0	4.0	8.6	4.6	11.2	5.5	12.8	6.9	23.6	10.1	9.1	7.2	4.8	4.3	43.8	38.6	81.0
5	–	–	10.0	4.8	12.4	5.9	12.5	6.7	24.9	10.5	9.2	6.8	4.5	3.9	–	37.1	–
7	5.2	4.1	10.2	5.4	12.3	6.4	14.2	8.0	25.4	11.4	10.2	8.1	5.1	5.1	49.2	39.4	87.6
.6	4.7	3.5	11.1	5.4	12.6	5.2	13.8	7.8	24.7	10.6	10.1	7.6	5.4	4.8	47.5	40.2	85.5
.7	4.9	4.0	11.2	5.2	12.0	7.3	13.8	7.1	24.4	10.8	10.7	7.8	5.7	5.1	48.5	39.8	88.0
.9	5.0	3.6	11.5	5.1	12.2	5.8	14.2	7.0	24.5	10.2	10.5	7.6	6.3	5.5	43.7	40.5	83.2
.3	4.7	3.7	9.1	4.5	12.1	6.1	12.8	6.2	24.7	9.6	10.5	7.2	6.2	5.2	48.0	40.6	88.3
.2	4.6	3.4	8.7	4.9	10.8	5.3	12.5	6.2	22.5	9.3	9.2	7.5	4.6	4.3	43.0	35.9	77.7
.3	–	–	9.3	4.7	10.8	5.5	12.8	6.3	22.3	9.0	9.2	7.1	4.7	4.2	–	36.0	–
.0	4.1	3.8	9.6	4.8	11.8	5.6	13.3	7.0	24.2	9.9	9.5	7.6	–	–	45.0	38.9	83.8

ntre of M_1. 3. Mandible depth below point between P_3 and P_4. 4. Mandible width
7. Length P_2. 8. Width P_2. 9. Length P_3. 10. Width P_3. 11. Length P_4.
6. Width M_2. 17. Length M_3. 18. Width M_3. 19. Alveolar length P_1-P_4.

late Pleistocene age, but it could be of postglacial or even historic age. The specimen was washed out from a cut made by A. Sailer on the left limit of Dominion Creek in 1975. A third cervical vertebra was recovered with the cranium, perhaps indicating that a partly articulated specimen was preserved in the deposits.

This cranium has a markedly elevated forehead (or "stop" in the parlance of modern dog fanciers), relatively small teeth, and a tendency to flattening of the auditory bullae, which are among cranial characters customarily found reliable in separating northern forms of *Canis lupus* from *Canis familiaris* (Harrison 1973, p. 186). Also, the length of the carnassial is less than the combined length of M^1 and M^2 (Clutton-Brock 1969, p. 304). The specimen is larger than modern coyote skulls examined, and it differs from the dhole in its much greater length of snout (i.e. anterior to P^3s), the elevated forehead (which tends to be convex rather than concave in the dhole), and the relatively large M^2s (which appear almost vestigial in relation to M^1s in the dhole).

Another interesting point of difference from the other canids mentioned, is the inward convexity of NMC 29047A, which is most pronounced near the anterior margin of P^3s where the palatal breadth measured at the outer margins of the teeth rapidly decreases by approximately 40%. The maxillary teeth taper inward anteriorly more gradually in specimens of wolf, coyote and dhole that have been examined. In a sense, this can be considered as a "lateral stop". It is a characteristic feature of other domestic dogs, but perhaps not all dogs.

Plotting the values of basioccipital width against postzygomatic width and carnassial length plus M^1 width against the C^1-M^2 alveolar length for NMC 29047A on the scattergrams used by Harrison (1973, pp. 188-189) to separate dogs from wolves, this Yukon dog seems to be relatively large and is near the limit between dogs and wolves. A scattergram of this nature did not separate completely the North American sled dogs and wolves used for comparison in this study, although NMC 29047A was well within the domestic dog zone, and the Pleistocene wolf NMC 9929 lay within the wolf zone.

NMC 10489 from Herschel Island Locality 6 is a right mandible with RI_2-RI_3, RC_1 and RP_2-RM_1. The alveoli for RI_1 and the anterior root of RM_2 are also evident. RP_1 is not present. P_1s are often absent in domestic dogs, but almost never in wild canids (B. Lawrence, personal communication 1975). All teeth show moderate wear, indicating that the individual represented by the fossil was mature at death. The mandible is shorter, deeper and generally more robust than those of coyotes *(Canis latrans)* that I have seen. The small size of the heel of M_1 with greatly reduced entoconid and very small metaconid, the shortness of P_4 posterior to the main cusp, and the short, thick canine (10.2 mm x 6.3 mm x 15 mm high) also help to distinguish the specimen from coyote mandibles. NMC 10489 has two cusps on the posterior margin of M_1, unlike the dhole *(Cuon* sp. *)* which has only one - a centrally placed hypoconid and no entoconid. The specimen's small size and shortness, in conjunction with the apparently mature chronological age of the individual represented, distinguishes it from the wolf *(Canis lupus)* and the dire wolf *(Canis (Aenocyon) dirus)*. I am grateful to Barbara Lawrence for confirming my identification of NMC 10489 as *Canis familiaris.* Her conclusion was based on examination of a good cast.

A rather similar specimen called a "Birnirk dog" has been illustrated by Bee and Hall (1956, pp. 172-173). Like the "Birnirk dog" which was excavated from an early Eskimo house near Point Barrow, Alaska, NMC 10489 lacks P_1, and its P_1-M_2 alveolar length of 61.4 mm is not very different from those provided for three of these dogs: 60.2, 59.6, 61.5 mm. It is markedly smaller than a series of mandibles from Recent huskies, and slightly smaller than some material from a Dorset Eskimo site on Mill Island just north of Hudson Bay in the collections of the Museum of Comparative Zoology, Harvard University (B. Lawrence, personal communication 1975). It is interesting to note Møhl's comment that dogs from the early archeological site at Trail Creek, Alaska are considerably smaller than Eskimo dogs of the present day (Larsen 1968).

NMC 10489 was collected by R.S. McNeish in 1954 from the southwesternmost spit of Herschel Island. He recorded that it was "associated with mammoth ivory". Many Pleistocene vertebrate fossils have been found along the coasts of Herschel Island. Among them are specimens of the woolly mammoth *(Mammuthus primigenius)*, Yukon wild ass *(Equus (Asinus) lambei)*, large-horned bison *(Bison* cf. *crassicornis)*, extinct muskox (?*Bootherium* sp.), and tundra muskox *(Ovibos moschatus)* (Harington 1976 MS, p. 59). I suspect that the dog mandible is of Pleistocene age because both the mandibular bone and teeth are stained dark brown to black, which, using the rule-of-thumb apparently applicable to permineralization of fossils in the Dawson and Old Crow areas, would suggest a pre- late Wisconsin age.

Discussion

The potential scientific value of these specimens lies in determining their age. As they were not found in place in sedimentary deposits, the stratigraphic method of dating them is inapplicable. Nor can radiocarbon dating be reasonably employed, for it would mean destroying specimens of possibly great significance. In view of these facts, arrangements have been made to submit small samples of the bone and teeth to N. Rutter, University of Alberta, for amino acid racemization dates (Anonymous 1975a, p. 349). If not useful in the "absolute" sense, the results should at least be useful in terms of relative age.

No dogs of Pleistocene age have been reported from Canada or Alaska (the exact age of the Trail Creek dogs are not known). However, among the earliest recognized dog fossils in the world are those excavated at Jaguar Cave, Idaho (Lawrence 1967, 1968). Here, small dogs, similar in size to Basket Maker dogs of the Southwest, and large husky-like dogs lived together about 11,000 years ago south of the retreating Wisconsin ice. These data imply that domestication took place long before 11,000 years ago, and that hunters entering Alaska and the Yukon from Asia were accompanied by dogs. So it is theoretically reasonable to seek fossils of late Pleistocene dogs in Eastern Beringia.

Perhaps even earlier than the Jaguar Cave dog fossils, is a dog jaw with teeth from a cave at Palegawra, Iraq. An age estimate based on flourine analysis of the bone indicates that dogs were present when people first occupied the Palegawra Cave some 14,000 years ago (Anonymous 1975b, p. 54).

Degerbøl (1961) and La Baume (1962) have argued convincingly that the nearest ancestor of the domestic dog is a small race of *Canis lupus*. Lawrence (1967, p. 57) believes that North American dogs cannot have been domesticated from North American wolves, and suggests that *Canis familiaris* must have stemmed from small wolves, such as the extinct *C. l. variabilis* of the Pleistocene of China and Siberia (Pei 1934, p. 13; Vangengeim 1961, p. 73) or the living Indian wolf *C. l. pallipes*, which Trouessart (1911, p. 909) believed had given rise to all domestic dogs of Europe and Asia and the dingo. Clutton-Brock (1969, p. 307) argues for the Indian wolf as the most likely progenitor of the domestic dog. She states that its skull is extraordinarily similar in size and shape to the dingo and also the Indian pariah dog, with which it freely interbreeds, and that this stock gave rise to the dogs identified from prehistoric sites in western Asia. She also suggests that the much larger dogs from English (e.g. Star Carr) and Danish sites could have evolved from tamed European wolves. Olsen (1974, p. 345) favors the small race of the Chinese wolf *(Canis lupus chanco)* as an ancestor for the dog. Zeuner (1963, pp. 79-111) provides a wide-ranging account of the history of domestic dogs. On behavioral as well as anatomical grounds, it is assumed that the wolf is the ancestor of the domestic dog.

Domestic dogs are remarkable for their variety of sizes, shapes and uses. The American Kennel Club (1975, pp. 7-8) currently recognizes six major groups of dogs: (1) sporting dogs containing 24 breeds including setters, pointers and spaniels; (2) hounds with 19 breeds such as Beagles, Greyhounds and Elkhounds; (3) working dogs containing 30 breeds including Collies, German Shepherds, and huskies; (4) terriers with 22 breeds such as Airdales and Scottish Terriers; (5) toys with 17 breeds such as the Pekingese, and Poodle; (6) non-sporting dogs containing 11 breeds such as Bulldog and Chow Chow. These groups give an idea of the various ways people use dogs. There are many hybrids or mongrels. Domestic dogs are virtually world-wide in distribution - even in Antarctica, where huskies, adapted to survival as working dogs under cold climatic conditions, are used by scientific expeditions.

From a paleoenvironmental viewpoint remains of domestic dogs indicate the presence of man. People often control the reproduction of the animals by selective breeding, spaying, or other means. Like wolves, dogs are gregarious, and Eskimos have made good use of their natural association in packs by harnessing teams of huskies to provide sled transport in winter. Hunters generally provide their dogs with meat from the kill. In more civilized places the animals are given dog food consisting of meat and cereal, occasionally supplemented with bones. These animals sometimes live in dwellings occupied by people, or they may be left outside most of the time, in which case small shelters or kennels are usually provided by their owners. Domestic dogs are often killed by people when they are incapacitated by age, disease or severe injury. Some societies have bred dogs for food. Occasionally domestic dogs are attacked and killed by bears, wolves or large cats such as the mountain lion.

Alopex lagopus (arctic fox)

Although most arctic fox specimens (Figure 30A-D, Table 29) collected from Pleistocene deposits in the Yukon Territory have been collected from the Old Crow Basin, two

Figure 30. Left mandible with LP_2-LM_2 (NMC 29044, Dawson Locality 10) of a Pleistocene arctic fox *(Alopex lagopus)*. A. Lateral view. B. Occlusal view. Right mandible with RP_2-RM_2 (NMC 18329, Old Crow Locality 29) of a Pleistocene arctic fox *(Alopex lagopus)*. C. Lateral view. D. Occlusal view.

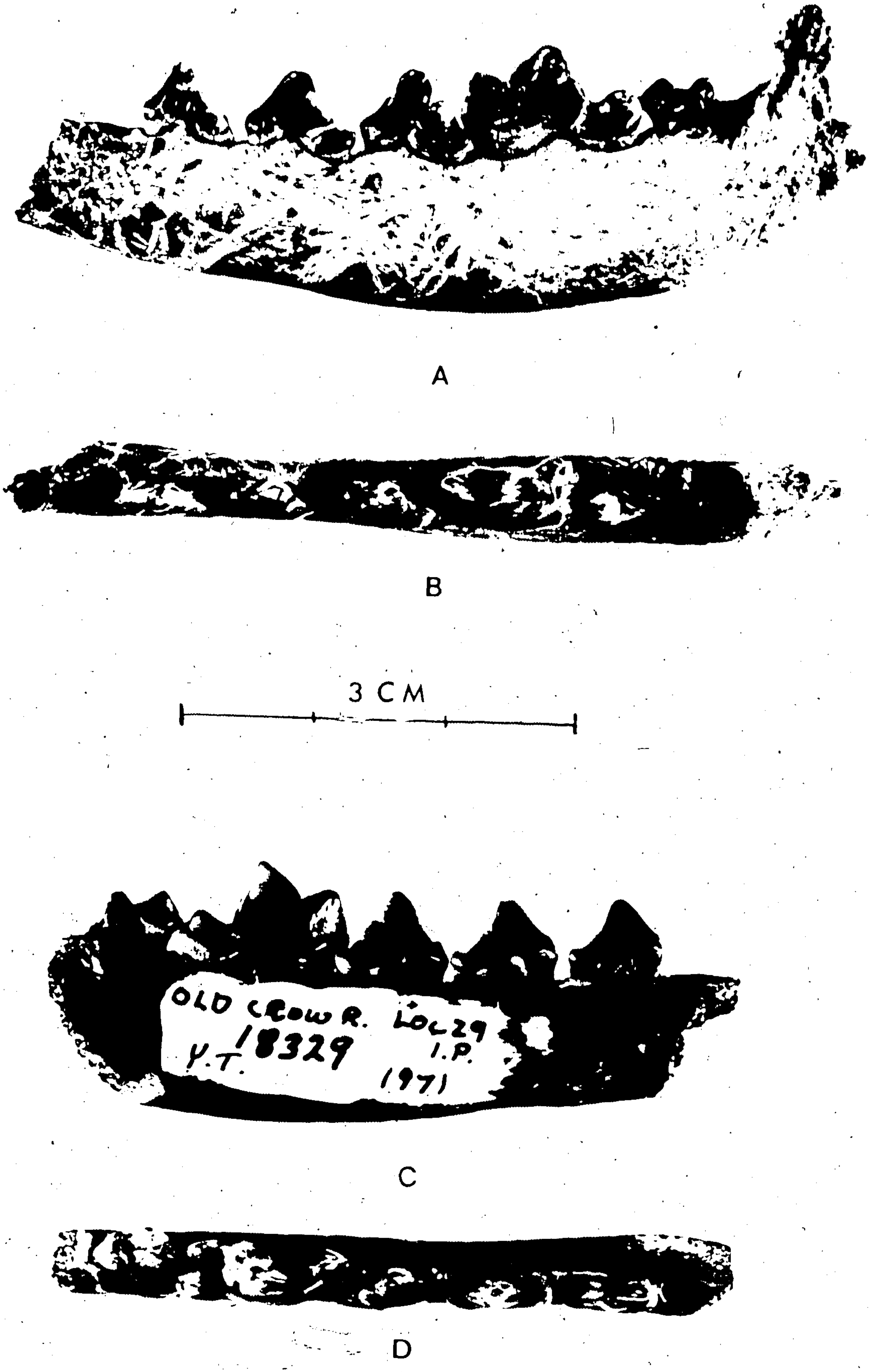

A
B
3 CM
OLD CROW R. LOC 29
Y.T. 18329
I.P.
1971
C
D

Table 29. Measurements of Pleistocene arctic fox (*Alopex lagopus*) mandibles from the Yukon Territory compared to those of Recent arctic foxes and red foxes (*Vulpes vulpes*) from the Northwest Territories and Alaska.

SPECIMENS	SEX	MEASUREMENTS (mm) *																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Alopex lagopus, Pleistocene, Y.T.																			
NMC 29044 Dawson Area	-	13.8	6.7	11.6	5.7	7.3	3.1	8.6	3.3	8.8	3.8	13.6	5.7	6.0	4.5	29.0	22.3	4.0	50.7
NMC 13218 Old Crow Loc. 29	-	15	6.9	11.2	6.0	6.6+	3.1	-	-	9.0	4.2	13.5	5.4	6.2	4.4	29.5	21.8	4.4	52.0
NMC 13329 Old Crow Loc. 29	-	12.5	6.1	10.7	5.5	7.1	2.8	8.4	3.1	8.7	3.8	13.1	5.1	6.1	4.3	29.3	-	4.2	-
NMC 29858 Old Crow Loc. 74	-	13.4	6.0	10.3	5.4	-	-	8.6	3.0	8.8	3.8	13.2	4.9	-	-	30.3	21.6	4.5	52.0
NMC 13247 Old Crow Loc. 11A	-	14.6	6.1	11.9	5.5	7.4	3.3	-	-	9.4	4.0	14.1	4.2	-	-	30.8	-	5.0	-
NMC 15563 Old Crow Loc. 44	-	-	-	10.5	5.6	7.8	2.9	7.4+	-	-	-	-	-	-	-	-	-	-	-
NMC 13331 Old Crow Loc. 29	-	-	6.0	10.4	5.5	7.3	3.1	-	-	-	-	13.7	5.2	-	-	28.5	-	4.8	-
NMC 13372 Old Crow Loc. 22	-	-	5.1	11.5	5.1	-	-	-	-	-	-	13.5	5.0	-	-	30.0	-	4.4	-
NMC 15233 Old Crow Loc. 29	-	13.7	6.2	-	-	-	-	-	-	-	-	13.5	5.0	6.1	4.5	-	-	4.6	-
NMC 22543 Old Crow Loc. 27W	-	-	-	10.3	5.0	7.0	3.0	-	-	-	-	-	-	-	-	28.5	-	-	-
NMC 15579 Old Crow Loc. 23	-	9.1	4.6	9.2	-	-	-	-	-	-	-	-	-	-	-	29.8	-	-	-
NMC 28722 Old Crow Loc. 65	-	-	-	10.4	5.5	-	-	-	-	-	-	-	-	-	-	29.5	-	-	-
NMC 26974 Old Crow Loc. 22	-	-	-	10.4	5.9	-	-	-	-	-	-	-	-	-	-	27.9	-	-	-
NMC 28768 Old Crow Loc. 27	-	14.1	6.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NMC 13310 Old Crow Loc. 29	-	-	-	9.6	5.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alopex lagopus, Recent, N.W.T.																			
NMC 21308	♂	14.8	6.2	11.9	5.7	-	-	8.2	3.8	8.8	4.4	14.0	5.5	5.7	4.1	29.7	21.1	4.8	50.9
NMC 21307	♀	13.3	5.8	11.6	5.4	7.8	3.4	9.0	3.5	9.9	4.1	14.5	5.6	6.2	4.3	30.3	22.1	4.6	52.5
NMC 21305	♂	13.4	5.9	11.4	5.6	9.0	3.5	8.7	3.6	9.2	4.2	14.4	5.7	6.3	4.5	30.5	22.3	4.6	52.4
NMC 21303	♂	14.5	6.7	11.6	6.0	8.1	3.6	8.9	3.7	9.7	4.7	14.4	5.7	6.2	4.3	29.2	23.4	4.2	52.1
NMC 21309	♂	14.0	6.4	11.9	5.4	8.3	3.5	9.2	3.6	9.9	4.7	15.3	5.5	6.7	4.8	31.6	24.8	5.5	55.8
Alopex lagopus, Recent, Pribilof Is.																			
NMC 30221	♂	[illegible]	6.3	13.0	6.3	7.0	3.3	7.6	3.5	9.1	4.3	14.0	5.4	6.2	4.3	28.9	22.2	4.4	51.9
NMC 30217	♂	14.9	6.6	12.8	6.9	6.8	3.1	7.8	4.1	8.5	4.1	12.7	5.3	5.5	3.9	28.0	21.0	3.6	49.4
NMC 30215	♂	14.2	5.9	12.2	5.9	7.9	2.9	8.2	3.1	9.1	3.8	13.1	5.2	5.6	4.3	29.8	21.2	4.1	53.8
NMC 30212	♂	14.3	5.9	12.4	6.1	7.4	3.2	7.7	3.1	8.5	3.8	12.4	5.0	5.5	4.1	30.0	20.3	3.7	50.2
NMC 30216	♂	15.1	6.4	12.6	6.0	7.5	3.1	8.2	3.3	9.3	4.3	13.3	5.4	5.4	4.0	30.2	20.3	4.0	50.8
NMC 30220	♂	16.1	6.7	13.0	6.5	6.8	3.0	7.5	3.4	8.6	4.1	12.7	5.0	5.0	4.0	29.7	21.2	3.8	50.5
Vulpes vulpes, Recent																			
NMC 17955 Y.T.	-	16.3	6.6	12.1	6.2	8.8	3.6	10.1	3.4	10.8	4.4	15.7	6.2	6.9	5.2	34.5	24.0	4.4	57.8
NMC 31973 Y.T.	♂	16.2	7.3	13.2	6.7	10.2	3.9	10.4	4.2	11.3	5.2	17.1	6.8	6.9	5.2	35.7	28.0	4.7	60.1
NMC [illegible]434 Alaska	♂	16.1	6.4	12.7	6.4	9.1	3.5	10.0	3.7	11.0	4.2	15.6	6.6	7.5	5.4	34.2	26.0	4.0	59.7
NMC 17956 Y.T.	-	15.6	7.4	13.2	6.3	8.9	3.7	9.9	3.6	10.4	4.7	15.6	6.4	6.6	5.2	37.8	[illegible]	4.7	63.4
NMC 31729 Y.T.	-	15.6	5.6	13.1	6.2	9.2	3.5	10.2	3.5	10.7	4.3	15.6	6.3	7.7	5.4	38.0	27.2	4.5	64.9
NMC 18132 Y.T.	?♀	15.6	6.4	12.3	6.6	9.4	3.7	10.0	3.8	10.5	4.8	16.7	6.8	7.0	5.4	34.5	24.0	4.9	57.3

* 1. Mandible depth below centre of M_1. 2. Mandible width below centre of M_1. 3. Mandible depth below point between P_3 and P_4. 4. Mandible width below point between P_3 and P_4. 5. Length P_2. 6. Width P_2. 7. Length P_3. 8. Width P_3. 9. Length P_4. 10. Width P_4. 11. Length M_1. 12. Width M_1. 13. Length M_2. 14. Width M_2. 15. Alveolar length P_1-P_4. 16. Alveolar length M_1-M_3. 17. Talonid length M_1. 18. Alveolar length P_1-M_3.

Light copy

are from the Dawson Area. Mandibles with teeth are most commonly preserved. Fossils of arctic foxes far outnumber those of red foxes *(Vulpes vulpes)* in the Yukon Territory.

Referred specimens

A right maxillary fragment containing RP^4 and partial alveolus for RP^3 (NMC 15723) from Old Crow Locality 28 represents a very old individual according to the degree of tooth wear. The tooth is 12.0 mm long x 5.3 mm wide, lying well below the sampled range for the red fox *(Vulpes vulpes)*. Although slightly smaller than any of the P^4 measurements of six Recent arctic foxes, it most closely matches a female from Tuktoyaktuk, Northwest Territories (NMC 21319) and is referred to *Alopex lagopus*. An RM^1 (NMC 28734) from Old Crow Locality 27 is perfectly preserved except for the roots. It too is relatively small (8.4 mm long x 9.6 mm wide). It compares closely with RM^1s of Recent male (NMC 21308) and female (NMC 21319) arctic foxes from the Northwest Territories. Both fossils are stained brown.

The mandibles described here have some or all of the following characteristics which tend to separate arctic foxes from red foxes: (a) shallower, shorter mandible; (b) relatively poorly developed posterolingual cusp on M_1; (c) distinctly shorter P_1-P_4 alveolar length; M_1-M_3

alveolar length is relatively short, but the difference is not so pronounced.

The best preserved specimen in the collection is a left mandible (NMC 29044) from Dawson Locality 10. It contains LP_2-LM_2 and lacks both the ascending ramus and tip of the mandible anterior to LP_1. Wear on the cusps is noticeable but not heavy. The teeth are stained a darker brown than the mandibular bone. The entire specimen is etched with impressions of rootlets, suggesting deposition in a grassland environment. Fine, micaceous, oxidized silt adheres to the mandible.

A right mandibular fragment (NMC 18329), similar to NMC 29044, containing RP_2-RM_2, was excavated from organic sandy gravel overlying the basal clay unit at Old Crow Locality 29. The specimen is stained dark brown and, according to the slight degree of wear on the cusps, represents a younger fox than NMC 29044. NMC 18218 from Old Crow Locality 29 is a right mandibular fragment with RP_2 and RP_4-RM_2. The roots of RP_4 are exposed well above the alveolar margin. The specimen is reddish brown. NMC 20858 from Old Crow Locality 74 is a right mandible with RP_3-RM_1. The teeth show heavy wear, suggesting that an old individual is represented. It is stained dark brown. Again, rootlet impressions are seen on the surface of the mandible. Another mandibular fragment with LP_2 and LP_4-LM_1 (NMC 18247) from Old Crow Locality 11A has heavily worn teeth. It is stained blackish brown.

NMC 15863 from Old Crow Locality 44 is important because it indicates the presence of arctic foxes in the Old Crow Basin more than 54,000 years ago, possibly during the Sangamon interglacial. It consists of a left mandibular fragment with LP_2-LP_3 and is stained dark brown. NMC 18331 is a left mandible with LP_2 and LM_1. The teeth are almost black, while the bone is stained brown. It was excavated from deposits overlying the basal clay unit at Old Crow Locality 29. NMC 14352, a right mandibular fragment containing a well worn RM_1 and sockets for RI_1 and RC_1-RP_4, is olive brown. The tooth is darker. The specimen was collected from the base of a sand deposit overlying the basal clay unit at Old Crow Locality 22. NMC 18330 from Old Crow Locality 29 is a left mandibular fragment with LM_1-LM_2 and the socket for LM_3. The tips of the cusps are slightly worn. The entire specimen is stained brown and compares closely with a Recent specimen of a male arctic fox (NMC 21305) from Tuktoyaktuk, Northwest Territories. NMC 22043 from Old Crow Locality 27W is a right mandible with RP_2 and sockets for RP_1 and RP_3-RP_4. The mandible is very shallow, despite the fact that it represents a mature individual according to heavy wear on RP_2. NMC 15579 from Old Crow Locality 28 is an edentulous right mandible containing alveoli for RC_1-RM_1. It is stained dark brown and is remarkably shallow. I tentatively refer it to a juvenile. NMC 28623, a left mandibular fragment containing sockets for LP_1-LP_4, was excavated at Old Crow Locality 65. The lateral surface has fine scratches and grooves as if it had been gnawed by another small carnivore when the bone was fresh. NMC 16974 is a left mandible with sockets for LP_1-LP_4 from the sand bar opposite to Old Crow Locality 22. It is a blackish brown color and has a burnished surface, which may be due to the action of wind blown sand. NMC 28668 from Old Crow Locality 27 is the posterior part of a left mandible containing sockets for RM_2-RM_3 and the posterior root of RM_1. It is light brown. A left mandibular fragment, NMC 18510, excavated from organic sandy gravel overlying the basal clay unit at Old Crow Locality 29, contains sockets for LP_3 and LP_4. It is stained black.

Approximately 70% of the arctic fox mandibles from Pleistocene deposits of the Old Crow Basin are from localities near, or just upstream from the mouth of Timber Creek. Perhaps a "proto-Timber Creek" concentrated these bones from former loess-steppe (note the rootlet impressions on some of the fossils) areas on the northern margin of the basin.

The second arctic fox specimen from the Dawson Area is a complete right tibia (NMC 29299) to which a lower segment of the fibula is fused. It was found in place in the muck overlying the gold-bearing gravel at Dawson Locality 10. Radiocarbon dates from bones in stratigraphically similar situations at five different localities in the Dawson Area range in age from approximately 15,000 to 32,000 years B.P.; the average being about 24,600 years B.P. (Harington 1975b, p. 5). Presumably the tibia is of late Wisconsin age. The specimen is fresh-looking, tan in color, and has a total length of 122.8 mm. It is closely comparable to the tibia of a Recent male arctic fox (NMC 14060) from Ellesmere Island, Northwest Territories.

Measurements of the Old Crow and Dawson fossils generally fall within the sampled ranges of those for Recent arctic foxes from the Northwest Territories. An interesting feature of the metric comparisons is that the mandibular depth between P_3 and P_4 varies, averaging 10.6 mm for the Yukon fossils, 11.7 mm for the Recent Northwest Territories specimens, and 12.7 mm for Recent specimens from the Pribilof Is

Discussion

The arctic fox, like the red fox, probably arose from *Vulpes alopecoides* during the middle Pleistocene in Eurasia, but it is not recorded until the late Riss (Illinoian) glaciation in Europe. There are a few records from Eem (Sangamon) interglacial deposits, but the species evidently did not become widely dispersed until the Würm (Wisconsin) glaciation (Kurtén 1968, p. 116). In northeastern Siberia, the species has been reported from late Pleistocene (Illinoian to Wisconsin?) deposits on Bolshoi Lyakhov Island, New Siberian Islands (Vangengeim 1961) and early Wisconsin deposits (Iedoma Suite) of the Kolyma Lowland (Sher 1971). Arctic fox specimens from late Pleistocene deposits near Fairbanks, Alaska are being described by R. Tedford and B. Taylor (personal communication 1976) of the American Museum of Natural History.

In the Yukon, the earliest arctic fox specimens are probably of Sangamon interglacial age (NMC 15863 from Old Crow Locality 44). Two fossils of late Wisconsin age are known from Hunker Creek in the Dawson Area. The Yukon fossils constitute the first arctic fox records from Pleistocene deposits in Canada.

Arctic foxes are circumpolar in distribution. Generally, they innabit tundra and, as fossils, are good cold climate indicators. However, sometimes these small foxes venture far south of their normal range into boreal forest areas; or they may move onto sea ice where they are known to follow polar bears and feed on the remains of their kills. Arctic fox populations usually undergo great fluctuations every three to five years. Crashes tend to follow crashes in lemming populations. Lemmings and other arctic voles are the main diet of the arctic fox. It also feeds on arctic hares, ground squirrels, ptarmigan, young birds and bird eggs (Banfield 1974, pp. 295-298).

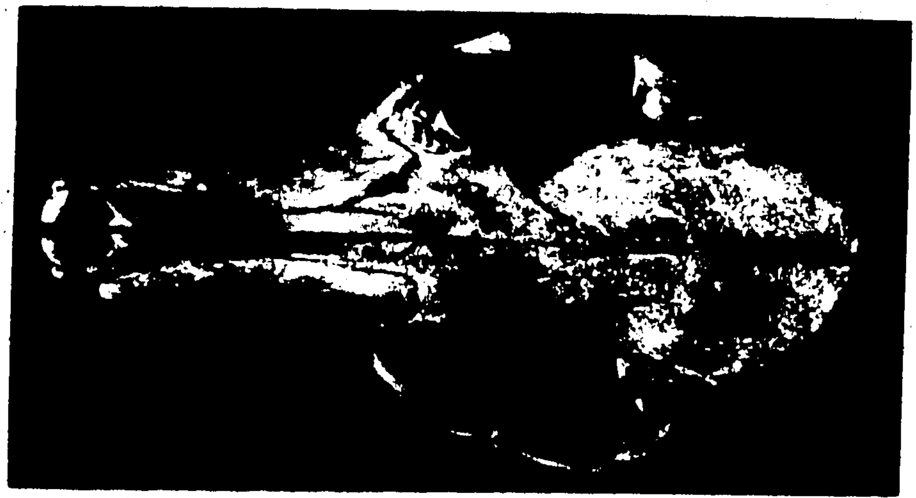
Vulpes vulpes (red fox)

Referred specimen

A single specimen consisting of a nearly complete cranium (NMC 28359; Figure 31A-C , Table 30) was collected on the surface at Locality 115 on the Old Crow River. The bone is stained deep brown, but the teeth, although they have a yellowish cast, look very fresh. All teeth are present and in good condition except for I^1s, I^2s, RC^1, P^1s and LP^3. The central part of the right zygomatic arch is missing.

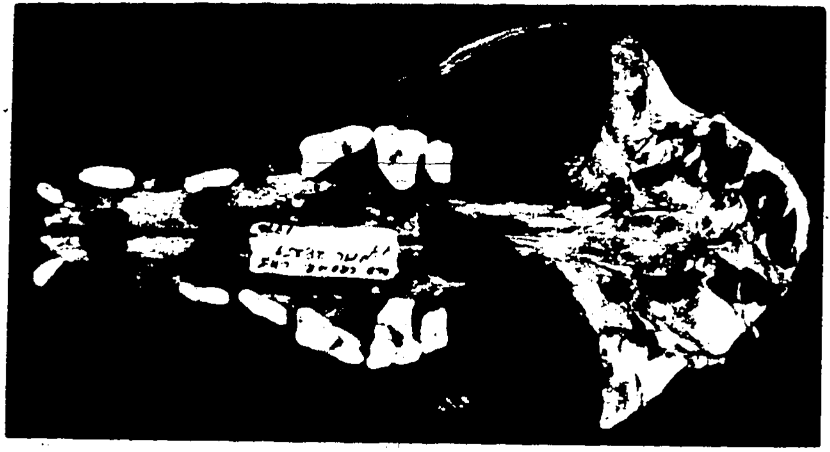
A key to separating the red fox from the arctic fox *(Alopex lagopus)* on the basis of cranial measurements

Figure 31. Cranium (NMC 28359, Old Crow River Locality 115) of a Pleistocene red fox *(Vulpes vulpes)*. A. Dorsal view. B. Left lateral view. C. Ventral view.



A

B



C

Table 30. Measurements of a Pleistocene red fox (*Vulpes vulpes*) cranium from the Yukon Territory compared to crania of Recent red foxes and arctic foxes (*Alopex lagopus*) from northern North America.

SPECIMENS	SEX	MEASUREMENTS (mm) *																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Vulpes vulpes. Pleistocene, Y.T.																				
NMC 28359 Old Crow Loc. 115	-	150.0	77.6	66.5	85.0e	46.7	17.8	30.4	23.2	10.6	3.6	11.2	3.9	17.3	7.5	[illegible]	13.7	5.5	8.1	[illegible]
Vulpes vulpes. Recent																				
NMC 31673 Y.T.	♂	156.0	75.6	68.4	80.3	43.8	16.9	29.2	21.7	10.8	3.8	11.4	4.2	17.2	7.8	10.4	11.4	5.7	7.6	71.4
NMC 31729 Y.T.	♂	150.8	75.2	65.4	81.4	43.4	15.7	28.3	23.9	9.7	3.4	10.9	3.8	[illegible]	7.2	9.9	[illegible]	5.9	8.5	[illegible]
NMC 17956 Y.T.	-	147.9	75.5	62.9	76.9	43.4	16.0	27.9	24.3	9.4	3.6	10.5	3.8	15.9	6.6	10.0	[illegible]	5.8	[illegible]	[illegible]
NMC 17355 Y.T.	-	142.9	72.9	67.6	72.4	39.8	14.4	26.9	24.7	9.0	3.2	10.6	[illegible]	15.5	6.9	9.7	11.2	5.3	7.2	[illegible]
NMC 18132 Y.T.	♀	141.8	73.9	60.7	75.8	42.6	15.0	29.2	24.8	10.0	3.4	10.5	[illegible]	[illegible]	7.6	9.5	11.3	5.2	7.9	[illegible]
NMC 2434 Alaska	♂	139.7	69.2	61.1	78.5	43.0	13.7	30.3	24.2	9.9	3.5	10.3	[illegible]	[illegible]	7.1	10.5	11.9	5.6	8.7	63.4
Alopex lagopus. Recent																				
NMC 21309 N.W.T.	♂	124.1	59.3	54.4	65.3	38.2	16.3	27.3	25.9	8.3	3.5	9.2	3.7	13.2	7.3	8.8	11.2	4.7	7.3	57.7
NMC 21303 N.W.T.	♂	123.2	58.3	54.4	71.5	40.6	18.4	29.3	25.4	8.2	4.0	9.1	4.2	14.5	7.2	8.7	10.4	4.9	7.4	[illegible]
NMC 21307 N.W.T.	♀	120.5	58.5	52.8	68.1	39.4	16.4	26.7	22.9	8.2	3.5	9.0	3.7	14.3	7.0	8.5	10.3	4.5	6.8	55.9
NMC 21398 N.W.T.	♂	119.2	57.0	52.8	69.8	40.0	16.0	27.8	24.1	7.3	3.4	8.9	3.6	14.1	6.4	8.4	10.3	4.4	6.7	53.5
NMC 21305 N.W.T.	♂	117.8	55.5	51.9	68.1	40.1	15.9	26.5	22.9	8.0	3.6	8.9	3.7	13.6	6.6	8.7	10.2	4.4	7.0	[illegible]
NMC 21319 N.W.T.	♀	116.3	54.4	52.9	65.9	36.0	15.2	22.0	24.5	7.8	3.6	8.1	3.6	13.0	6.6	8.5	10.1	4.9	6.6	[illegible]

* 1. Condylobasal length. 2. Palatal length. 3. Postpalatal length. 4. Zygomatic breadth. 5. Width across outer faces of M^1s. 6. Palatal width inside P^2s. 7. Interorbital width. 8. Width at postorbital constriction. 9. Length P^2. 10. Width P^2. 11. Length P^3. 12. Width P^3. 13. Length P^4. 14. Width P^4. 15. Length M^1. 16. Width M^1. 17. Length M^2. 18. Width M^2. 19. Alveolar length (C^1-M^2).

is that in the former, the rostral width measured at P^2 is less than 18% of the condylobasal length (Youngman 1975, p. 124). In this case, the percentage is 16.6, indicating that NMC 28359 is referable to *Vulpes vulpes*. Also, as Kurtén (1966, p. 5) has pointed out, the infraorbital foramina in the red fox (and this specimen) are situated directly above the posterior roots of the P^3s, while in the arctic fox they are situated farther back, above and between the P^3s and P^4s.

The Old Crow specimen is larger than most Recent red fox specimens from the Yukon and Alaska with which it was compared. Only a male cranium from the Yukon (NMC 31073) approaches the fossil in size. The fossil is much larger in most measurements (e.g. condylobasal length and carnassial length) than Recent crania of arctic foxes from the Northwest Territories with which it was compared.

Discussion

The red fox may have evolved in Eurasia from *Vulpes alopecoides* of Villafranchian age. Its earliest European representatives occurred in the Holstein (= ?Yarmouth) interglacial and were of small size. The species probably entered North America during the Illinoian glaciation, for the oldest fossils there are from deposits of that age (e.g. Conard Fissure, Arkansas) (Kurtén 1968, p. 116). Both the red fox and arctic fox have been recorded from early Wisconsin deposits (Iedoma suite) in the Kolyma Lowland of northeastern Siberia (Sher 1971).

In Canada, remains of the red fox have been reported from Sangamon interglacial deposits at Medicine Hat, Alberta (Stalker and Churcher 1970) and from postglacial deposits estimated to be 5,000 to 6,000 years old near Hamilton, Ontario (Wetmore 1958, Churcher and Karrow 1963). The specimen from the Old Crow Basin appears to be of late Pleistocene age. Nothing more specific can be said.

Late Pleistocene sites where *Vulpes vulpes* has been recorded are rare in the United States. It is known from the Fairbanks area of Alaska (Péwé 1975a, p. 97), Burnet Cave and Isleta Caves, New Mexico, Ventana Cave, Arizona, and Little Box Elder Cave, Wyoming (Anderson 1968, p. 27).

The red fox is found throughout North America in a variety of habitats ranging from tundra to forests and from dry uplands to swamps. It prefers partly open country. An interesting feature of its distribution in the present interglacial is that, since the early 1900's, red foxes have dispersed rapidly northward as far as Ellesmere Island (Macpherson 1964). Red foxes are omnivorous. Their main diet consists of rodents and hares, but they also feed on birds, fishes, other small animals and plants.

Cuon sp. (dhole)

A single specimen of the dhole (Figure 32A-C, Table 31) has been recovered from Yukon Pleistocene deposits. Fragmentary postcranial specimens from the Old Crow Basin that are intermediate in size between coyote and wolf may in part represent the dhole, but they are not described.

Referred specimen

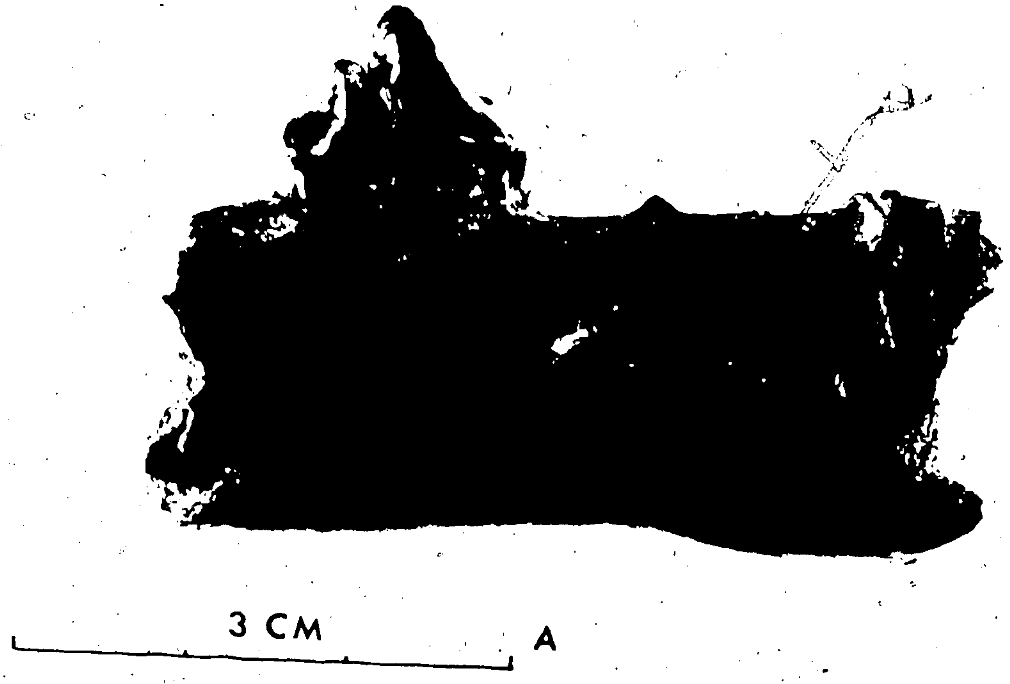
NMC 14353 from Old Crow Locality 14N is a right mandible fragment with RP_4, the socket for part of the anterior root of RM_1, the alveolus for RP_3, the alveolus for RP_2 lacking part of the socket for the anterior root, and the posterior part of the socket for RP_1. RP_4 is virtually unworn and does not differ from RP_4s in two Recent Chinese *Cuon* specimens (AMNH 54984 and 43144) except that it is slightly larger - and there is a good deal of variation in the size of that genus. The RP_4 has a small but clear anterointernal cusplet, which is also

Figure 32. Right mandibular fragment with RP$_4$ (NMC 14353, Old Crow Locality 14N) of a Pleistocene dhole (*Cuon* sp.).

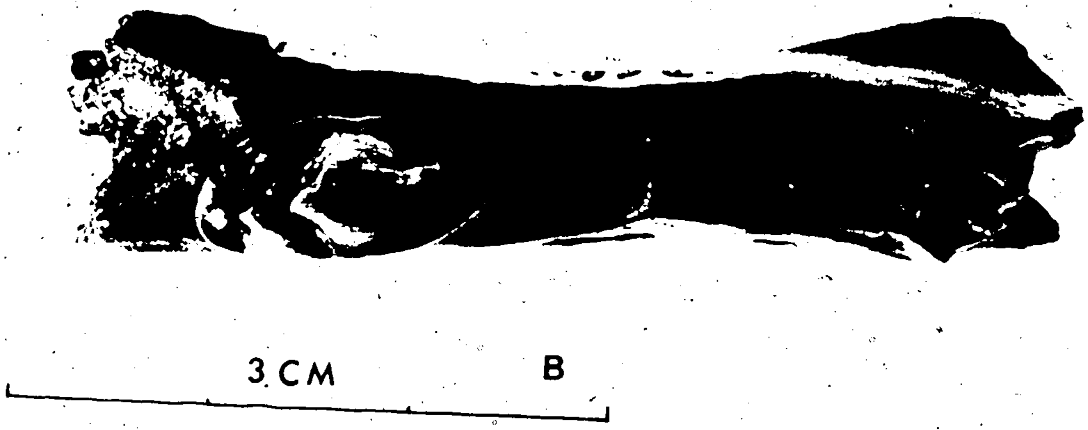
A. Lateral view.

B. Occlusal view.

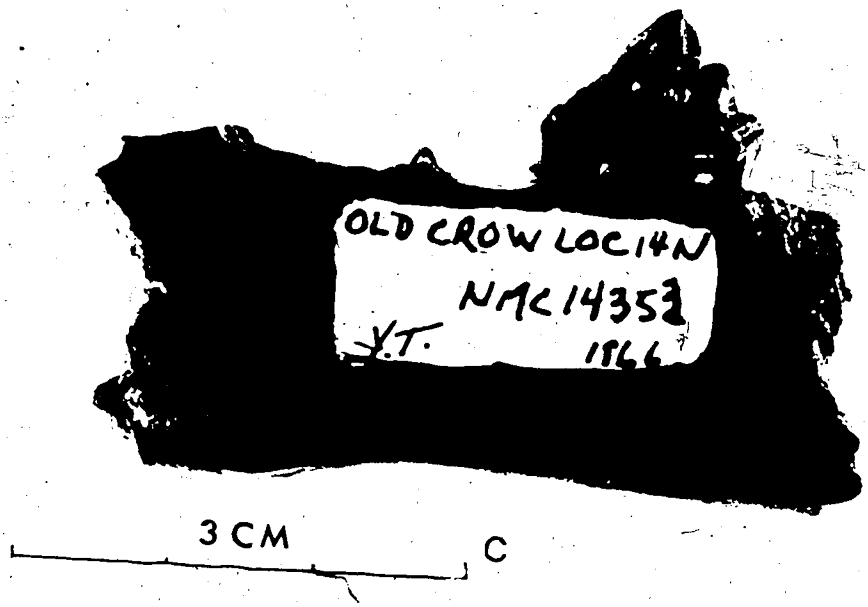
C. Medial view.



A



B



C

Table 31. Measurements of a Pleistocene dhole (*Cuon* sp.) mandible from the Yukon Territory compared to mandibles of Recent dholes from China.

Specimens	Sex	Measurements (mm)*																				
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17***	18***	19	20	21
Cuon sp. Pleistocene, Y.T.																						
NMC 14353 Old Crow Loc. 14N	-	21.0**	12.0**	19.0**	9.0**	-	-	-	-	-	-	15.0	6.9	-	-	-	-		-	-	-	-
Cuon sp. Recent, China																						
AMNH 54984 Yunan Province	♂	23.9	11.2	20.7	10.2	5.3	3.5	8.6	4.8	9.8	4.8	12.6	6.3	20.2	7.9	6.7	5.6	-	-	37.7	27.1	63.9
AMNH 43144 Yunan Province	♂	22.2	10.2	20.6	9.0	4.6	3.3	7.2	4.5	9.6	4.7	11.6	6.0	20.7	7.9	6.0	5.9	-	-	35.6	27.9	62.7

*1 - Mandible depth below centre of M_1.
2 - Mandible width below centre of M_1.
3 - Mandible depth below point between P_3 and P_4
4 - Mandible width below point between P_3 and P_4
5 - Length P_1
6 - Width P_1
7 - Length P_2
8 - Width P_2
9 - Length P_3
10 - Width P_3
11 - Length P_4
12 - Width P_4
13 - Length M_1
14 - Width M_1
15 - Length M_2
16 - Width M_2
17 - Length M_3
18 - Width M_3
19 - Alveolar length P_1-P_4
20 - Alveolar length M_1-M_2.
21 - Alveolar length P_1-M_2.

** Approximate.

*** M_3 not present in *Cuon*.

observable in the Chinese specimens. The nearly straight, rather crowded tooth row of NMC 14353 is characteristic of the dhole mandible (B. Lawrence, personal communication 1975). A slight departure from straightness results from the outward turning of the anterior part of RP_2, but this appears to be a function of its being crowded between RP_3 and RP_1, which are in direct line with RP_4. The mandible, like that of the coyote *(Canis latrans)*, is narrower mediolaterally than in the wolf *(Canis lupus)*, but in this fossil and in Recent *Cuon* examined it is flatter and deeper than in the coyote. The jaw thickens toward the symphysis, but not enough of this diagnostically valuable region is preserved to securely distinguish the fossil from canids other than the dhole. Important features of NMC 14353 seen in comparative specimens and figures (e.g. Novikov 1962, p. 88) of *Cuon* are the pronounced concavity of the inferior profile of the jaw below P_3, and the series of three mental foramina - the largest below the anterior root of P_2 and smaller ones below the anterior and posterior roots of P_3. The latter feature is observable in AMNH 54984, but is somewhat variable, for only two foramina are present in another mandible of the same species (AMNH 43144).

I am grateful to R.H. Tedford (personal

communication, 1970) for examining the original specimen and confirming my preliminary identification of NMC 14353 as *Cuon*. In comparing the Yukon fossil with Recent Asian and Pleistocene specimens of *Cuon* in collections of the American Museum of Natural History, he suggested that it appeared to be closest to *Cuon javanicus*. However, as the specimen is relatively incomplete it seems best to refer it to *Cuon* sp., until better material becomes available.

Discussion

The fossil is stained black, suggesting a pre-late Wisconsin age. I suspect that a fossil from Alaska is also referable to *Cuon*. It is a mandible (F:AM 67180) collected by Otto Geist from Illinoian sediments at Cripple Creek near Fairbanks. The specimen was later identified by M.C. McKenna as *Xenocyon* (Péwé and Hopkins 1968, p. 269). I follow Romer (1966, p. 384) and Gromova (1968, p. 32) in considering *Xenocyon* a junior synonym of *Cuon*. These two specimens are the first records of the dhole from America.

In Siberia, *Cuon* is known from ?late Pleistocene deposits in the Lower Udin Caves (Gromova 1968, p. 269), but it has not been reported in any of the major Pleistocene vertebrate faunas of northeastern Siberia.

The true dhole, resembling *Cuon alpinus priscus*, has been found as early as Mindel (?Kansan) time in China (Choukoutien) (Kurtén 1968, p. 114).

Both dhole and the hunting dog *(Lycaon)* are closely related to *Canis*, probably diverging from that stock as late as the Astian (late Pliocene). The general trend in the evolution of the dhole is a reduction in the number of tooth cusps and an increase in trenchancy of those remaining. The most primitive species, *Cuon majori* of the late Villafranchian of Europe and China, was characterized by slightly smaller, sharper teeth than in *Canis*. By Waalian (?Nebraskan) or Cromer (?Aftonian) interglacial time *Cuon* had lost M_3, as demonstrated in fossils of the very large *C. majori stehlini*. *Cuon alpinus* first appeared in Germany during the late Günz (?late Nebraskan), and M_2 changed from a three-cusped condition to a trenchant single-cusped tooth between that time and the late Pleistocene, as exemplified by fossils of the large, wolf-sized *C. alpinus europaeus* (Kurtén 1968, p. 113). In Europe the dhole has been reported from Czechoslovakia, Hungary, Austria, Switzerland and Monaco during the late Pleistocene. It became extinct there at the close of the Würm (Wisconsin) glaciation.

Evidently *Cuon* originated from ancestral *Canis* stock in Eurasia during the late Pliocene and had reached North America by Illinoian time as indicated by the mandible from near Fairbanks, Alaska. Probably its ability to survive in cool alpine and steppe conditions enabled it to move across the Bering Isthmus in pursuit of game during the late Pleistocene.

The dhole looks like a small, rust-colored wolf. It has relatively long slender legs, a short muzzle, erect ears with rounded tips and a very furry tail. Presently it is found from southern Siberia to Malaya, Sumatra and Java, and it seems to prefer alpine forest regions. In some cases it is found above the treeline. It hunts in packs, preying on goats, sheep and deer (Stroganov 1969, p. 79). Dholes are occasionally trapped by man. As can be seen by its dentition, the dhole is more exclusively carnivorous than most canids (Kurtén 1968, p. 114).

Family Ursidae

Arctodus simus yukonensis
(Yukon short-faced bear)

Several cranial and postcranial specimens (Figures 33A-C, 34A-C, 35A, Table 32) are referred to this

Figure 33. Cranium (NMC 7438, Dawson Locality 31) of a Pleistocene Yukon short-faced bear *(Arctodus simus yukonensis)*. A. Dorsal view. Note damage to upper part of cranium. B. Right lateral view. C. Ventral view.

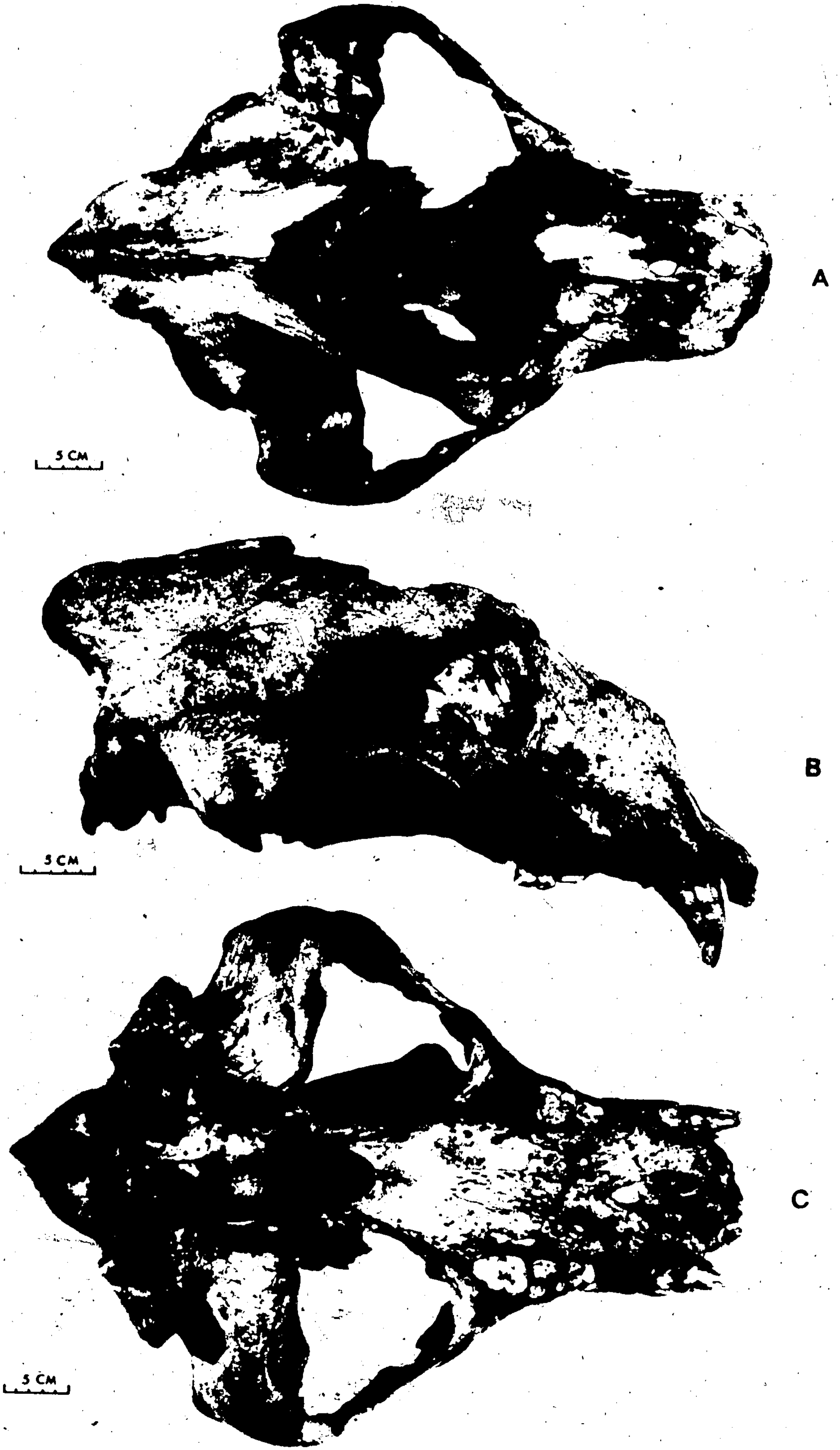

A
5 CM
B
5 CM
C
5 CM

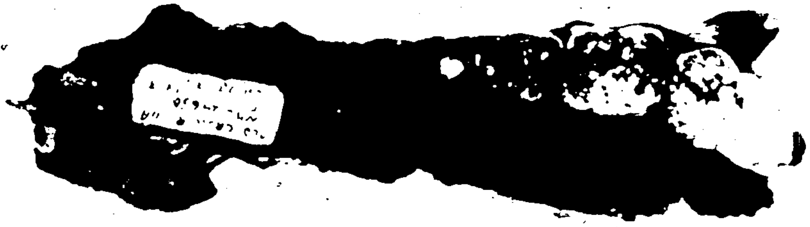
Figure 34. A. Lateral view of a left facial fragment with LP^3-LM^2 (NMC 24650, Old Crow Locality 11A) of a Pleistocene Yukon short-faced bear *(Arctodus simus yukonensis)*.

B. Ventral view of NMC 24650 showing occlusal surfaces of teeth.

C. Restoration of a Yukon short-faced bear *(Arctodus simus yukonensis)* attacking a large-horned bison *(Bison crassicornis)*. Ink sketch by Bonnie Dalzell.

C

A



B

Table 32. Measurements of Pleistocene Yukon short-faced bear (*Arctodus simus yukonensis*) crania from the Yukon Territory compared to those of Yukon short-faced bears from Alaska, Nebraska and California.

Specimens	Measurements (mm)*																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Arctodus simus yukonensis, Pleistocene, N. America																	
NMC 7433 Dawson Loc. 31, Y.T.	440	463	521	260	364	135	152	205	105	26.0	22.5	17.[illegible]	[illegible]7.0	25.0	37.5	25.0	22.0
NMC 24650 Old Crow Loc. 11A, Y.T.	-	-	-	-	-	-	-	-	-	-	20.0	15.[illegible]	23.2	19.8	35.1	20.8	17.5
NMC 19006 Old Crow Loc. 66, Y.T.	-	-	-	-	-	-	-	-	-	-	21.6	16.8	25.2	22.8	37.4	23.6	19.8
F:AM 30492 Upper Cleary Ck., Alaska**	416	444	496	249	354	136	141	194	107	25.1	24.6	16.8	27.7	27.3	40.8	25.8	23.7
F:AM A-366-1075 Ester Ck., Alaska**	416	438	480	240	-	124	141	177	94	22.1	22.3	15.4	26.6	25.1	[illegible].7	24.2	23.0
F:AM 25531 Hay Springs, Nebraska**	413	436	490	236	-	125	-	184	-	21.0	23.4	18.9	26.3	26.1	41.4	25.8	21.7
UC 40086 Irvington, California**	-	-	470?	-	-	122	124	-	87	23.3	23.9	18.0	-	-	-	-	-

* 1 - Basal length
2 - Condylobasal length
3 - Maximum length
4 - Palatal length
5 - Zygomatic width
6 - Rostral width at canines
7 - Width over M^2
8 - Width over postorbital processes
9 - Width of nasal opening
10 - C^1 width
11 - P^4 length
12 - P^4 width
13 - M^1 length
14 - M^1 width
15 - M^2 length
16 - M^2 anterior width
17 - M^2 central width

** Measurements from Kurtén (1967).

subspecies. They come from Pleistocene deposits in the Dawson and Old Crow areas. The large size of the fossils, in addition to other characteristics, allow them to be readily distinguished from black *(Ursus americanus)*, brown *(Ursus arctos)* and polar *(Ursus maritimus)* bears.

Referred specimens

While digging for gold on fractional claim 57a on Gold Run Creek (Dawson Locality 31), J.S. Perron found most of a bear cranium at a depth of 40 feet (12.2 m) in frozen ground. The specimen was sold to P.F.X. Genest of Ottawa, who in turn sold it to the Geological Survey of Canada (Harington and Clulow 1973, p. 699). It later became part of the collections of the National Museums of Canada.

Lambe (1911a) first referred to the specimen as *Arctotherium* cf. *simum*, and later (Lambe 1911b) described it as the type of a new species of short-faced bear *Arctotherium yukonense*, which he considered to be most closely allied to *A. simum* Cope. Kurtén (1967, p. 57) recognized a subspecific difference between the very large forms from the Yukon, Alaska, California (Irvington), and Nebraska (Hay Springs), and the remaining forms. He named the former *Arctodus simus yukonensis* and the latter *A. s. californicus*.

The cranium (NMC 7438) is in good condition except for damage to the upper anterior portion. The nasals and the greater part of the frontals are lacking. On the left side LI^2 and premolars anterior to LP^4 are missing, as are the three incisors, and the premolars anterior to RP^4 and RM^2 on the right side. The size of the skull, the large canines, the well-developed sagittal crest and the heavy tooth wear suggest that an old male is represented. The great zygomatic breadth of the cranium is remarkable; it is nearly 70% of the length of the skull. The upper part of the occiput considerably overhangs the occipital condyles. Perhaps Lambe (1911b, p. 22) was incorrect in interpreting the three alveoli between the canines and P^4s as sockets for P^1 and a double-rooted P^3. As Merriam and Stock (1925, p. 12) have noted, the three anterior premolars are single-rooted, so probably the alveoli referred to by Lambe are actually for P^1, P^2 and P^3. Table 32 shows the relatively large size of NMC 7438: apparently it exceeds all other skulls of *A. simus* (Kurtén 1967, p. 8). It is difficult to determine the original color of the skull for it was covered with dark shellac. Probably it is of late Pleistocene age.

NMC 24650 from Old Crow Locality 11A is a left facial fragment with LP^3-LM^2, and partial sockets for LI^1-LI^3, LC^1, LP^1 and LP^2. The premaxilla is well fused to the maxilla. The clearly exposed socket for LC^1 shows that the root was approximately 36 mm in anteroposterior diameter and 70 mm long. The lateral face of the paracone of LP^4 has been broken off. The paracone and metacone of LM^1 are moderately worn, and there is slight wear on the paracone of LM^2, suggesting that the bear was mature. The teeth are brownish green while the facial bone is blackish brown.

NMC 19006 from Old Crow Locality 66 is a fragmentary right maxilla containing RP^4-RM^2. RP^4 is virtually unworn, while the paracone and metacone of RM^1 are less worn than those of NMC 24560. Staining is similar to the previous specimen, except that the teeth are blacker.

Two complete canines are in the collection. NMC 15266 from Old Crow Locality 22 appears to be LC^1. The tip is blunt and a large wear facet is developed on the medial surface where occlusion occurred with LC_1. Part of the cementum has been stripped from the anterior of the root, exposing a series of what may be annular growth rings. An attempt will be made to section these canines in order to learn about the life span of these extinct bears. Maximum dimensions of the tooth are 34.7 mm long x 24.2 mm wide. NMC 21057 from between Old Crow Localities 14 and 14N may be RC^1. It is worn at the tip and is partly split lengthwise. Its maximum dimensions are 31.5 mm long x 20.7 mm wide. The former tooth is stained reddish brown, the latter dark brown.

NMC 21091 from Old Crow Locality 14 is the anterior part of a mandible with LC_1 and alveoli for most of the incisors, RC_1, LP_1 and LP_4-LM_2. The canine is very heavily worn and polished. LP_2 and LP_3 are absent in this fossil, which evidently represents an old individual. Three mental foramina typical of *Arctodus* are seen from a lateral view below the alveolar margin of LC_1, below the "diastema" between LP_1 and LP_4, and below the anterior root of LP_4. Minimum depth of the mandible below the diastema is approximately 55 mm, which is comparable to *Arctodus simus* specimens UC 3001 and 3003 from Potter Creek, California (Kurtén 1967, p. 27). The mandibular bone is dark brown, the canine being stained reddish black.

A few of the more complete postcranial elements will be mentioned. NMC 28299 from Old Crow Locality 136 is an axis vertebra lacking the transverse processes. Maximum width across the articular surface for the atlas is 77.8 mm; greatest width across the postzygapophyses is 57.1 mm; the neural spine is slightly more than [illegible] mm long; and the greatest length of the centrum 81.9 mm.

NMC 27831 from Old Crow Locality 67 is the distal end of a right humerus. The outer bar enclosing the entepicondylar foramen is missing in part. Its maximum distal width is 115.8 mm, and its maximum width across the distal articular surface is 83.6 mm. These measurements are relatively small compared to other *A. simus* humeri from California Pleistocene deposits (Kurtén 1967, p. 31). NMC 26864 from Old Crow Locality 22 is a left radius lacking the distal epiphysis. The total length of this bone is 410^{+} mm, which makes it markedly longer than complete radii of *A. simus* from Potter Creek Cave, California (UC 10262 and 3427 are 374.5 mm and 389.3 mm long respectively). Maximum proximal diameter is 68.2 mm; midshaft width is 37.0 mm; midshaft depth is 23.1 mm; and the maximum distal width is 77.9 mm. This bone indicates that *Arctodus simus yukonensis* was a very long-legged bear. Kurtén (1967, p. 47) has remarked on this feature of *A. simus* previously. NMC 27581 from Old Crow Locality 66 is the proximal half of another left radius, which is more massive than NMC 26864: probably it was larger all over than that specimen. The part preserved is 214.8^{+} mm long; maximum proximal diameter is 66.6^{+} mm (the articular margins are heavily eroded); midshaft width is 42.4 mm; and midshaft depth is 27.7 mm. NMC 2729[illegible] from Old Crow Locality 29 is a left calcaneum measuring 114.1 mm in total length, 70.6 mm in maximum width, and 40.2 mm in width of the cuboid facet. These measurements are small compared to those of a series from California measured by Merriam and Stock (1925, p. 31).

Discussion

Most fossils of the Yukon short-faced bear are very darkly stained, suggesting a pre- late Wisconsin age. Likely these bears reached Eastern Beringia, the northernmost part of their range, during an interglacial - perhaps the last (Sangamon) interglacial. Yet fossils of this animal have been excavated from deposits (e.g. Old Crow Locality 44) that appear to be of Sangamon age. A cranium (NMC 9438) from the Dawson Area may be of late Wisconsin age. The only other Canadian record of *Arctodus simus* is a mandible fragment with M_3 from what appear to be outwash deposits laid down at the close of the Sangamon interglacial near Fort Qu'Appelle, Saskatchewan (Harington 1973, p. 14).

Two very large skulls of the Yukon short-faced bear are known from Ester and Upper Cleary creeks in the Fairbanks area of Alaska. They are probably of late Pleistocene age (Kurtén 1967, p. 8).

Arctodus belongs to the Tremarctinae; the other two subfamilies of bears being the Agriotheriinae and the Ursinae. *Ursavus*, which lived from early to middle Miocene time, probably gave rise to the two living bear subfamilies. Of these, the Tremarctinae are known only from America, the earliest representative of the group being *Plionarctos* of late Pliocene age. Likely this genus is ancestral to the spectacled bear, *Tr*[illegible], and the short-faced bear, *Arctodus*. The early history of *Arctodus* is poorly known, but it seems to have become widespread in North America about Kansan time (e.g. Rock Creek, Texas; Irvington, California; Port Kennedy Cave, Pennsylvania; and possibly Fossil Lake, Oregon and Hay Springs, Nebraska). Three species of Pleistocene South American short-faced bears are recognized; *Arctodus (Arctotherium) bonariensis*, the largest; *Arctodus (Arctotherium) pamparus*, from Argentina; and *Arctodus brasiliensis*, the smallest *Arctodus* known - which may lie near the ancestor which gave rise to the Nearctic and Neotropical branches of of the genus.

Of the two North American species, *Arctodus pristinus*, a rather lightly built bear with small teeth and slender limb bones, appears to be the more primitive and occupied territory near the Atlantic coast. *Arctodus simus* is characterized by a shorter face, longer teeth and larger, more powerful limbs. Its remains have been found almost exclusively west of the Mississippi River. It ranged from Alaska to Mexico. Northern populations of *A. simus* seem to have been the largest in size. A distribution map of *Arctodus* localities in North America (Harington 1973, Figure 2) indicates that *A. simus* occupied higher, well-drained grasslands, whereas *A. pristinus* preferred more heavily wooded Atlantic coastal regions. *A. simus* became extinct toward the close of the Wisconsin glaciation some 10,000 years ago, perhaps partly because of the earlier extinction of some of its large herbivorous prey and partly because of increased competition with brown bears *(Ursus arctos)*, which seem to have entered North America from Eurasia during the Illinoian glaciation. Remains of brown and short-faced bears have been found together in late Wisconsin deposits of Little Box Elder Cave in Wyoming (Kurtén and Anderson 1974, p. 3).

The spectacled bear *Tremarctos ornatus* of South America is the closest living relative of *Arctodus*.

Kurtén (1967, p. 50) considers *A. simus* to have been a predominantly carnivorous species, and by far the most powerful land predator in the Pleistocene of North America. It may have preyed on large herbivores, such as bison, deer, horses, and ground sloths. Certainly bison and mammoths were among its contemporaries in both southern Saskatchewan and the Yukon - Alaska region during the late Pleistocene.

Ursus cf. *americanus* (American black bear)

Referred specimen

A single specimen (Table 33) from the Old Crow Basin Pleistocene deposits is tentatively referred to the black bear. NMC 16425 from Old Crow Locality 57 is a complete right scapholunar. It is similar in size and morphological features to the same element from a Recent black bear (NMC 7061). The fossil is smaller than a scapholunar of a Recent brown bear from the Northwest Territories, and is stained dark brown.

Table 33. Measurements of a Pleistocene black bear (*Ursus* cf. *americanus*) scapholunar compared to that of a Recent black bear, Recent brown bear *Ursus arctos*) and Pleistocene short-faced bears (*Arctodus* sp.)

Specimens	Measurements (mm)* 1	Measurements (mm)* 2
Ursus cf. *americanus*. Pleistocene, Y.T.		
NMC 16425 Old Crow Loc. 57	40.5	38.0
Ursus americanus. Recent, Quebec		
NMC 7061	37.4	35.3
Ursus arctos. Recent, N.W.T.		
NMC 2772	46.4	46.5
Arctodus sp. Pleistocene, California (Merriam and Stock 1925, P. 26)		
UC 5975	56.3	56.0
UC 24253	71.6	71.8

* 1 - Maximum length.
2 - Maximum width.

Discussion

The Yukon specimen appears to be of pre- late Wisconsin age. The only other report of this species of relatively great age in Canada is in the Acasta Lake fauna from the Northwest Territories, which is approximately 7,000 years old according to radiocarbon dates (Harington 1976 MS. p. 53). *Ursus* sp. is reported from Illinoian deposits near Fairbanks, but there are no definite records of the black bear in the Pleistocene of Alaska. The earliest specimens from North America appear to be of Kansan age. They were found in Port Kennedy Cave, Pennsylvania. However, the possibility exists, if Bjork's (1970, p. 17) ideas are correct, that an ursine bear that he describes as *Ursus abstrusus*, closely related to *Ursus boeckhi* of Eurasia, entered North America during the Pliocene and either became extinct or gave rise to *Ursus americanus* independent of Eurasian bears of the subgenus *Euarctos*. Admitting that the evidence is slim, I prefer the former explanation, which implies a secondary migration of bears of the subgenus *Euarctos* from Asia to North America about Kansan time.

Ursus americanus apparently has affinities with the living Asiatic black bear *(Ursus thibetanus)* and the extinct *Ursus etruscus*, which evidently gave rise to the brown, polar and cave bears. Erdbrink (1953, p. 316) makes the interesting remark that an attempt at a reconstruction of the Etruscan bear would be aided by considering the external appearance, size and general habits of the American black bear. Kurtén (1968, p. 129) agrees, stating: "This species might almost be regarded as a surviving slightly modified Etruscan bear....".

Ursus thibetanus has not been identified from Pleistocene deposits of northeastern Siberia. However, to the south, specimens of late Villafranchian age in China are transitional between *U. etruscus* and *U. thibetanus*. The latter species seems to have been predominantly Asiatic in distribution, occurring in China from the middle to late Pleistocene. By the Cromer (?Aftonian) interglacial it had spread to central Europe (the European black bear is sometimes regarded as a distinct species, *U. mediterraneus*).

In summary, it is clear that the Asiatic black bear *(U. thibetanus)* evolved from the Etruscan bear *(U. etruscus)* during the late Villafranchian in eastern Asia. It had reached central Europe by the ?Aftonian interglacial and, as an ancestor of the American black ar, had spread to eastern North America by Kansan ne, suggesting a crossing of the Bering Isthmus during the Kansan glaciation. This early form of the American black bear was still very similar to its ancestor, the Asiatic black bear (Kurtén 1968, p. 129).

Ursus americanus is confined to North America, ranging from the plateau of Mexico northward to the tree line. It is found throughout the Yukon Territory. These bears are relatively small, lacking the "dished" face of the brown bear, and displaying a variety of pelt colors. They prefer coniferous or deciduous forests as habitats, and are often found near marshes and berry patches. Generally, they occupy winter dens from October to April. [illegible] are omnivorous and opportunistic feeders, rather like [illegible] brown bears, but concentrating more on plant food. About three-quarters of their diet is vegetable matter (Banfield 1974, p. 306). Men and brown bears sometimes prey on black bears.

Ursus arctos (brown bear)

In this discussion, I refer to any member of the species *Ursus arctos* as a brown bear. The modern North American subspecies, *Ursus arctos horribilis* and *Ursus arctos middendorffi*, are referred to as the grizzly bear and Kodiak bear, respectively. Because of their general incompleteness and scarcity, the Yukon fossils are referred to *Ursus arctos*, rather than either of the living subspecies.

Brown bear fossils (Figure 35B-C, Tables 34-35) are rarely collected from Pleistocene deposits in the Yukon Territory. Three specimens are from the Old Crow Basin, and one is from the Dawson Area. The fossil mandibles are much larger in every respect than those of the black bear *(Ursus americanus)* and smaller than those of Kodiak bears *(Ursus arctos middendorffi)* seen. The mandibles are most like those of the grizzly bear *(Ursus arctos horribilis)*, but because the teeth and other important features are missing, the fossils are referred to *Ursus arctos*.

Referred specimens

NMC 25141 from Old Crow Locality 12 is a left mandible lacking teeth, which is badly damaged near the canine socket. The posterior two-thirds of the ascending ramus is missing. In addition to the partial socket for LC_1, alveoli for LP_4-LM_3 are present. Four anterior mental foramina are situated approximately half way up the mandible. The two anterior ones are relatively large and situated below the diastema. The third is small and is below the anterior root of P_4, while the fourth lies beneath the posterior root of LP_4. The specimen is stained blackish brown.

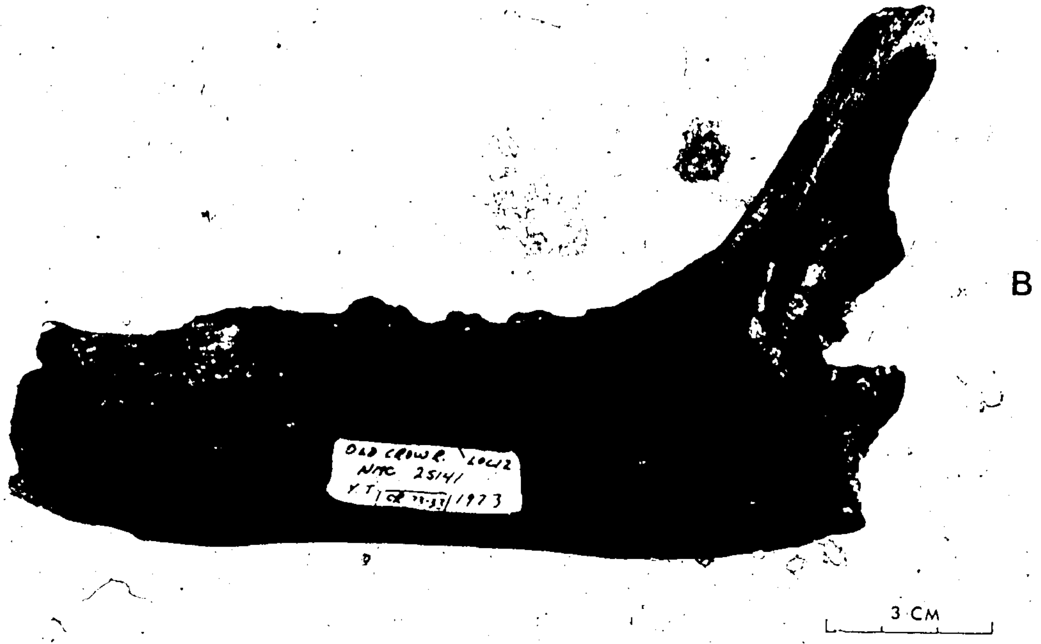
NMC 17388 from Old Crow Locality 20 is the anterior part of a left mandible containing the diastema and socket for LC_1. Three small indentations, which are interpreted as vestigial alveoli for LP_1-LP_3, are seen on the superior

Figure 35. A. Occlusal view of a right maxillary fragment with RP^4-RM^2 (NMC 19006, Old Crow Locality 66) of a Pleistocene Yukon short-faced bear *(Arctodus simus yukonensis)*.

B. Lateral view of a left mandible (NMC 25141, Old Crow Locality 12) of a Pleistocene brown bear *(Ursus arctos)*.

C. Anterior view of a right tibia (NMC 20386, Old Crow Locality 21) of a Pleistocene brown bear *(Ursus arctos)*.


A
3 CM


OLD CROW R. LOC 12
NMC 25141
Y.T. [illegible] 1973
B
3 CM

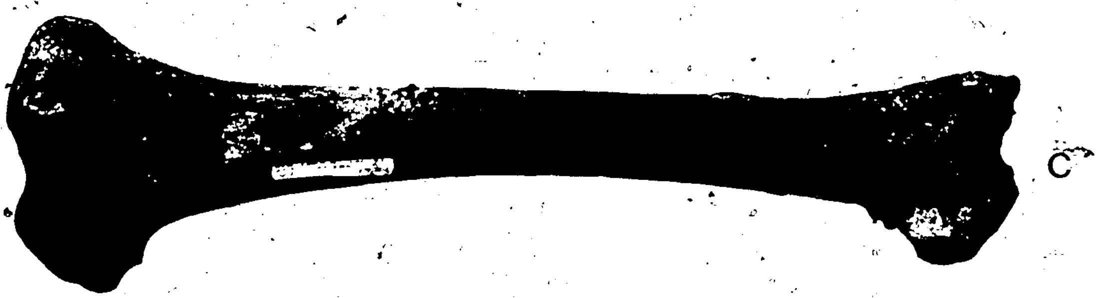

C

Table 34. Measurements of Pleistocene brown bear *(Ursus arctc* mandibles from the Yukon Territory.

Specimens	Sex	Measurements (mm)*				
		1	2	3	4	5
Ursus arctos. Pleistocene, Y.T.						
NMC 25141 Old Crow Loc. 12	-	44.1	18.4	43.0	18.7	84.6
NMC 17388 Old Crow Loc. 20	-	37.6	17.2	-	-	-

*1 - Depth of mandible immediately anterior to P_4.

2 - Thickness of mandible immediately anterior to P_4.

3 - Depth of mandible at centre of M_2 taken on lateral side.

4 - Thickness of mandible at centre of M_2.

5 - Alveolar length P_4-M_3.

Table 35. Measurements of Pleistocene brown bear *(Ursus arctos)* tibiae from the Yukon Territory compared to those of Recent brown bears from Canada, a Recent black bear *(Ursus americanus)* from Quebec, and a Pleistocene short-faced bear *(Arctodus* sp.*)* from California.

Specimens	Measurements (mm)*						
	1	2	3	4	5	6	7
Ursus arctos.Pleistocene, Y.T.							
NMC 20386 Old Crow Loc. 21	265.7	72.5	51.2	21.9	26.7	57.0	33.9
NMC 29005 Dawson Loc. 17	-	-	-	-	-	61.8	34.8
Ursus arctos.Recent, Canada							
NMC 3983	266.1	70.4	49.2	21.1	28.3	55.2	30.6
NMC 3980	271.2	73.2	52.2	23.0	29.4	57.3	30.7
NMC 3979	260.7	70.6	53.9	21.2	32.7	50.7	30.7
NMC 3976	284.8	72.4	52.6	19.4	29.9	54.0	33.0
Ursus americanus.Quebec							
NMC 7061	249.3	67.8	48.9	20.2	22.4	48.8	25.7
Arctodus sp. California (Merriam and Stock 1925, p. 29)							
LAM Z31	404.0	110.7	-	40.7	41.6	88.4	52.0

*1 - Total length.
2 - Distal width.
3 - Distal depth.
4 - Midshaft width.
5 - Midshaft depth.
6 - Distal width.
7 - Distal depth.

surface of the diastema. A single large mental foramen lies below the centre of the diastema. R.H. Tedford assisted me in comparing NMC 17388 to specimens of the black bear *(Ursus americanus)*, spectacled bear *(Tremarctos ornatus)*, extinct short-faced bear *(Arctodus)* and grizzly bear *(Ursus arctos horribilis)* in the collections of the American Museum of Natural History. It is closest to the grizzly bear, and is referred to *Ursus arctos*, pending better evidence. NMC 25141 and 17388 are alike in dimensions of the diastema and the fact that the mental foramina are highly situated on the mandible compared to those observed in recent *U. arctos*.

NMC 20386 from Old Crow Locality 21 is a complete right tibia. The crest is sharp and the medially trending ridges for muscle attachment are well marked. The lateral ridge, extending most of the length of the tibia on the posterior surface, is well developed as in other Recent brown [illegible] tibiae to which it was compared. It is poorly developed [illegible] specimen of *Ursus americanus* examined. The anterior margin of the medial malleolus of NMC 20386 forms a well developed ridge seen in other Recent brown bear tibiae, but not in a Recent black bear tibia. A slight swelling, perhaps pathological, occurs on the lower third of the medial side of the shaft of the fossil. A nutrient foramen is situated on the posterior upper quarter of the shaft, between the ridges marking the border of the flexor digitorum muscle. These foramina are quite variable in position in *U. arctos*. The fossil is stained reddish brown.

NMC 29005 from Dawson Locality 17 is distal third of a left tibia which is comparable in size to those of recent grizzly bears from Canada. It is light buff in color.

Discussion

The dark staining of the Old Crow specimens suggest that they are of pre- late Wisconsin age, while the tibial fragment from the Dawson Area is relatively fresh in appearance, suggesting a late Wisconsin age.

Specimens identified as *Ursus* sp. have been reported from Illinoian deposits at Cripple Creek Sump near Fairbanks, Alaska (Péwé 1975a, p. 96), but it is not certain that they represent the brown bear. *Ursus arctos* is definitely known from Wisconsin deposits near Fairbanks, and I (Harington 1976 MS. p. 75) have identified a brown bear mandible from Pleistocene sediments of the Ikpikpuk River on the Arctic Slope of Alaska.

Fossils from southeastern Canada are of greater immediate importance in estimating the time of migration of the brown bear from Eurasia to North America. Part of a mandible attributed to *U. arctos* was derived from Sangamon, or perhaps more likely, early Wisconsin sediments at Toronto, Ontario, and part of a left humerus of *U. arctos* was collected from mid-Wisconsin deposits at nearby Woodbridge, which are estimated to be 40,000 to 50,000 years old (Churcher and Morgan 1975, p. 341). Grizzly bears also occupied Ontario during late Wisconsin time, for a well preserved skull with partial postcranial skeleton was found in beach deposits near Orillia. Radiocarbon analysis of a limb bone fragment associated with the skull yielded a date of 11,700 ± 250 years B.P. (Peterson 1965, p. 1233).

Evidence concerning the presence of grizzly bears east of their present range has been discussed by Harington *et al.* (1962) and Guilday (1968). In addition to the late Wisconsin specimen mentioned by Peterson, the skull of "*Ursus procerus*" from late Pleistocene (?Sangamon interglacial) gravels near Overpeck, Ohio is considered by Harington and Kurtén to represent *Ursus arctos* (Harington *et al.* 1962, p. 295; Guilday 1968, p. 248). The brown bear is also known from what are presumed to be postglacial deposits in Welch Cave, Kentucky (Guilday 1968, p. 248). The occurrence of brown bears in eastern North America during the late Pleistocene adds credence to persistent and evidently well-founded rumors of their survival until Recent times in the Ungava Peninsula (Elton 1954, p. 345; Harper 1961, pp. 104-110; Wright 1962, pp. 83-89).

Other records of *Ursus arctos* from southern North America are: two skulls of "Pleistocene" age from Lawton and Cheyenne, Oklahoma (Stovall and Johnston 1935); a skull of probable Pleistocene or possibly later age from Lenora, Oklahoma (Stovall 1936, p. 781); remains of late Wisconsin (approximately 10,370 years B.P.) age from Jaguar Cave, Idaho (Kurtén and Anderson 1972, seven skull fragments, teeth and some postcranial material from late Wisconsin deposits at Little Box Elder Cave, Wyoming (Anderson 1968, p. 30); and a small skull from Rancho La Brea, California, considered by Kurtén (1960, p. 6) to be of postglacial age.

In northeastern Siberia, *Ursus* sp. is recorded from the Olyor Suite of Mindel (?Kansan) age. *Ursus arctos* first definitely occurs in the early Wisconsin Iedoma Suite of the Kolyma Lowland (Sher 1971). Remains of brown bears are relatively common in late Pleistocene to Recent sediments in caves in the karst region of southern Siberia (Ovodov 1970, p. 124).

The earliest brown bears are known from Mindel (?Kansan) deposits of Choukoutien, China. They were large and probably stemmed directly from the smaller Etruscan bear (*Ursus etruscus*), which lived in southern Europe during the Villafranchian. Brown bears continued to occupy eastern Asia from the early Pleistocene to the present, evidently entering Europe during the Holstein (?Yarmouth) interglacial and ultimately displacing the cave bear *(Ursus spelaeus)* there (Kurtén 1968, p. 127). Evidence considered previously indicates that brown bears first entered North America from Siberia during the late Illinoian glaciation, and that they had reached eastern North America by early Wisconsin, or possibly Sangamon time.

Brown bears are one of the largest carnivores living in the Holarctic region, some individuals being comparable in size to the largest polar bears *(Ursus maritimus)*. Human competition has forced the once widespread brown bears to withdraw to rather isolated mountainous or tundra areas in northwestern North America.. They are found throughout the Yukon Territory. Closely related brown bears occur in a broad belt across Eurasia and in parts of Europe, where they are threatened by local extinction. Brown bears prefer open areas, as shown by their present distribution in alpine and arctic tundra, and subalpine forest of the Cordillera. They formerly occupied the Great Plains, and survivors of that population are sometimes encountered in the Swan Hills of Alberta.

In late autumn they seek caves or other shelters for the winter, sometimes excavating dens on hillsides. Denning generally lasts from November to April. Brown bears are omnivorous. They graze and scavenge; hunt moose, wapiti, mountain sheep and ground squirrels; and catch salmon in coastal streams. In summer they feed heavily on berries of various kinds. Humans are the main predator of this species, but occasionally brown bears kill people.

Family Mustelidae

Mustela erminea (ermine)

Referred specimens

Few ermine specimens (Figure 36A-D, Tables 36-37) have been collected from Pleistocene deposits in the Old Crow Basin. The best specimen consists of most of a left mandible with LP_3-LM_2 (NMC 28782) excavated from redeposited sands at Old Crow Locality 20. It is stained black, suggesting a pre- late Wisconsin age. The apex of the coronoid process seems to have been slightly eroded, which probably accounts for its lack of depth in the ascending ramus compared to a sample of Recent ermine from the Northwest Territories. Apart from a slightly deeper mandible, the specimen is closely comparable with Recent samples. Two Recent ermine mandibles from the Ural region of the Soviet Union (NMC 27544,

Figure 36. A. Lateral view of a left mandibular fragment with LP_3-LM_2 (NMC 28782, Old Crow Locality 20) of a Pleistocene ermine *(Mustela erminea)*.

B. Occlusal view of NMC 28782.

C. Medial view of a right ulna (NMC 25320, Old Crow Locality 27W) of a Pleistocene ermine *(Mustela erminea)*.

D. Anterior view of NMC 25320.


A
5 MM
B
C
5MM
D

Table 36. Measurements of Pleistocene ermine (*Mustela erminea*) mandibles from the Yukon Territory compared to those of Recent ermine from the Northwest Territories and the Soviet Union.

		Measurements (mm)*				
Specimens	Sex	1	2	3	4	5
Mustela erminea. Pleistocene, Y.T.						
NMC 28782 Old Crow Loc. 20	-	5.3	1.9	10.0	4.0	10.2+
NMC 25076 Old Crow Loc. 27W	-	5.8	-	-	4.2	-
Mustela erminea. Recent, N.W.T.						
NMC 21218	♂	5.2	1.9	10.4	3.6	10.7
NMC 21313	♀	5.2	2.0	10.3	3.7	10.5
NMC 21208	♀	5.2	1.9	10.3	3.6	10.8
NMC 21209	♂	5.3	1.9	10.2	3.7	10.5
NMC 21229	♂	5.3	1.8	10.4	3.5	10.9
NMC 21237	♂	5.4	1.8	10.6	3.7	10.4
Mustela erminea. Recent, U.S.S.R.						
NMC 27544	♂	5.8	2.0	11.4	4.4	12.4
NMC 27545	♂	5.7	2.0	11.4	4.5	12.1

* 1 - Length M_1. 2 - Width M_1. 3 - Alveolar length $P_3 - M_2$. 4 - Mandible depth below centre of M_1. 5 - Ascending ramus depth.

Table 37. Measurements of a Pleistocene mandible fragment from the Yukon Territory tentatively referred to ermine (*Mustela erminea*) compared to mandibles of Recent ermine, long-tailed weasels (*Mustela frenata*) and least weasels (*Mustela nivalis*) from Canada.

Specimens	Sex	Measurements (mm)* 1	2	3
Mustela erminea, Pleistocene, Y.T.				
NMC 25076	-	5.8	4.2	2.5
Mustela erminea, Recent, Y.T.				
NMC 35870	♀	6.0	4.0	2.6
NMC 2109	♀	4.0	3.1	1.7
NMC 18095	♂	4.5	3.1	2.1
NMC 2120	♂	4.6	3.4	2.0
NMC 18021	♂	5.0	4.0	2.5
NMC 31075	♀	4.7	3.2	2.0
Mustela frenata, Recent				
NMC 29234 B.C.	♂	6.3	5.0	2.9
NMC 76530 Alta.	♀	5.7	4.2	2.7
NMC 8060 Alta.	♂	7.1	5.4	3.1
NMC 10884 Alta.	♀	5.8	5.3	2.8
NMC 27117 Alta.	♂	6.4	5.3	3.4
NMC 10872 Alta.	♀	6.4	4.7	3.0
Mustela nivalis, Recent				
NMC 34110 Y.T.	♂	3.6	2.5	1.5
NMC 34370 N.W.T.	♂	3.8	2.3	1.6
NMC 34371 N.W.T.	♂	3.4	2.2	1.6
NMC 30622 -	♂	3.6	2.9	1.9
NMC 39761 Y.T.	♂	4.3	3.1	1.9
NMC 21097 N.W.T.	♀	3.1	2.[illegible]	1.5

* 1 - Length M_1. 2 - Mandible depth below centre of M_1.
3 - Mandible width at centre of M_1.

27545) are larger in most respects than the Canadian Pleistocene and Recent ermine specimens measured.

A right mandibular fragment (NMC 25076) containing the basal region of RM_1 and parts of its posterior cusps, and lacking the ascending ramus and the portion of the jaw anterior to RM_1, is tentatively referred to *Mustela erminea.* It was collected at Old Crow Locality 27W and is stained black. The only feature in which it varies from Recent and Pleistocene North American ermine specimens to which it was compared is in the somewhat greater length of RM_1 (but it is exceeded in this measurement by a Recent female from the Yukon (NMC 35870)). There is a possibility that NMC 25076 could represent the long-tailed weasel *(Mustela frenata)* (Table 37), but this is considered unlikely. Although the least weasel *(Mustela nivalis)* may be expected to occur in Yukon Pleistocene deposits (Youngman 1975, p. 147), this fossil is too large to belong to that species.

A complete right ulna (NMC 25320) of the ermine was screened from organic sandy gravel overlying the basal clay unit at Old Crow Locality 27W. It is stained orange and could be younger in geological age (late Wisconsin?) than the specimen previously mentioned. The ulna is 26.7 mm long and matches closely a Recent ermine specimen from Canada, NMC 29833.

Discussion

Ermine fossils have not been reported previously from Pleistocene deposits in Canada or Alaska. Presently, the species has a Holarctic distribution. The subspecies that now live in the Yukon - *Mustela erminea arctica* in the north and *Mustela erminea richardsoni* in the south - may indicate a Beringian origin for the former and a southern origin for the latter (Macpherson 1965, p. 164; Youngman 1975, p. 142).

The origins of *Mustela erminea* are poorly known. Possibly it arose during the latter part of the middle Pleistocene. It is commonly represented in European deposits of last interglacial (Sangamon) and last glacial (Wisconsin) age. Ermine have been present in North America since Illinoian time (Kurtén 1968, p. 102).

Ermine are agile hunters that feed mainly on rodents, shrews and hares. They occupy a wide range of habitats from boreal and mixed forests to arctic and alpine tundra.

Mustela (Putorius) eversmanni
(black-footed ferret)

Two mandibles (Figure 37A-C, Table 38) of large ferrets have been collected from Pleistocene deposits in the Old Crow Basin. They constitute the first records of this species in the Yukon Territory.

Referred specimens

NMC 16323 from Old Crow Locality 65 is a right mandible with RP_2 and RM_1 and complete or partial alveoli for the canine, RP_3, RP_4 and RM_2. The narrow talonid and absence of a metaconid on M_1 serve to distinguish this fossil and black-footed ferret mandibles from those of the true weasels of the subgenus *Mustela*. The ascending ramus of NMC 16323 is lacking and the anterior tip of the mandible is damaged. The anterior part of the masseteric fossa extends forward to a point below the posterior root of M_1. I am grateful to Elaine Anderson for identifying this specimen. It is similar in size to a Recent black-footed ferret jaw from Texas (UMMZ 76971). The degree of wear on RM_1 and the fact that the root of RP_2 is exposed well above the alveolar margin are presumably indicative that an old individual is represented. The specimen is stained dark brown.

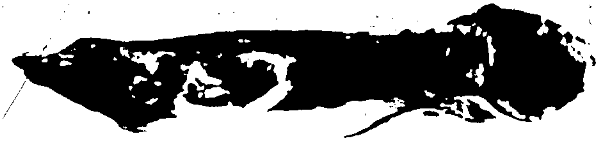
Figure 37. Right mandible with RP_2 and RM_1 (NMC 16323, Old Crow Locality 65) of a Pleistocene black-footed ferret *(Mustela (Putorius) eversmanni)*.

A. Lateral view.

B. Occlusal view.

C. Medial view.

A



B

C

Table 38. Measurements of Pleistocene black-footed ferret (*Mustela (Putorius) eversmanni*) mandibles from the Yukon Territory compared to those of some Pleistocene and Recent black-footed ferrets from the United States.

Specimens	Sex	Measurements (mm)*								
		1	2	3	4	5	6	7	8	9
Mustela (Putorius) eversmanni. Pleistocene, Y.T.										
NMC 16323 Old Crow Loc. 65	-	7.4	4.5	2.5	1.6	-	-	8.3	3.3	20.2
NMC 25079 Old Crow Loc. 83	-	9.1	5.2	-	-	2.9	2.3	9.2	3.2	20.2
Mustela (Putorius) eversmanni. Recent, U.S.										
UMMZ 76971 T[illegible]	♂	9.1	4.6	2.5	1.7	3.2	2.2	8.6	3.2	18.9
Mustela (Puto[illegible] [illegible]anni. Pleistocene, Little Box Elder Cave, Wyoming (Anderson 1968, p. 34)										
M		-	-	-	-	-	-	8.0	2.7	-
OR		-	-	-	-	-	-	7.3-8.9	2.1-3.0	-
N		-	-	-	-	-	-	24	22	-
Recent, Colorado (Anderson 1968, p. 34)										
M		-	-	-	-	-	-	7.3	2.7	-
OR		-	-	-	-	-	-	7.0-7.6	2.4-2.9	-
N		-	-	-	-	-	-	4	4	-
Recent, Texas (Anderson 1968, p. 34)										
M		-	-	-	-	-	-	-	2.8	-
OR		-	-	-	-	-	-	7.7	2.7-2.9	-
N		-	-	-	-	-	-	2	2	-

* 1 - Mandible depth below centre of M_1. 2 - Mandible width below centre of M_1. 3 - P_2 length. 4 - P_2 width. 5 - P_3 length. 6 - P_3 width. 7 - M_1 length. 8 - M_1 width. 9 - Alveolar length P_2-M_2.

NMC 25079 from Old Crow Locality 83 is a right mandible with RP_3 and a damaged RM_1. Part of the canine socket is lacking, while alveoli for RP_2, RP_4 and RM_2 are present. The mandibular foramen is preserved in this fossil but not in NMC 16323. The specimen is comparable to a Recent black-footed ferret mandible (UMMZ 76971). It is interesting to note that NMC 25079 was excavated from oxidized, organic, fine gravel overlying the basal clay unit, as was NMC 16323, which was collected one bend downstream from Old Crow Locality 83.

Discussion

The dark staining of both fossils suggests a pre- late Wisconsin age. The only other Canadian Pleistocene record is a mandible from Sangamon interglacial deposits at Medicine Hat, Alberta (Anderson 1973, p. 778).

The anterior part of a skull and two left mandibles from Pleistocene sediments near Fairbanks, Alaska most closely resemble the largest steppe ferret subspecies *Mustela (Putorius) eversmanni michnoi*, which occurs in the Transbaikal region of Siberia. *M. eversmanni* is similar in size, cranial and dental morphology, and external appearance to North American *M. nigripes*; I follow Anderson's (1973, p. 778) suggestion in considering them to be conspecific. The species name *eversmanni* has precedence over *nigripes*.

In the conterminous United States, there are records of Wisconsin age from Burnet Cave and Isleta Caves in New Mexico, and Little Box Elder Cave in Wyoming (Anderson 1968, pp. 31-33).

Ferrets are not recorded in the most important Pleistocene vertebrate faunas of northeastern Siberia.

The earliest known true ferret *(Mustela (Putorius) stromeri)* appeared in the late Villafranchian of Europe, where it survived until late Günz (late ?Nebraskan) time. It may have given rise to the living Eurasian polecat *Mustela (Putorius) putorius*, from which the larger *M. (P.) eversmanni* may have stemmed. Either or both of these mustelids are known from the Cromer (?Aftonian) interglacial and Mindel (?Kansan) glacial deposits of England and Germany. *M. eversmanni* is definitely known from the Eem (Sangamon) and Würm (Wisconsin) of Europe (Kurtén, pp. 98-100).

Although some key pieces of evidence are missing, I postulate that black-footed ferrets were derived from ferrets like *M. (P.) putorius* in the middle Pleistocene, and that they first entered North America via the Bering Isthmus during the Illinoian glaciation (when steppe conditions would have been conducive to their dispersal (Hopkins 1967, pp. 472-473)), reaching central North America (Medicine Hat) by the Sangamon interglacial. The discovery of black-footed ferret remains in the Old Crow Basin and central Alaska strongly indicates the presence of dry grasslands with abundant rodents in those places during the late Pleistocene.

The black-footed ferret is a large, whitish mink-sized mustelid with a dark brown "mask". The legs, feet and end of the tail are of similar chocolate color. Its Holarctic distribution is presently broken in the Beringian area where the species became regionally extinct, or which it abandoned, during the late Pleistocene. The Palearctic group ranges from southeastern Europe to western China: the Nearctic group occurs in west central North America. It is interesting to note that the Eurasian group is increasing in numbers and moving northward, while the North American group is undergoing a marked reduction in numbers, and its historic range, which extended from Texas to the southern prairies of Canada, is contracting. Indeed, the species is near the point of extinction in North America (Banfield 1974, p. 329).

The preferred habitat of the species is arid short-grass prairies or steppe, and it is a good paleoenvironmental indicator of that kind of habitat. Black-footed ferrets often usurp rodent burrows for their dens, usually enlarging them. They are keen hunters, preying mainly on rodents such as prairie dogs *(Cynomys ludovicianus)*, ground squirrels (*Spermophilus* sp.), hares, voles and marmots (Stroganov 1969, p. 384; Banfield 1974, p. 328). In Siberia, their main prey is the red-cheeked ground squirrel *(Spermophilus majori)*, and I suggest that, as prairie dogs have not been reported from the Yukon or Alaska, they probably focussed their hunting on arctic ground squirrels *(Spermophilus undulatus)* and possibly pikas (*Ochotona* sp.), which were common in parts of Eastern Beringia during the late Pleistocene. At Medicine Hat, however, both prairie dogs and ground squirrels were available as prey for black-footed ferrets during the Sangamon interglacial (Stalker and Churcher 1970; C.S. Churcher, personal communication 1973).

During the first half of the 1900s, European settlers in western North America waged a constant war against prairie dogs by poisoning, trapping and shooting them in order to protect the crops they cultivated. Thus, prairie dog range, and consequently black-footed ferret range, became greatly restricted.

Martes nobilis (noble marten)

This species (Figures 38A-C, 39A-D, Tables 39-40) has not been reported previously from Eastern Beringia or Canada. Three specimens from Pleistocene deposits in the Old Crow Basin, two mandibles and a humerus, have the general characteristics and proportions of the noble marten as outlined by Anderson (1970, pp. 73-86).

Referred specimens

NMC 24360 from Old Crow Locality 11A is a right mandible with RP_3-RM_1. The root of the canine is lodged in its damaged socket, and alveoli are present for RP_2 and RM_2. No trace of RP_1 or its alveolus is evident. The teeth are heavily worn indicating that an old individual is represented. Two mental foramina are seen. The anterior one lies below the anterior root of P_2, while the posterior one is situated below the centre of P_3. They are similarly located in another fossil mandible from the Yukon (NMC 19098). The ascending ramus is intact. Its posterior profile is convex, the posteriormost projection being midway between the lower border and the tip of the coronoid process. This feature appears in a noble marten mandible (UCMP 9389) from Samwel Cave, California

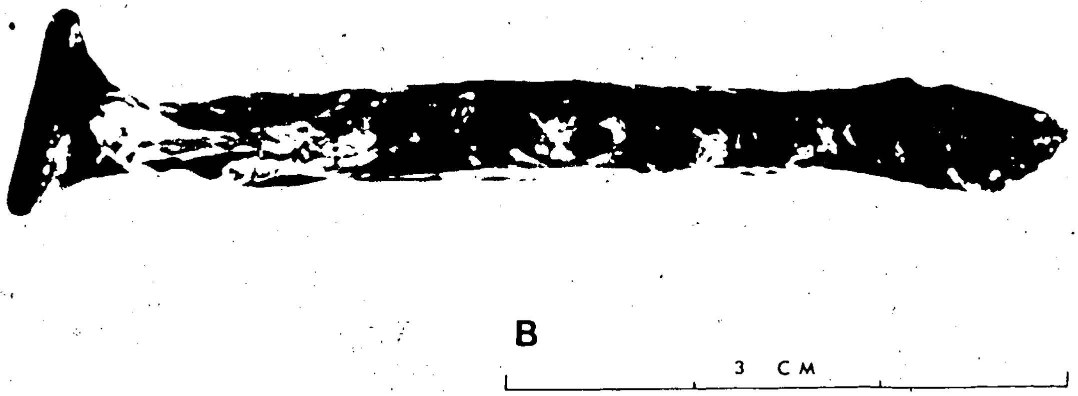
Figure 38. Right mandible with RP_3-RM_1 (NMC 24360, Old Crow Locality 11A) of a Pleistocene noble marten *(Martes nobilis)*.

A. Lateral view.

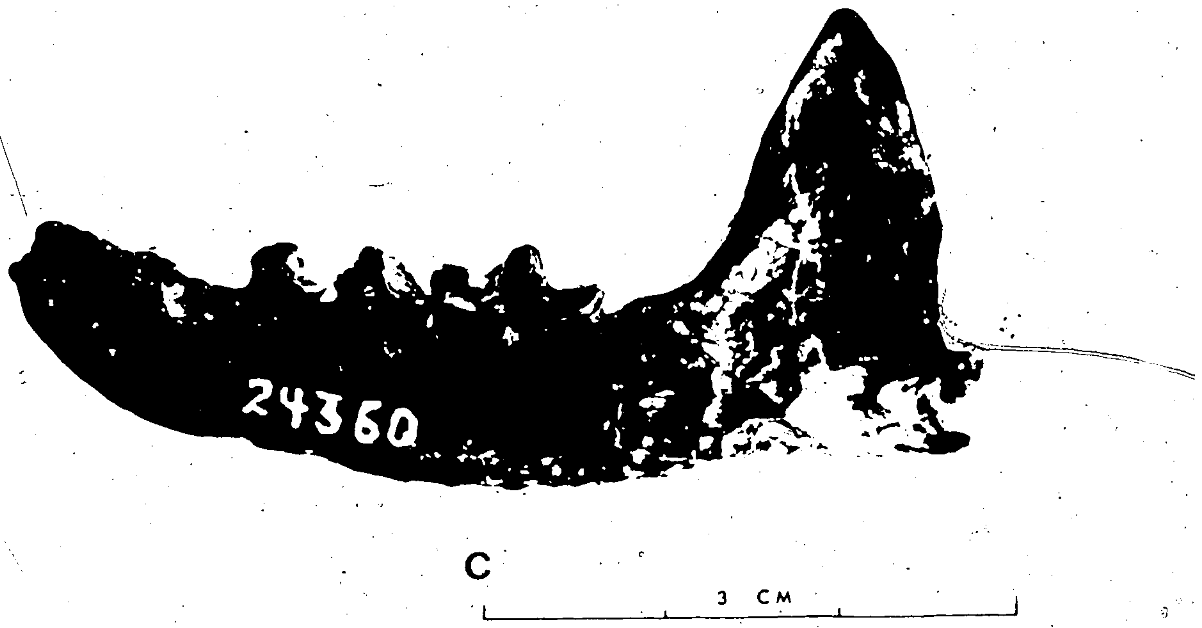
B. Occlusal view.

C. Medial view.

A



B



C

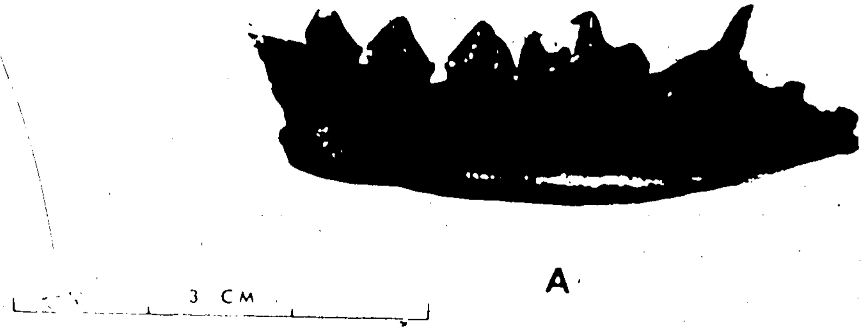
Figure 39. Left mandible with LP_2-LM_1 (NMC 19098, Old Crow Locality 28) of a Pleistocene noble marten *(Martes nobilis)*.

A. Lateral view.

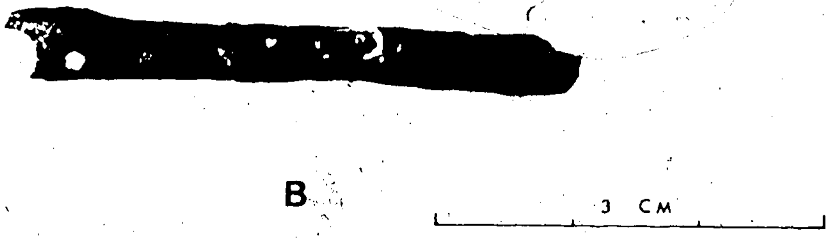
B. Occlusal view.

Left humerus (NMC 28605, Old Crow Locality 65) of a Pleistocene noble marten *(Martes nobilis)*.

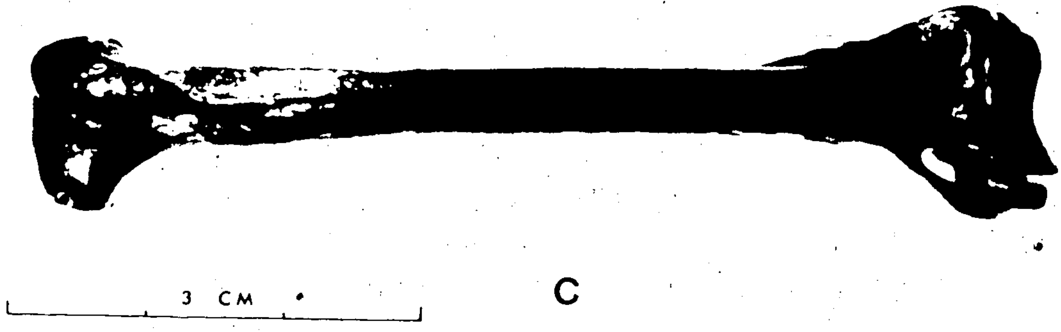
C. Anterior view. D. Posterior view.



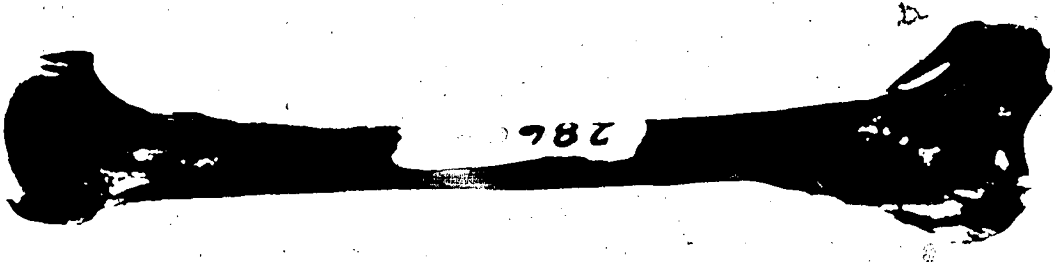
A



B



C



D

Table 39. Measurements of Pleistocene noble marten (*Martes nobilis*) mandibles from the Yukon Territory compared to those of Pleistocene noble martens from the western United States.

Specimens	Measurements (mm)*											
	1	2	3	4	5	6	7	8	9	10	11	12
Martes nobilis. Pleistocene, Y.T.												
NMC 24360 Old Crow Loc. 11A	10.1	5.2	-	-	4.8	2.4	5.9	2.9	9.9	3.7	6.6	30.9
NMC 19098 Old Crow Loc. 28	9.5	4.7	4.4	2.6	5.5	2.7	6.1	3.1	9.8	3.8	6.6	30.3
Martes nobilis. Pleistocene, U.S.A. (Anderson 1970, p 78, Table 26)												
<u>Males</u>												
M	-	-	4.8	2.6	5.1	2.8	6.0	3.3	11.1	4.2	7.4	-
N	-	-	2	2	4	4	6	6	9	8	9	-
OR	-	-	-	2.5- 2.6	5.0- 5.3	2.6- 3.0	5.5- 6.5	3.1- 3.7	10.8- 11.3	3.7- 4.6	7.1- 7.8	-
SD	-	-	-	-	0.14	0.20	0.34	0.22	0.19	0.21	0.23	-
<u>Females</u>												
M	-	-	4.3	2.4	4.9	2.6	5.5	3.1	10.1	4.1	6.9	-
N	-	-	10	11	12	12	8	8	15	14	15	-
OR	-	-	3.9- 4.6	2.2- 2.6	4.6- 5.2	2.4- 2.8	5.2- 5.9	2.8- 3.2	9.6- 10.5	3.8- 4.5	6.5- 7.2	-
SD	-	-	0.22	0.12	0.19	0.11	0.24	0.14	0.26	0.20	0.20	-

* 1 - Mandible depth below centre of M_1.

2 - Mandible width below centre of M_1.

3 - P_2 length.

4 - P_2 width.

5 - P_3 length.

6 - P_3 width.

7 - P_4 length.

8 - P_4 width.

9 - M_1 length.

10 - M_1 talonid length.

11 - M_1 trigonid length.

12 - Alveolar length, posterior of canine alveolus to posterior of alveolus for M_2.

light copy

Table 40. Measurements of a Pleistocene noble marten *(Martes nobilis)* humerus from the Yukon Territory compared to those of noble martens from the western United States.

Specimens	Measurements (mm)*						
	1	2	3	4	5	6	7
Martes nobilis.Pleistocene, Y.T.							
NMC 28605 Old Crow Loc. 65	74.6	12.9	12.2	5.1	6.2	16.0	8.4
Martes nobilis.Pleistocene, U.S.A. (Anderson 1970, p. 82, Table 28)							
<u>Males</u>							
M	74.3	13.5	-	5.5	-	17.0	-
OR	72.4- 77.8	12.8- 14.5	-	4.9- 6.0	-	15.8- 18.3	-
N	3	3	-	4	-	4	-
<u>Females</u>							
M	61.0	10.5	-	4.2	-	13.0	-
OR	57.2- 66.3	9.8- 11.9	-	3.7- 4.5	-	12.2- 14.5	-
N	8	9	-	9	-	6	-

* 1 - Total length
2 - Proximal width
3 - Proximal depth
4 - Midshaft width
5 - Midshaft depth
6 - Distal width
7 - Distal depth

(Anderson 1970, p. 76, Figure 26). The height of the ascending ramus of NMC 24360 is 25.4 mm and the width of the condyloid process is 11.4 mm. The surface of this blackish brown fossil is minutely pitted, which I attribute to the activity of aci in the groundwater. The specimen is intermediate in size between mandibles of the American marten *(Martes americana)* and the fisher *(Martes pennanti)*, and the trigonid of M_1 is relatively shorter than in *M. americana* or *M. pennanti*. When plotted on Anderson's (1970, p. 82, Figure 31) scattergram showing relationship between M_1 length and M_1 trigonid length in *M. nobilis* (Pleistocene), *M. diluviana* (Pleistocene), *M. pennanti* (Recent) and *M. americana* (Pleistocene, postglacial and Recent), NMC 24360 clearly falls in the lower range of *Martes nobilis*, as does the other Yukon specimen NMC 19098, which falls just beside NMC 24360. I am grateful to Elaine Anderson (personal communication 1975) for examining a cast of NMC 24360 and confirming my identification of it as *Martes nobilis*.

NMC 19098 from Old Crow Locality 28 is a left mandible with LP_2-LM_1 and the alveolus for LM_2. The anterior part of the mandible is damaged leaving only the posterior half of the canine socket. The teeth are slightly worn indicating that an individual in early maturity is probably represented. Most of the ascending ramus is lacking. What appear to be two tooth marks are located side by side 3.9 mm apart on the inner surface of the mandible below the socket for LM_2. Perhaps they were made by another marten and are indicative of intra-specific strife, or maybe they were made by another predator, such as the fisher. The surface of this specimen is much better preserved than that of NMC 24360, so there is no danger of mistaking these marks for pits eroded by acidic groundwater. As has been noted previously, NMC 19 possesses the features, such as the diagnostic measurements and proportions of LM_1, that enable it to be identified as *Martes nobilis*. It is dark brown in color; slightly paler than NMC 24360. Comparative measurements of the mandibles from the Old Crow Basin suggest both represent females.

NMC 28605 from Old Crow Locality 65 is a complete left humerus of a marten that is larger than male American martens and smaller than the fisher. In morphological features it matches a humerus of *M. nobilis* from Little Box Elder Cave, Wyoming (Anderson 1970, p. 80, Figure 28), and in size it lies within the observed ranges and near to the means for specimens attributed to males of the noble marten by Anderson (1970, p. 82).

It is therefore referred to *Martes nobilis*.

Discussion

The Yukon specimens are probably of pre- late Wisconsin age. Although NMC 19098 was excavated from organic sand overlying the basal clay unit at Old Crow Locality 28, it is not a high bluff exposure like Old Crow Locality 44, and the upper sands containing the fossils may well have been reworked and deposited during post-glacial time. Fossils of this species may be expected to occur in Pleistocene sediments of Alaska and southwestern Canada.

Apart from the Yukon records, *M. nobilis* is known only from late Wisconsin age deposits in Samwel and Potter Creek caves, California; Little Box Elder Cave, Wyoming; and Jaguar Cave, Idaho (Anderson 1970, p. 73). It was Nearctic in distribution.

The dispersal history of *M. nobilis* is not very clear. In the late Astian (late Pliocene) and perhaps the early Villafranchian a large marten, *M. wenzensis*, lived in Europe (Kurtén 1968, p. 93). It could have given rise to the next martens *(M. vetus)* that appeared in Europe during the early Pleistocene (Anderson 1970, p. 121). The Eurasian pine marten *(M. martes)* probably arose from

M. vetus in the middle Pleistocene. According to Anderson (1970, p. 124), the noble marten may have stemmed from the basic pine marten stock, but the details of their relationship are not spelled out.

It is interesting to note the similarities, yet radical difference between *M. nobilis* and *M. diluviana* of middle Pleistocene (?Kansan to Illinoian from Port Kennedy Cave, Pennsylvania; Cumberland Cave, Maryland; and Conard Fissure, Arkansas) age from the eastern United States. Statistical analyses show that *M. nobilis* was more like *M. diluviana* than *M. americana* in structural proportions. Scattergrams of M_1 length and M_1 trigonid length show that *M. nobilis* lies on a different trend axis than *M. americana* or *M. pennanti*, but one that is very close to *M. diluviana*. Limb bones of the noble marten were similar in proportions to *M. diluviana*, but different from *M. americana* and *M. pennanti*. Anderson (1970, p. 77) thought at first that *M. nobilis* was a subspecies of *M. diluviana* that had survived until the late Pleistocene, but subsequently showed that the former was a true marten rather than a fisher, for it lacks an external median rootlet on P^4. Evidently the genus *Martes*, in fisher (*M. diluviana*) and marten (*M. nobilis*) forms, had two chances to exploit a similar North American environmental niche in a similar way and failed both times.

Certainly, *M. nobilis* is not closely related to *M. americana*. Probably the former species or its ancestors entered North America from Asia in late Illinoian or early Wisconsin times and spread into forested western regions where it survived in relict populations until its extinction in the early postglacial (Anderson 1970, pp. 85-86). In the southern part of its range, perhaps warming climate and human activity, besides competition with the American marten, caused its extinction.

Some characteristics of living American martens are provided, as they are probably grossly comparable to those of noble martens. Males are about 15% larger than females. Young are born in leaf-lined nests, in hollow trees, or in cavities in rock piles or under stumps or brush. They prefer coniferous forest, avoiding burned-over areas. A resumé of paleoenvironmental evidence from the cave deposits in which fossils of the noble marten have been found suggests that cool coniferous forest with nearby tundra-like conditions may have been its favored habitat. Certainly this type of landscape could have been found in the Yukon Territory during the late Pleistocene (McAllister and Harington 1969, pp. 1188-1189;

Harington and Clulow 1973, p. 743). American martens commonly prey on voles, particularly red-backed voles *(Clethrionomys rutilus)*, a species that is known to have occurred in the Old Crow Basin during the late Pleistocene. Red squirrels, hares and pikas are also eaten, as are berries in summer. At present human trappers are their main predators. Occasionally fishers, lynx, coyotes, owls and eagles prey on them (Banfield 1974, pp. 315-318).

Martes pennanti (fisher)

Two specimens (Figure 40A-C, Table 41) from Pleistocene deposits in the Old Crow Basin are referred to the fisher, a species that has not been reported previously from Eastern Beringia or Canada.

Referred specimens

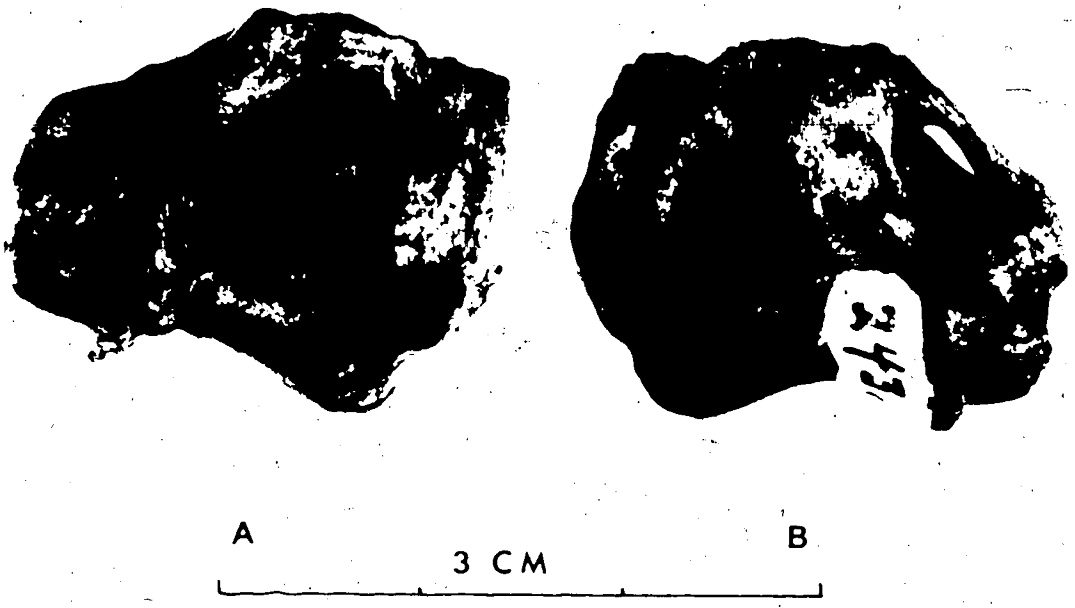
NMC 24368 from Old Crow Locality 11A is the distal end of a right humerus. The slip of bone enclosing medially the entepicondylar foramen is intact, and all features of the distal articular surface including the olecranon fossa are well preserved. The specimen is much larger in distal width than the largest referred males of *Martes nobilis* recorded by Anderson (1970, p. 80, Table 28). Of three Recent fisher humeri to which the

Figure 40. Distal end of a right humerus (NMC 24368, Old Crow Locality 11A) of a Pleistocene fisher *(Martes pennanti)*.

A. Posterior view.

B. Anterior view.

C. Anterior view of a right calcaneum (NMC 22322, Old Crow Locality 27W) of a Pleistocene fisher *(Martes pennanti)*.


A
B
3 CM

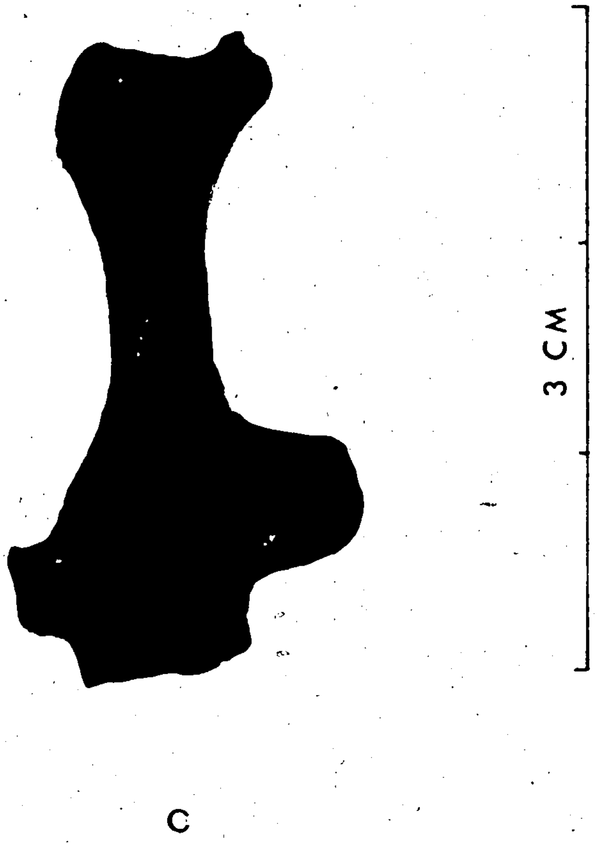

3 CM
C

Table 41. Measurements of a Pleistocene fisher *(Martes pennanti)* humerus from the Yukon Territory compared to those of Recent fishers from Quebec.

Specimens	Sex	Measurements (mm)* 1	2	3
Martes pennanti. Pleistocene, Y.T.				
NMC 24368 Old Crow Loc. 11A	-	25.5	8.3	15.9
Martes pennanti. Recent, Quebec				
NMC 16142	-	24.6	7.3	16.1
NMC 34632	♂	24.2	7.4	16.1
NMC 16143	♀	19.7	5.9	13.0

* 1 - Distal width.

2 - Minimum anteroposterior diameter of distal articulation.

3 - Width across anterior articular surface.

fossil was compared, it most closely resembles that of an adult male from Quebec (NMC 34632). The specimen is stained brown and appears to be of pre- late Wisconsin age.

NMC 22322 from Old Crow Locality 27W is a complete right calcaneum. It is similar to, but slightly larger than, the same element of a Recent Quebec fisher (NMC 34632). It is interesting to note the great degree of similarity between the fossil calcaneum and that of the Recent Asian yellow-throated marten, *Martes flavigula* (Gromova 1960, p. 56, Figure 14A). The maximum measurements of the fossil are: 30.3 mm long x 16.0 mm wide x 13.4 mm deep. The fossil calcaneum is similar in all basic morphological features to the same bone of a Recent male fisher from Quebec (NMC 34632), and is slightly larger than the latter specimen, which has maximum measurements of: 27.7 mm long x 16.0 mm wide x 12.7 mm deep. It is stained blackish brown and has many rootlet impressions on its surface.

Discussion

Although Youngman (1975, p. 142) states that the present distribution and ecology of the fisher suggest that it is a postglacial immigrant to the Yukon Territory, the fossils from the Old Crow Basin indicate its presence there earlier, in pre- late Wisconsin time. Perhaps during the

Sangamon interglacial suitable boreal forest habitat reached the Old Crow Area, and the fossils may be of that age. More evidence is required to solve this and other zoogeographic problems relating to the fisher.

Isolated teeth and jaw fragments with teeth have been reported from a number of late Wisconsin sites in the eastern United States, such as New Paris No. 4, Pennsylvania; Natural Chimneys, Virginia; Robinson Cave, Tennessee; and Ladds, Georgia. These localities are south of the present range of the fisher and probably were occupied by fishers during the peak of the Wisconsin when the boreal forest had shifted south before the advancing margin of the ice sheet. Anderson (1970, p. 91) refers fossil mandibles from Conard Fissure, Arkansas, which were previously reported as *M. pennanti* by Brown, to *M. diluviana*.

The origins of *Martes pennanti* are uncertain, but *M. paleosinensis*, which was about the size of a female fisher and which has been found in early Pliocene deposits of Shansi, China, was its direct or indirect (via *M. diluviana*) ancestor. *M. paleosinensis* has the external median rootlet on P^4 characteristic of the fishers (subgenus *Pekania*). *M. diluviana*, which apparently entered North America via the Bering Isthmus during the Kansan glaciation, could have been the direct ancestor of *M. pennanti*, but there is a critical gap in the fossil evidence. Anderson (1970, p. 126) seems to favor a second dispersal from eastern Asia to North America of a stock related to *M. paleosinensis* in late Illinoian or early Wisconsin times to explain the presence of *M. pennanti* there.

Martes pennanti is the largest living member of the genus *Martes*. It resembles a large black cat, but its body is more slender, its eyes are smaller and its limbs are shorter. No subspecies are recognized (Hagmeier 1959). The fisher is confined to North America. It is more southern in distribution than the American marten, occupying the broad belt of boreal forest that crosses north-central North America. It also occurs in the eastern hardwood forest and parts of the Cordillera, and occupies the extreme southeastern corner of the Yukon Territory. Fisher remains are probably paleoenvironmental indicators of boreal forest conditions. Unlike American marten, fishers will venture into deciduous groves and old burned-over areas. Fishers tend to be solitary. They make dens in hollow trees, and in crevices in rocks and brush piles. Populations fluctuate with a period of about 10 years. Red-backed voles, snowshoe hares, red squirrels and shrews are favorite prey. The first two species are known to have lived in the Old Crow Basin of the Yukon during late Pleistocene time. Fishers also commonly eat birds and fruit. At present, people are the only important predator of the fisher.

Gulo gulo (wolverine)

Many wolverine (Figures 41A-C, 42A-D, Tables 42-43) fossils have been collected in the Old Crow Area. Only a few of the better specimens containing teeth will be described.

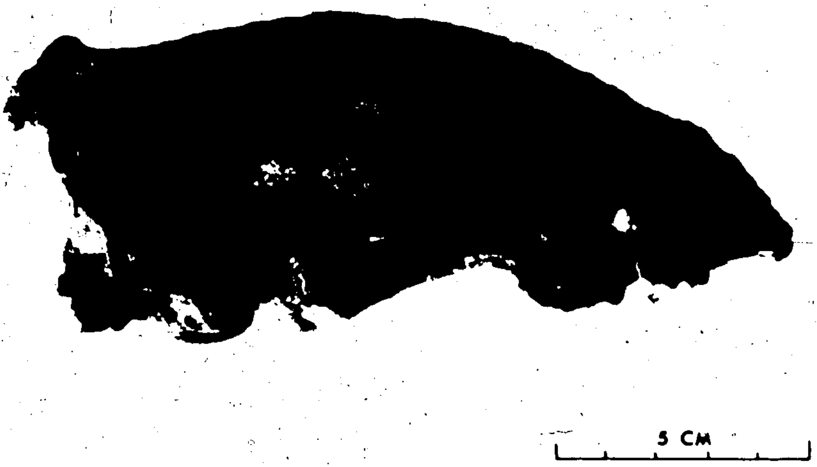
Referred specimens

The most complete specimen consists of a fragmentary cranium (NMC 14582) of what appears to be an adult male on the bases of nearly complete suture fusion, large zygomatic breadth and great occipital height (which includes the sagittal crest, usually prominent in adult male wolverines). The specimen was excavated from a sand bar opposite Old Crow Locality 22, whence it had evidently been washed from farther upstream. A unique feature of the fossil, which suggests that it may not be so old as most other darkly stained bones from the lower

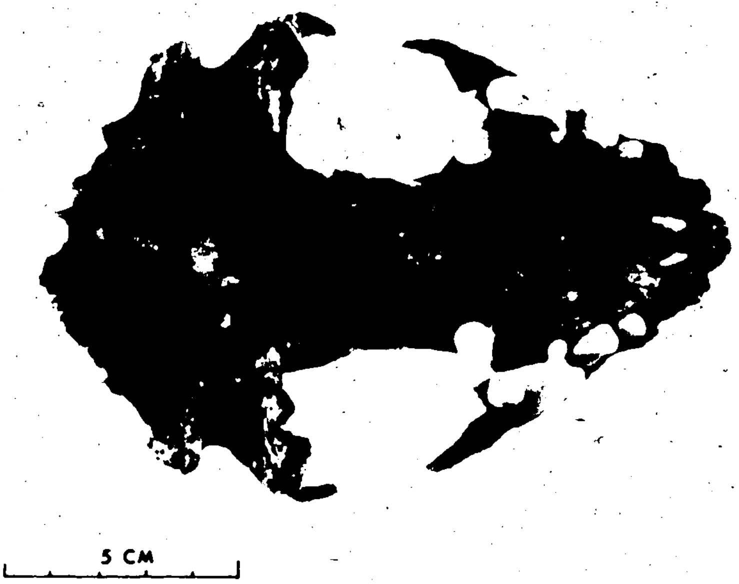
Figure 41. Cranium (NMC 14582, bar opposite Old Crow Locality 22) of a Pleistocene to Recent wolverine *(Gulo gulo)*.

A. Dorsal view. B. Right lateral view. C. Ventral view. Note white teeth relative to the heavily weathered and stained cranial bone.

A



B



C

Figure 42. Left mandible with LP_2-LM_1 (NMC 20746, Old Crow Locality 20) of a Pleistocene wolverine *(Gulo gulo)*.

A. Lateral view. B. Occlusal view.

Right mandible with RP_2-RM_1 (NMC 24797, Old Crow Locality 22E) of a Pleistocene wolverine *(Gulo gulo)*.

C. Lateral view. D. Occlusal view.

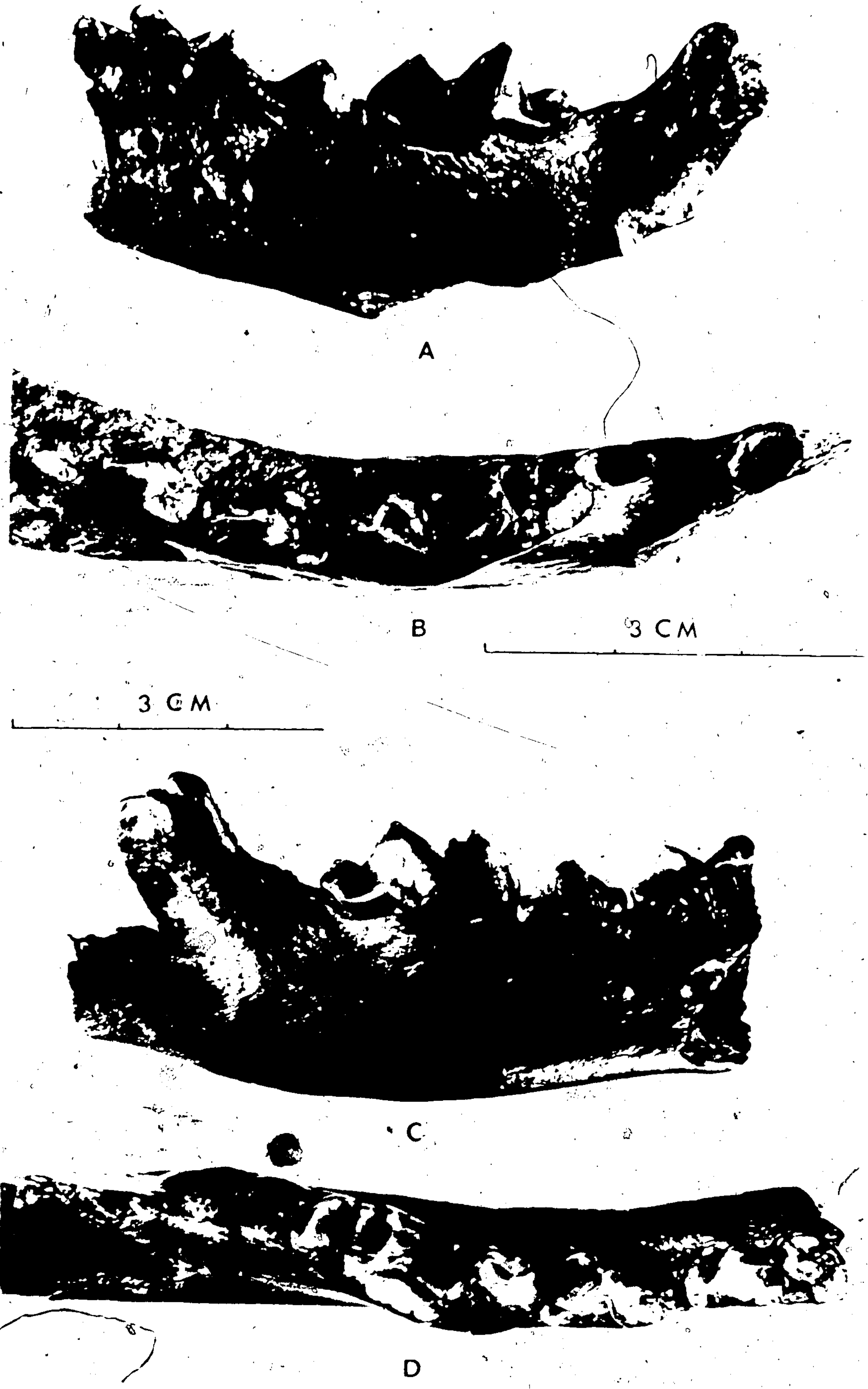

A
B
3 CM
3 CM
C
D

Table 42. Measurements of Pleistocene wolverine (*Gulo gulo*) crania from the Yukon Territory compared to those of Recent wolverines from the Yukon Territory.

Specimens	Sex	Measurements (mm)*																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Gulo gulo, Pleistocene, Y.T.																			
NMC 14582 Old Crow Loc. 22	-	44.7	39.5	37.1	102.3	55.6	35.7	90.5	127.5	34.9	6.3	5.6	10.5	6.5	20.8	12.0	8.1	14.2	68.0
NMC 16321 Old Crow Loc. 65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19.4	10.4	-	-	-
Gulo gulo luscus, Recent, Y.T.																			
NMC 33692	♂	44.1	39.1	34.4	107.3	57.2	37.9	90.0	130.5	37.2	7.2	4.9	10.5	6.5	22.4	11.9	8.8	1	7.8
NMC 31776	♂	42.5	41.8	34.5	103.8	51.2	37.1	86.6	131.0	38.2	7.0	5.0	10.9	6.6	21.5	12.4	8.2	14.	[illegible]
NMC 34310	♂	42.6	40.7	35.7	100.3	50.2	36.2	87.1	131.6	35.8	7.0	4.7	9.7	6.8	20.4	11.8	7.8	13.9	63.6
NMC 31773	♂	40.4	41.2	32.2	99.1	52.4	39.4	84.0	127.9	33.9	5.8	4.1	10.0	5.8	20.3	11.5	8.0	13.5	61.6
NMC 34311	♂	42.9	39.6	34.1	98.6	48.0	35.5	88.4	126.9	33.9	6.9	4.7	10.3	7.3	20.7	11.5	7.9	13.5	64.0
NMC 31054	♂	42.4	39.3	32.9	98.3	48.4	36.8	90.6	133.5	35.3	6.5	4.6	9.7	6.3	20.6	11.5	7.7	14.3	62.0
NMC 31035	♀	40.7	38.1	33.4	95.6	47.2	32.8	84.1	120.9	33.3	6.3	4.2	8.8	5.5	18.2	10.5	6.9	12.5	59.2
NMC 34309	♂	39.7	36.8	33.1	95.5	50.8	33.3	81.3	119.8	32.9	6.4	4.6	10.3	5.7	19.1	10.9	7.2	12.2	59.2
NMC 31769	♀	41.3	38.9	34.3	94.1	45.9	35.4	80.9	118.1	32.1	6.0	4.3	8.7	5.6	19.2	10.2	7.5	12.9	58.1
NMC 31775	♀	38.6	35.4	30.4	92.6	45.0	33.3	82.1	122.8	32.1	6.4	4.4	9.5	5.7	18.7	11.4	7.3	12.7	58.8
NMC 31056	♀	39.7	36.9	33.0	89.9	46.6	33.9	82.5	119.8	31.9	6.3	6.0	9.8	5.6	18.8	10.2	10.9	5.4	57.4

* 1 - Minimum rostral width at infraorbital foramen.

2 - Interorbital width.

3 - Width at postorbital constriction.

4 - Zygomatic width.

5 - Occipital height (ventral lip of foramen magnum to top of sagittal crest).

6 - Width of occipital condyles.

7 - Maximum width across mastoid processes.

8 - Basilar length.

9 - Alveolar length $P^1 - M^1$.

10 - Length P^3.

11 - Width P^3.

12 - Length P^4.

13 - Width P^4.

14 - Length M^1.

15 - Width (anterior) M^1.

16 - Length M^2.

17 - Width M^2.

18 - Maximum width across outer surface of M^1s.

Light copy

Table 43. Measurements of Pleistocene wolverine (*Gulo gulo*) mandibles from the Yukon Territory compared to those of Recent wolverines from the Yukon Territory.

Specimens	Sex	Measurements (mm)* 1	2	3	4	5	6	7	8	9	10	11	12	13
Gulo gulo. Pleistocene, Y.T.														
NMC 24797 Old Crow Loc. 22E	-	30.6	20.1	9.0	19.3	10.0	6.2	4.3	7.9	5.4	11.4	6.3	20.3	8.9
NMC 20746 Old Crow Loc. 20	-	31.3	22.2	11.6	21.1	11.2	6.9	4.4	8.9	5.4	11.2	6.6	21.0	9.1
NMC 24236 Old Crow Loc. 22	-	29.4	18.7	9.9	16.9	9.6	-	-	-	-	10.1	6.0	19.8	8.2
NMC 18333 Old Crow Loc. 29	-	29.9	18.3	9.6	18.9	10.8	-	-	7.7	5.6	10.4	6.7	20.5	9.2
NMC 13578 Old Crow Loc. 11A	-	27.9	18.7	9.3	18.0	9.8	-	-	7.4	-	10.1	6.3	18.7	8.5
NMC 18332 Old Crow Loc. 29	-	26.5	-	-	16.9	9.4	-	-	-	-	10.0	6.0	17.5	8.0
NMC 24214 Old Crow Loc. 66	-	29.1	-	9.8	-	10.3	6.6	4.2	8.4	5.3	-	-	19.3	8.5
NMC 13587 Old Crow Loc. 11A	-	31.9	20.5	11.1	20.7	11.7	-	-	-	-	11.7	6.7	21.5	9.4
NMC 13584 Old Crow Loc. 11A	-	29.9	17.9	9.4	18.2e	9.7	-	-	-	-	10.5	6.4	20.1	9.1
NMC 18334 Old Crow Loc. 29	-	-	16.2	8.9	15.9	8.6	5.9	4.0	-	-	9.8	5.4	-	-
NMC 25078 Old Crow Loc. 81	-	28.0	-	-	18.8	9.6	-	-	-	-	9.9	6.2	18.8	8.2
NMC 24661 Old Crow Loc. 22	-	-	-	-	-	-	-	-	-	-	10.4	6.2	-	-
NMC 24903 Old Crow Loc. 11A	-	-	-	-	20.5	10.8	-	-	-	-	-	-	20.8	9.2
NMC 18259 Old Crow Loc. 11A	-	-	-	-	19.3	9.8	-	-	-	-	-	-	19.6	8.5
NMC 20320 Old Crow Loc. 29	-	-	19.3	9.6	-	-	6.8	4.4	7.5	5.3	10.5	6.3	-	-
NMC 20008 Old Crow Loc. 65	-	-	16.2	7.5	-	-	-	-	7.9†	5.1	9.6	5.9	-	-
NMC 18255 Old Crow Loc. 11A	-	-	20.7	9.8	-	-	6.7	4.4	8.3	6.0	10.8	6.9	-	-
Gulo gulo luscus. Recent, Y.T.														
NMC 31773	♂	33.3	19.8	10.2	19.7	10.7	8.2	5.8	11.4	7.6	11.7	7.6	22.4	9.8
NMC 31776	♂	33.2	22.0	10.2	21.7	11.8	6.6	4.6	9.0	5.9	11.9	8.1	22.8	10.3
NMC 33692	♂	33.1	22.9	11.1	21.1	11.6	8.7	5.7	11.7	5.7	11.8	7.8	22.1	10.2
NMC 34311	♂	32.9	21.3	10.7	19.8	10.9	6.5	4.6	8.5	6.0	12.2	8.0	22.0	10.1
NMC 34310	♂	32.6	20.9	8.9	19.8	10.9	6.4	4.4	8.6	5.3	12.1	7.5	21.6	10.2
NMC 31054	♂	32.0	21.5	10.0	20.3	11.0	6.4	4.2	8.3	5.5	11.5	7.6	21.4	9.3
NMC 34312	-	31.6	20.8	9.[illegible]	20.2	10.3	5.1	4.0	8.0	5.0	11.4	7.1	20.9	9.2
NMC 34309	♂	31.3	18.6	8.[illegible]	17.5	9.8	-	-	7.5	5.3	11.8	6.8	20.7	9.0
NMC 31056	♀	30.5	18.9	8.9	17.6	9.6	5.6	3.6	7.6	4.9	10.8	6.7	20.1	8.5
NMC 31079	♀	30.0	18.2	8.6	17.1	[illegible].8	5.8	4.0	7.5	5.1	10.6	6.5	20.4	8.9
NMC 31775	♀	29.4	19.6	9.4	18.3e	[illegible].2	5.8	4.0	6.8	4.5	11.1	7.0	19.4	9.4
NMC 31055	♀	29.1	18.9	9.4	17.2	9.9	5.4	3.9	7.3	4.9	10.3	6.7	19.8	9.5

* 1 - Alveolar length P_4-M_1.

2 - Mandible depth below centre of P_3.

3 - Mandible width at P_3.

4 - Mandible depth at anterior cusp of M_1.

5 - Mandible width at anterior cusp of M_1.

6 - Length P_2.

7 - Width P_2.

8 - Length P_3.

9 - Width P_3.

10 - Length P_4.

11 - Width P_4.

12 - Length M_1.

13 - Width M_1.

Light copy

valley gravels, is that the teeth that are preserved (P^2-M^1 on both sides) are solid and ivory white, whereas the cranial bone is a dark, rusty brown and heavily stream-worn and weathered. It may be of very late Wisconsin to Recent age. The following regions of the cranium show damage: central parts of the zygomatic arches are lacking; the edges of the glenoid fossae; bone near the roots of the incisors and canines. Comparative measurements show that NMC 14582 falls within the upper range of Recent *Gulo gulo luscus* from the Yukon, and it probably belongs to that taxon.

NMC 16321 is a small fragment of left maxilla containing a complete LP^4 and the lateral root of LM^1 from Old Crow Locality 65. The bone and teeth are stained chocolate brown and show signs of root impressions. The LP^4 is smaller than most specimens to which it was compared. Two Recent Yukon females (NMC 31056, 31079) have slightly smaller P^4s.

Mandibular fragments, especially those containing P_4 and M_1, are most commonly found. They vary in staining from dark brown to black, the teeth often being darker than the mandibular bone. NMC 20746 from Old Crow Locality 20 is a left mandible with LP_2-LM_1. The anterior part of the jaw and ascending ramus are lacking. The animal represented was probably an adult when it died, for the tips of the cusps are worn and there is a facet on the lateral surface of M_1, made by the upper carnassial. NMC 24797 from Old Crow Locality 22E is a right mandible fragment containing RP_2-RM_1. Vertical cracks have formed on the lateral surface of the mandible below M_1, on the anterior cusp of M_1 and on the cusp of P_4. NMC 18333 from Old Crow Locality 29 is a right mandibular fragment with RP_3-RM_1, which lacks the anterior part and ascending ramus. The anterior cusps of M_1 are deeply cracked. NMC 24236 from Old Crow Locality 22 is one of the most complete mandibular fragments, but contains only RP_4 and RM_1, and a partial root of RP_2. Part of the symphyseal surface is lacking, as is the superior part of the ascending ramus and the medial part of the condyle. On the lateral surface of M_1 is a facet made by the upper carnassial.

NMC 13578 from Old Crow Locality 11A consists of the central part of the horizontal ramus of the left mandible with LP_3-LM_1, and partial sockets for LC_1-LP_3 and LM_2. The medial surface is paler than the lateral one, and may have been exposed to surface weathering at one time. NMC 13587 from Old Crow Locality 11A is a left mandible with LP_4-LM_1. It appears to represent an old individual according to the lateral wear facet on M_1 (the central cusp of which apparently was broken in life). An unusual feature of this specimen is that LP_1-LP_4 appear to have been broken off at the roots and healed over flush to the alveolar surface. Enamel on the anterior cusp of M_1 probably cracked off relatively recently. NMC 13584 from Old Crow Locality 11A consists of most of the horizontal ramus of the left mandible with LP_4 and LM_1, and the sockets for LC_1-LP_3 and LM_2. The ramus, particularly the interior surface, shows a large series of horizontal surface cracks. Cusps of the teeth are slightly worn.

NMC 24212 from Old Crow Locality 66 is a right mandibular fragment, the inferior half of which is lacking. LP_2-LM_1 are present. Of these teeth, the anterolateral surface of M_1 and the tip of P_4 may have been broken away during the wolverine's lifetime. NMC 18334 from Old Crow Locality 29 is the anterior part of a right mandible with LP_2 (the roots of which show well above the alveolar margin), LP_4 and the anterior half of LM_1. The small size of the specimen, its fragile, smooth-surfaced bone and two sharp cusps on the teeth indicate that the wolverine represented by the fossil died when it was fairly young. The surface staining of the bone is more reddish than in the other wolverine fossils. NMC 18332 from Old Crow Locality 29 consists of a fragment of the right mandible containing RP_4-RM_2. M_2s seem to drop out of their sockets readily, and are seldom preserved. Worn tips of cusps on P_4 and M_1 and the pronounced lateral facet on M_1 indicate an adult animal. NMC 25078 from Old Crow Locality 81 is a right mandibular fragment with RP_4 and RM_1. Wear on the cusps and the lateral faceting of M_1 indicate the specimen represents an adult animal.

NMC 20320 from Old Crow Locality 29 is an anterior fragment of a right mandible containing RP_2-RP_4. The cusp on RP_4 is heavily worn, suggesting an old individual. An almost identical fragment, NMC 18255 from Old Crow Locality 11A has heavily worn RP_4 and RP_3, but the tip of RP_2 is only slightly worn. NMC 20008 from Old Crow Locality 65 consists of a left mandibular fragment with LP_3 and LP_4. Its relatively shallow mandible suggests that it is from a wolverine that was relatively small for its age. The cusp of P_3 was probably worn away or broken off during the life of the individual.

NMC 24903 from Old Crow Locality 11A is a small posterior fragment of a left mandible with LM_1. The central cusp is cracked through vertically. Well marked ridges on the exposed anterior root of M_1 suggest that some idea of the individual ages of Pleistocene wolverines may be obtained by sectioning this root and searching with a microscope for annual layers in the cementum. NMC 18259 from Old Crow Locality 11A is a right mandibular fragment with RM_1. NMC 24661 from Old Crow Locality 22 is a fragment of a left mandible with LP_4 and LM_1. The heavy wear on the occlusal surfaces of the teeth and the pocked appearance of the periodontal bone indicates a very old animal.

Discussion

In the course of comparing the Old Crow mandibles with Recent ones from the Yukon Territory, I was impressed that the teeth of the former were slightly smaller than the latter. To test this idea, I compared means of P_4 and M_1 (most commonly preserved in the fossils) size in the two samples. A specimen of an obviously immature individual (NMC 18334) was omitted from the calculations. Fossil P_4s were 7.9% shorter and 12.3% narrower, while M_1s were 6.2% shorter and 8.5% narrower. On the average, the Old Crow specimens have P_4s and M_1s about 8.7% smaller than Recent Yukon specimens sampled. It is difficult to say what taxonomic importance, if, any, this observed size difference has.

Kurtén (1973, Table 2) gives mean lengths for M_1s of Recent Fennoscandian (20.7 mm), late Pleistocene

European (22.9 mm), Tornewton Cave, England (Illinoian; 21.0 mm), and European Cromerian (20.0 mm) wolverines. In comparison, the Old Crow mandibles have M_1s with a mean length of 19.8 mm – smaller than any of Kurtén's samples and closest in size to the Cromerian specimens. As I suspect that the Old Crow mandibles are of Sangamon age (or earlier), according to evidence from Old Crow Locality 44, I suggest that the reduction in size of the teeth may reflect that to be expected in an interglacial period (see, for example, Kurtén 1973, p. 5), rather than indicating close affinities with European wolverines of much earlier (Cromerian) Pleistocene age.

The earliest evidence of the wolverine is the small *Gulo schlosseri* from Günz (?Nebraskan) deposits of Episcopia on Cyprus. According to Kurtén (1968, p. 92), it probably arose from *Plesiogulo,* a less specialized ancestor that lived in Eurasia and North America during the Pliocene. However, Korotkevich and Semenov (1975, p. 38) state that *Plesiogulo crassa* cannot be a direct ancestor of *Gulo* because its dentition shows specialization in a different direction. *Gulo schlosseri* may have been adapted to a warmer environment than are living wolverines, and perhaps the boreal adaptation of the genus did not begin until the Mindel (?Kansan) glaciation when *Gulo gulo* appears at Mosbach, West Germany and Choukoutien, China (Kurtén 1968, pp. 90-93).

Apparently wolverines entered North America during the Kansan glaciation, for specimens from Port Kennedy Cave, Pennsylvania and Cumberland Cave, Maryland are considered to be of that age (E. Anderson, personal communication 1975). This raises the possibility that there was a Holarctic population of *Gulo schlosseri* during Kansan time, from which *Gulo gulo* may have evolved in both Eurasia and North America almost simultaneously, facilitated by genetic contact across Beringia (B. Kurtén, personal communication 1976). A few fossils of Wisconsin age are known from Little Box Elder and Jaguar caves in Wyoming and Idaho, respectively. Two fairly large samples have been collected at late Wisconsin or early postglacial sites; Animal Trap in Colorado, and Moonshiner Cave, Idaho (Kurtén and Anderson 1972, p. 33). The Old Crow specimens constitute the first Pleistocene records of wolverine for Canada. Although wolverine fossils probably have been found in Alaska (Geist 1953, p. 173; see chart in Guthrie 1972), to my knowledge, they have not been described.

The living North American wolverine *(Gulo gulo luscus)* is conspecific with the Eurasian animal *(Gulo gulo gulo)*

(Kurtén and Rausch 1959, p. 19). Thus, the species is a member of the Holarctic fauna and ranges from Scandinavia through northern Asia to northern North America. North American wolverines are not specialized in their habits, and frequent boreal forest, tundra and alpine tundra regions. The young are born in dens. Wolverines feed mainly on birds and mammals, such as ground squirrels, marmots and beavers, but occasionally they attack caribou, moose, deer and mountain goats. They are primarily scavengers and often follow migrating caribou herds, cleaning up carcasses left by wolves and bears, and crushing the bones with their powerful carnassial teeth.

Taxidea taxus (American badger)

Fossils of the badger (Figures 43A-D, Tables 44-45) are rare in Yukon Pleistocene deposits. Only two specimens are known, and both are from the Dawson Area.

<u>Referred specimens</u>

NMC 17260 from Dawson Locality 28 is a cranium with RP^3-RM^1 (RP^3 is badly damaged and the posterior margin of RP^4 is missing), LP^3-LM^1 (only the roots of LP^3 and LP^4 are preserved), and alveoli for the remaining teeth. The right auditory bulla is damaged, the posterior half of

Figure 43. Cranium (NMC 17260, Dawson Locality 28) of a Pleistocene American badger *(Taxidea taxus)*.

A. Dorsal view. B. Right lateral view.

C. Ventral view.

D. Anterior view of a right humerus (NMC 13486, Dawson Locality 32) of a Pleistocene American badger *(Taxidea taxus)*.

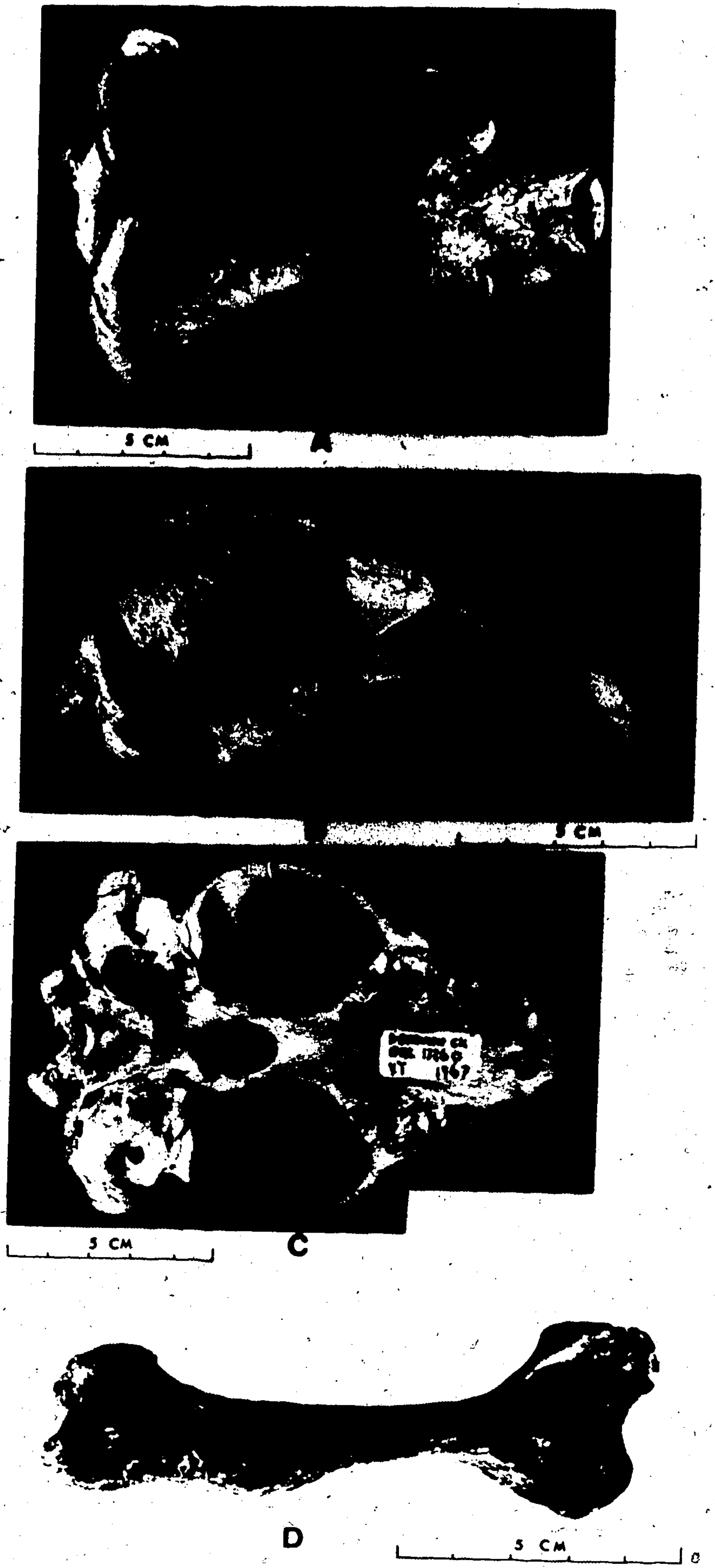

5 CM
A
5 CM
5 CM
C
D
5 CM

Table 44. Measurements of a Pleistocene American badger (*Taxidea taxus*) cranium from the Yukon Territory compared to crania of Recent American badgers from Canada, and Pleistocene and Recent American badgers from the United States.

Specimens	Sex	Measurements (mm)*												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Taxidea taxus.Pleistocene, Y.T.														
NMC 17260 Dawson Loc. 28	-	134.5+	121.2	95.4e	86.3	34.3	29.6	72.3	48.3	12.1	11.0	10.2	11.6	43.5
Taxidea taxus.Recent, Canada														
NMC 8086 Alberta	♂	130.0	116.0	88.9	82.2	29.4	29.2	68.1	44.9	12.2	10.6	11.2	10.1	43.4
NMC 8026 Alberta	♀	123.7	111.1	79.4	74.7	27.2	27.6	64.6	40.5	11.2	9.8	9.8	9.6	39.1
NMC 10712 B.C.	♂	130.9	117.8	86.7	81.2	32.2	30.5	69.8	43.6	11.9	10.3	11.2	11.0	43.1
NMC 10603 B.C.	♂	129.6	116.3	87.1	81.1	31.3	31.8	68.2	45.3	12.3	10.7	12.1	10.9	42.2
NMC 10600 B.C.	♂	126.0	114.6	82.7	85.4	29.4	29.3	67.3	41.6	12.5	11.0	12.3	10.6	43.1
NMC 10104 B.C.	?♀	128.1	116.6	81.6	81.2	31.2	29.8	67.9	41.9	12.4	10.5	11.2	11.0	43.4
Taxidea taxus.Pleistocene, U.S.A. (Anderson 1968, p. 40, Table 17) Little Box Elder Cave, Wyoming														
M		-	-	-	-	-	-	-	-	11.8	10.4	11.1	10.3	39.9
OR		143.3	128.2	94.4	91.2	31.3	-	70.8	47.9	11.4- 12.3	9.7- 12.2	10.3- 12.2	9.4- 10.8	38.8- 41.6
N		1	1	1	1	1	-	1	1	7	8	9	9	7
Taxidea taxus.Recent, U.S.A. (Anderson 1968, p. 40, Table 17) Colorado														
M		121.3	110.4	76.7	75.3	24.5	-	61.2	41.8	11.8	10.5	12.1	10.8	39.8
OR		113.6- 129.7	103.6- 118.4	69.3- 86.6	70.7- 87.7	27.6- 29.3	-	58.9- 65.6	39.9- 43.6	10.5- 12.8	9.5- 12.4	9.9- 12.5	9.6- 11.9	33.4- 40.0
N		12	12	14	13	14	-	14	14	14	14	14	14	14
Taxidea taxus.Recent, U.S.A. (Arizona) (Anderson 1968, p. 40, Table 17)														
M		120.9	-	76.9	73.5	31.2	-	58.6	37.9	11.6	9.7	10.4	10.2	40.0
OR		115.8- 125.0	-	72.8- 79.4	70.0- 76.7	28.9- 33.1	-	57.3- 60.4	36.8- 39.1	10.9- 13.1	9.5- 10.1	9.7- 12.2	9.6- 11.3	38.7- 40.9
N		3	3	3	3	3	-	3	3	3	3	3	3	3

* 1 - Total length.
2 - Basilar length (posterior margins of alveoli for upper incisors to lower border of foramen magnum).
3 - Zygomatic breadth.
4 - Mastoid breadth.
5 - Interorbital breadth.
6 - Postorbital constriction.
7 - Palatal length.
8 - Palatal width across P^4s.
9 - P^4 length.
10 - P^4 width.
11 - M^1 length.
12 - M^1 width.
13 - Alveolar length C^1-M^1.

Light copy

Table 45. Measurements of a Pleistocene American badger (*Taxidea taxus*) humerus from the Yukon Territory compared to humeri of Recent American badgers from Canada.

Specimens	Sex	Measurements (mm)*							
		1	2	3	4	5	6	7	8
Taxidea taxus.Pleistocene Y.T.									
NMC 13486 Dawson Loc. 32	-	109.2	25.4	29.1	9.1	12.7	34.5	15.6	3.1
Taxidea taxus.Recent, Canada									
NMC 9992	-	107.8	24.2	27.4	9.8	10.8	33.9	16.2	3.3
NMC 28358	-	108.1	25.0	27.0	9.1	11.1	31.9	15.8	2.6
NMC 3121	♀	97.8	22.2	24.3	8.7	12.0	31.5	14.6	2.5
NMC 32137	♀	89.3	21.4	22.5	7.6	9.5	28.6	13.7	2.3
NMC 32138 immature	♂	87.8	22.3	22.9	8.2	10.2	28.5	13.3	2.9
NMC 32139 immature	-	84.7	19.7	21.9	6.9	8.5	27.2	12.5	3.2

* 1 - Total length.
2 - Proximal width.
3 - Proximal depth.
4 - Minimum shaft width.
5 - Minimum shaft depth above the lateral condyloid crest.
6 - Distal width.
7 - Distal depth.
8 - Minimum anteroposterior diameter of shaft enclosing entepicondylar foramen.

the left zygomatic arch is lacking, and bone has been eroded away forming large cavities in the ventrolateral regions of the occiput. The occipital condyles are also heavily eroded. Sutures are well fused, the teeth are heavily worn, and the sagittal and lambdoidal crests are well developed, suggesting that an old individual is represented. NMC 17260 is similar in size (slightly shorter, but broader) to a late Wisconsin cranium (UCM 21928) from Little Box Elder Cave, Wyoming, which is larger than any specimens Anderson (1968, p. 39) had examined or seen reference to in the literature. It is larger in most dimensions, except P^4 and M^1 length, than Recent American badger crania from Alberta and British Columbia to which it was compared. The bone is tan in color like that of NMC 13486.

NMC 13486 from Dawson Locality 32 is a right humerus that is complete except for part of the lateral condyloid crest. Its total length and general robustness suggest that it represents an adult male. Of Recent specimens to which it was compared, the fossil most closely resembles a specimen of *Taxidea taxus jeffersoni* from Yahk, British Columbia (NMC 9992). This fossil constitutes the first record of a badger from the Yukon Territory (Harington [illegible] Clulow 1973, p. 700). The specimen is manila in color and has rootlet impressions over much of its lateral surface, as if it had been deposited in a grassland. *Bison crassicornis* and mammoth (*Mammuthus* sp.) bone from deposits at this locality yielded radiocarbon dates of 22,000 ± 1,400 years B.P. (I-3570) and 32,350 ± 1,750 years B.P. (I-4226), respectively. Presumably this specimen is of late Wisconsin age.

Discussion

Badger fossils from the Dawson region are probably of Wisconsin age. Their rarity suggests that suitable grassland habitat was confined in area or available to badgers for a relatively short time, or both. Evidently this species did not reach as far north as the Old Crow Basin - perhaps because of more severe permafrost conditions. Badgers did penetrate as far northwest as the Fairbanks region of Alaska however, for Geist orally reported their presence in Pleistocene deposits there to Péwé (1975a, p. 97). Hibbard (Skinner *et al.* 1972, p. 110) mentions examining seven badger skulls from late Pleistocene deposits of Alaska. In southern Canada, the badger (*Taxidea* sp.) has been reported from a Sangamon interglacial fauna at Fort Qu'Appelle, Saskatchewan (Khan 1970, p. 13) and probably from Wisconsin interstadial or Sangamon deposits at Saskatoon, Saskatchewan (Harington 1976 MS. p. 25).

According to Thenius and Hofer (1960, p. 165), *Melodon* from the upper Miocene to lower Pliocene of Asia and *Parataxidea* from the lower Pliocene of Eurasia are nearest the origins of both European *(Meles)* and American *(Taxidea)* badgers. *Taxidea* sp. and *Taxidea* cf. *taxus*, from the upper Pliocene Hagerman and Rexroad faunas of Idaho and Kansas respectively, are the earliest badgers known from North America, implying movements of an ancestral stock across the Bering Isthmus from Asia to North America prior to the reopening of the seaway in late Pliocene time (Hopkins 1967, p. 458). *Taxidea* has also been reported from the earliest Pleistocene (late Blancan) faunas of Cita Canyon, Texas; Deer Park, Kansas; Broadwater and Sand Draw, Nebraska (Skinner *et al.* 1972, p. 128).

Badger remains are known from several early and middle Pleistocene localities in the eastern United States, including Cumberland Cave, Maryland (Gidley and Gazin 1938) and Port Kennedy Cave, Pennsylvania, which now appear to be of Kansan age (E. Anderson, personal communiction 1976). Remains of *Taxidea taxus* are also common in many Wisconsin localities in the United States such as: Little Box Elder Cave, Wyoming; Jones Ranch, Kansas; Isleta Caves and Burnet Cave, New Mexico;

Papago Springs and Ventana Cave, Arizona; Schuiling Cave, Rancho La Brea, Carpenteria, McKittrick and Potter Creek Cave, California (Anderson 1968, p. 40).

The unusual degree of variability in qualitative characteristics, such as the number of cusps on M_1, M^1 and P^4, even within a single population of one subspecies, makes definition of new species and subspecies of *Taxidea* difficult. A single living species, *Taxidea taxus*, is recognized.

Badgers of the genus *Taxidea* are confined to North America, ranging from southwestern Canada to central Mexico - west of the Mississippi, except in the Great Lakes region. Pleistocene records from the Dawson Area are therefore some 1,200 miles (1,930 km) northwest of the present limits of *Taxidea taxus* in Alberta. I think large stretches of grassland or parkland must have existed between the prairies and Dawson and Fairbanks during the late Pleistocene in order to explain the presence of badger fossils in the latter areas.

Badgers are relatively large members of the weasel family with stout, dorsoventrally flattened bodies and short legs. Their foreclaws are strongly developed for digging. Females are about 10% smaller than males.

Badgers occupy open prairies and parklands. They are good paleoenvironmental indicators of grasslands; in this respect it is worth referring again to apparent grass rootlet impressions on the surface of the fossil humerus NMC 13486. Badgers are primarily fossorial and nocturnal animals that tend to hibernate during the winter months, particularly in the northern parts of their range (which would have been advantageous to survival in the Yukon Territory during the late Pleistocene). Badgers live in grassy nests set in chambers at the ends of burrows. They often enlarge ground squirrel and prairie dog burrows for their own use. Their diet consists mainly of ground squirrels, pocket gophers, prairie dogs and other animals such as mice, voles, ground nesting birds and insects. Presumably arctic ground squirrels *(Spermophilus parryi)* would have been their basic prey in the late Pleistocene of the Yukon. The American badger seems to have few predators.

Spilogale sp. (spotted skunk)

A single specimen of the spotted skunk (Figure 44A-C, Table 46) has been collected from the Pleistocene deposits of the Yukon Territory. It constitutes the first record of the species from Eastern Beringia, and is of

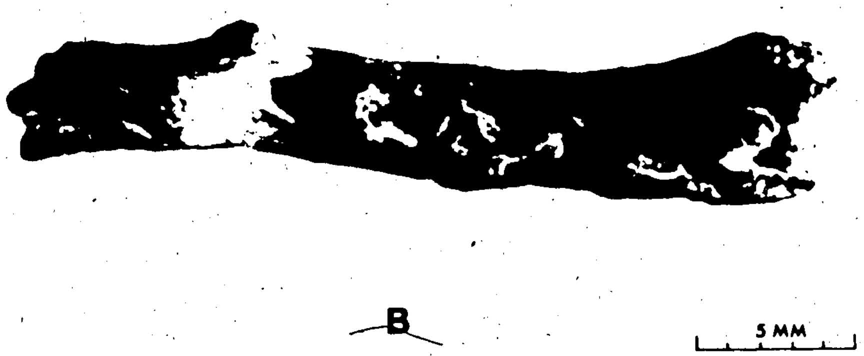
Figure 44. Right mandible with RP_2-RM_1 (NMC 25529, Old Crow Locality 44) of a Pleistocene spotted skunk (*Spilogale* sp.).

A. Lateral view.

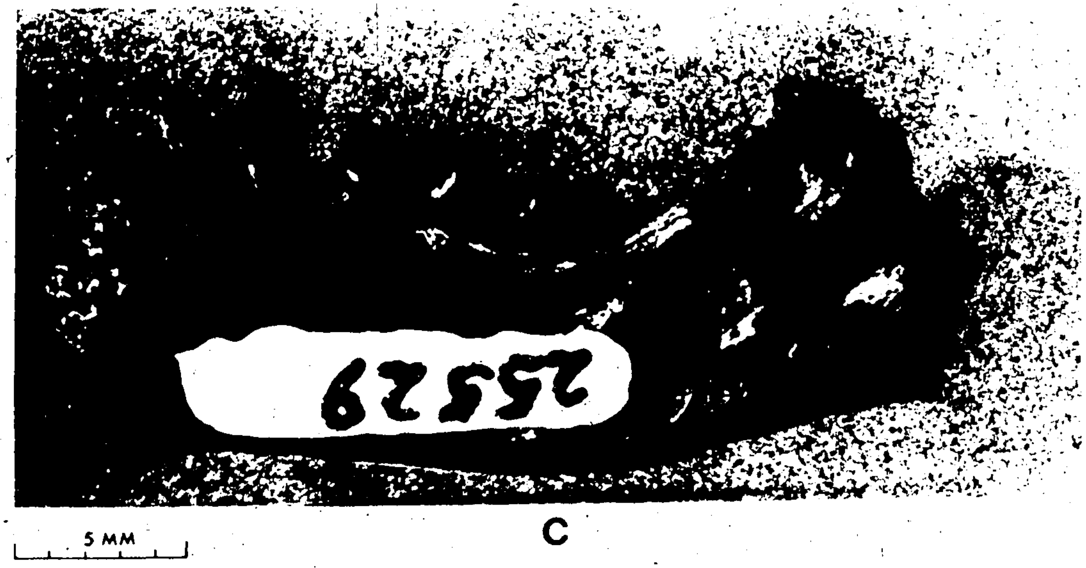
B. Occlusal view.

C. Medial view.

A



B



C

Table 46. Measurements of a Pleistocene spotted skunk (*Spilogale* sp.) mandible from the Yukon Territory compared to mandibles of Recent spotted skunks (*Spilogale gracilis*) from British Columbia and Recent striped skunks (*Mephitis mephitis*) from Alberta.

Specimens	Sex	Measurements (mm)*							
		1	2	3	4	5	6	7	8
Spilogale sp. Pleistocene, Y.T.									
NMC 25529 Old Crow Loc. 44	–	6.8	3.7	8.8	7.9	3.4	4.9	2.9	16.8
Spilogale gracilis. Recent, B.C.									
NMC 29260	♂	4.3	3.2	6.6	7.9	3.5	4.9	3.1	15.4
NMC 873	♂	5.9	3.5	6.7	7.9	3.8e	4.4	3.5	16.8
NMC 851	–	4.4	3.2	6.1	7.8	3.5	4.6	3.4	16.0
NMC 883	♂	5.0	3.2	5.9	7.9	3.4	4.4	2.8	15.3
NMC 823	♂	4.6	3.0	5.9	8.0	3.3	4.5	3.2	15.6
NMC 822	♀	6.0	3.0	5.9	7.6	3.1	4.2	2.9	15.6
Mephitis mephitis. Recent, Alta.									
NMC "69"	–	7.8	4.9	9.3	10.3	5.0	6.3	4.9	22.9
NMC 18494	♂	6.8	4.2	8.2	10.2	5.0	5.8	4.9	21.6
NMC 18478	♀	8.5	4.5	9.4	10.0	4.7	5.6	4.7	21.4
NMC 18502	–	9.7	5.4	9.2	10.7	5.0	5.7	5.0	20.8
NMC 18480 (immature)	♀	5.9	4.3	7.6	9.3	4.9	5.6	4.7	19.8
NMC 18501	–	7.3	4.0	7.5	9.9	4.9	5.2	4.8	19.0

* 1 – Mandible depth below centre of M_1.

2 – Mandible width at centre of M_1.

3 – Mandible depth below centre of P_3.

4 – M_1 length.

5 – M_1 width.

6 – Length M_1 trigonid.

7 – Width M_1 talonid.

8 – Alveolar length P_3-M_2.

Light copy

particular interest because it is known to be more than 54,000 years old - possibly of Sangamon interglacial age. ~~In~~ the present interglacial, spotted skunks are found only far south of the Yukon.

Referred specimen

NMC 25529 from Old Crow Locality 44 is a right mandible with RP$_2$-RM$_1$ and the alveolus for RM$_2$. The anterior of RP$_3$ is damaged, and this region is difficult to interpret. Apparently alveoli for RP$_2$ (one filled by a partial root) lie immediately anterior to RP$_3$ and behind the posterior portion of the socket for the vertically rising canine. The trigonid of M$_1$ shows signs of heavy wear: evidently an old individual is represented. The shape and proportions of the teeth and the size of the mandible are indicative of a skunk smaller than the striped skunk *(Mephitis mephitis)*. Of the comparative Recent skunk material at hand, NMC 25529 is closest to *Spilogale*, and it is referred to *Spilogale* sp. until further comparative material becomes available and a specific designation can be given. The fossil mandible falls within the range for *Spilogale gracilis* in all dimensions measured except in depth and width of the mandible at M$_1$ and depth of the mandible below P$_3$. In addition to the robustness of the mandible, the specimen is notable for the trenchancy of RP$_4$, despite wear on its tip, and the general straightness of the inferior profile of the mandible. Both are characteristic of *Spilogale*. Mental foramina of the fossil are located below P_3 and P_4, as in *Spilogale*, and the degree of dental crowding seen in NMC 25529 is characteristic of *Spilogale*. A natural size line illus[illegible] of a male *Spilogale putorius interrupta* (KU 14[illegible] [illegible]all and Kelson 1959, p. 929, Figure 496) is clos[illegible] appearance to NMC 25529 than any recent specimens of *Spilogale gracilis* that I have examined. KU 14237 has a thicker anterior mandible like the Old Crow fossil because of a downward deflection of the jaw at the symphysis.

Discussion

It is interesting to note that the spotted skunk, now considered by mammalogists to be adapted to relatively warm conditions because of its southerly distribution in North America (Hall and Kelson 1959, p. 930, Map 472) should have reached a position approximately 1,380 miles (2,220 km) north northwest of the northernmost limit of its range in the present interglacial (Alta Lake, 70 miles (113 km) north of Vancouver, British Columbia). This fact does not seem quite so remarkable when the stratigraphic situation of the fossil is considered. It was excavated from the fossiliferous zone at Old Crow Locality 44, and is therefore more than 54,000 years old, and very likely of Sangamon interglacial age. Frenzel (1973, pp. 132-138) shows that the climate over the Northern Hemisphere during the Sangamon was substantially warmer, and perhaps wetter in places, than at present.

Skunks have not been reported previously from Eastern Beringia. In Canada, a specimen of the spotted skunk, *Spilogale* cf. *putorius*, is known from an early mid-Wisconsin fauna at Medicine Hat, Alberta (C.S. Churcher, personal communication 1974). Most of the other mammals belonging to this fauna suggest a prairie grassland habitat (Harington 1976 MS. p. 37). There are no other Canadian Pleistocene records.

The skunks (Mephitinae), presently found only in the New World, are closely allied to the badgers, but their teeth are better adapted to grinding than shearing and they are less carnivorous than badgers. *Mioemephitis*, from the early Miocene of Europe, is the geologically earliest skunk recognized. *Promephitis*, of the Eurasian Pliocene, is closer to the ancestral stock of the living skunks.

Probably the ancestors of the spotted skunk entered North America via the Bering Isthmus about middle Pliocene time with the ancestors of the American badger. *Spilogale rexroadi*, from the upper Pliocene (early Blancan) Rexroad fauna of Kansas, seems to be the first representative of the genus in North America. It is worth mentioning two other genera that have broad affinities with *Spilogale*. *Buisnictis*, a small, short-faced skunk that lived in western North America from middle Pliocene to early Pleistocene time, probably had similar habits to *Spilogale*. *Buisnictis burrowsi*, from the earliest Pleistocene of Nebraska, had the anterior deepening of the mandible seen in NMC 25529, but differs from *Spilogale* in its larger size, straighter inferior margin of the mandible and more sectorial teeth (Skinner *et al.* 1972, pp. 110-128). *Brachyprotoma pristina*, a small, extinct, short-faced skunk that apparently survived until Illinoian time in the Appalachians (Guilday 1971, p. 237), also has similar features to *Spilogale*. A detailed study of the affinities of these three genera is required.

Among other faunas of later Pleistocene age that have produced *Spilogale* remains are: the Borchers fauna, Kansas (Aftonian interglacial); Inglis IA (early Yarmouth interglacial); faunas of the Appalachian region and

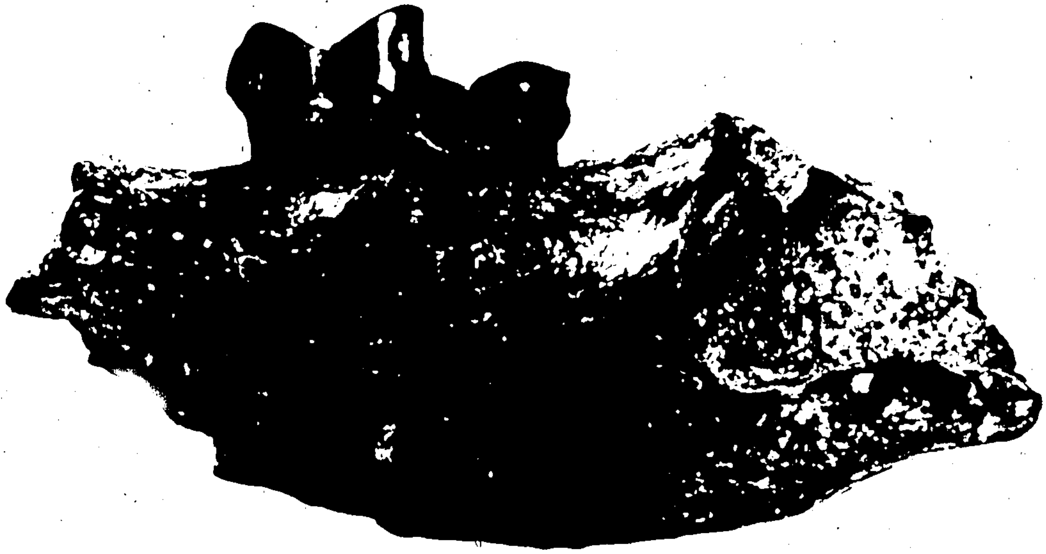
Coleman IIA, Florida (Illinoian); Slaton, Texas, Cragin Quarry, Kansas, Reddick IA, Florida (Sangamon interglacial); and the following faunas of Wisconsin age: various faunas in Texas; Jones Ranch, Kansas; Papago Springs, Arizona; Jaguar Cave, Idaho; McKittrick, Carpinteria, Rancho La Brea, Potter Creek Cave in California; and various faunas in Florida (Hibbard 1958, p. 19; Hibbard 1970; Guilday 1971, p. 237; Kurten and Anderson 1972, pp. 33-34; Webb 1974, Table 2.1).

The spotted skunk presently occurs from southern Central America to southern North America. Although most workers consider that *Spilogale* is monotypic, Hall and Kelson (1959, p. 930) recognize four nominal species. Of these, *Spilogale gracilis* penetrates northward to extreme southwestern coastal British Columbia, and *Spilogale putorius* approaches the southern Manitoba - Ontario border area. Spotted skunks are smaller and more agile than the striped skunk *(Mephitis)*. They are excellent climbers and strictly nocturnal. Families stay together and often hibernate in community dens. For dens, they may usurp woodchuck burrows or use hollow logs or trees or any place that is dark and dry. They are not true hibernators, but several will bed together during severe winter weather. Presumably this adaption in social behavior may have allowed them to survive beyond the Arctic Circle in the Yukon during the late Pleistocene. Spotted skunks are found in a variety of habitats including scrubland, open woodland areas, rocky outcrops and along streams. In British Columbia, *Spilogale* habitat includes lowland thickets and rock slides (Cowan and Guiguet 1965, p. 327). Mammals such as voles and rabbits are their main winter and spring diet, while insects and plants form the bulk of their summer and autumn diet. Beetles and larvae are favorite foods, and it is worth recalling the abundance of beetle remains found in the same stratigraphic zone as the *Spilogale* fossil at Old Crow Locality 44 Birds and bird eggs are also eaten. Their most dangerous predator is the Great Horned Owl. The skunk's defensive scent spray is not effective against predatory birds.

Lontra canadensis (Nearctic river otter)

A single specimen of the river otter (Figure 45A-B, Table 47) is known from Pleistocene deposits of the Yukon Territory. It is the first report of this species for Eastern Beringia. I concur with van Zyll de Jong (1972, pp. 1, 32) that the generic name *Lontra* should replace *Lutra* in describing New World river otters.

Figure 45. Left mandibular fragment with LP_4 (NMC 20320, Old Crow Locality 29) of a Pleistocene Nearctic river otter *(Lontra canadensis)*. A. Lateral view. B. Occlusal view.



A

3 CM

B

Table 47. Measurements of a Pleistocene river otter (*Lontra canadensis*) mandible from the Yukon Territory compared to mandibles of Recent river otters from the Yukon Territory and British Columbia.

Specimens	Sex	Measurements (mm)*		
		1	2	3
Lontra canadensis. Pleistocene, Y.T.				
NMC 20329 Old Crow Loc. 29	-	13.2	12.1^{+}	6.9
Lontra candensis. Recent				
NMC 31814 Y.T.	♂	12.9	14.9	8.3
NMC 33411 Y.T.	♂	11.4	14.8	7.5
NMC 36292 Y.T.	♀	10.5	14.1	7.1
NMC 31744 Y.T.	♂	11.8	13.8	7.8
NMC 29269 B.C.	♀	11.0	15.0	8.3
NMC 29261 B.C.	♂	12.0	14.0	7.3
Lontra canadensis pacifica (= "*Lutra canadensis yukonensis*"). (van Zyll de Jong 1972, p. 104)				
M	-	-	13.6	7.1
N	-	-	16	16
SD	-	-	0.53	0.39

* 1 - Mandible depth below posterior root of M_1.

2 - M_1 length.

3 - M_1 width.

Referred specimen

NMC 20320 from Old Crow Locality 29 is a left mandibular fragment with LM_1, the alveolus for the posterior root of LP_4 and the alveolus for LM_2. The ascending ramus and bone anterior to LP_4 are lacking. The cusps on LM_1 are well worn; presumably the fossil represents an adult otter. The posterior margin of the LM_1 talonid is missing. The position of the LM_1 cusps exactly match those of Recent *Lontra canadensis*. The relatively deep anterior part of the masseteric fossa extending forward to a point beneath LM_2, the position of the mandibular foramen, and the posterior rise in the inferior profile of the mandible all fit those characters in Recent river otters. Nor are there remarkable differences in size between the fossil mandible and those of Recent river otters. Therefore, NMC 20320 is referred to *Lontra canadensis*. The bone of the ramus is stained dark brown, whereas the tooth is black.

Discussion

The Yukon fossil appears to be of pre- late Wisconsin age. It seems unusual that Pleistocene otter remains are so rare in the Old Crow Basin, for water and fishes were common there during that period. Despite favorable appearances, perhaps the Old Crow Basin is not good otter habitat, for in travelling much of the river's length over several years between 1966 and 1975, I have sighted only two of the animals, and they were together. The turbidity of water may be a factor in the local rarity of this species, and their nocturnal habits may militate against their observation by people.

The otters (Lutrinae) evidently originated in Eurasia. *Lutra licenti* from the early Pleistocene of China resembles Recent American river otters in all principle characters, except in its slightly larger size (van Zyll de Jong 1972, p. 73). Otters of this kind make their earliest appearance in North America during the Kansan, suggesting that they crossed the Bering Isthmus about that time. The first record of an otter of the American type from North America is *Lutra rhoadsi* from Port Kennedy Cave, Pennsylvania, which is considered to be of Kansan age. C.G. van Zyll de Jong (1972, p. 79) assumes that *Lutra rhoadsi* is conspecific with *Lontra canadensis* because of their great similarity, and likewise confirms Hall's (1936) opinion that *Lutra parvicuspis* from Kansan deposits in Cumberland Cave, Maryland is conspecific with *Lontra canadensis*. A cranium assumed to be of Pleistocene age from Wright County, Iowa and called *Lutra iowa* by Goldman presents a combination of characters linking it with most of the living American species of *Lontra*. Its species name is best retained. Among other localities, the river otter has been reported from four sites of late Wisconsin age in Florida: Ichetucknee River; Seminole Field; Melbourne; and Vero 2 and 3 (Webb 1974, Table 2.1). One species, *Lontra canadensis*, and seven subspecies of Nearctic river otter are recognized (van Zyll de Jong 1972, p. 81).

The Nearctic river otters occur throughout most of the United States (except the arid southwest), Canada and Alaska (except for most tundra areas). They have long, streamlined bodies, broad flattened heads, and short powerful legs with webbed toes – all excellent adaptations for an amphibious life. Otters prefer to live on shores of deep, clear lakes, rivers, large marshes and ocean bays. They occur rarely in lakes and rivers on the tundra north of the treeline. They are useful paleoenvironmental indicators of the presence of rivers, lakes and fishes. These otters are mainly nocturnal and are active all winter, sheltering only in the most severe weather. They make beds of dried vegetation in hollow logs or usurp dwellings of beavers or muskrats. River otters capture most of their food underwater. Fishes compose the largest part of their diet, but invertebrates, such as stonefly nymphs, water beetles and crayfish are important too. Wolves and coyotes occasionally kill otters migrating overland. Otherwise they are fairly safe in their aquatic environment.

Family Felidae

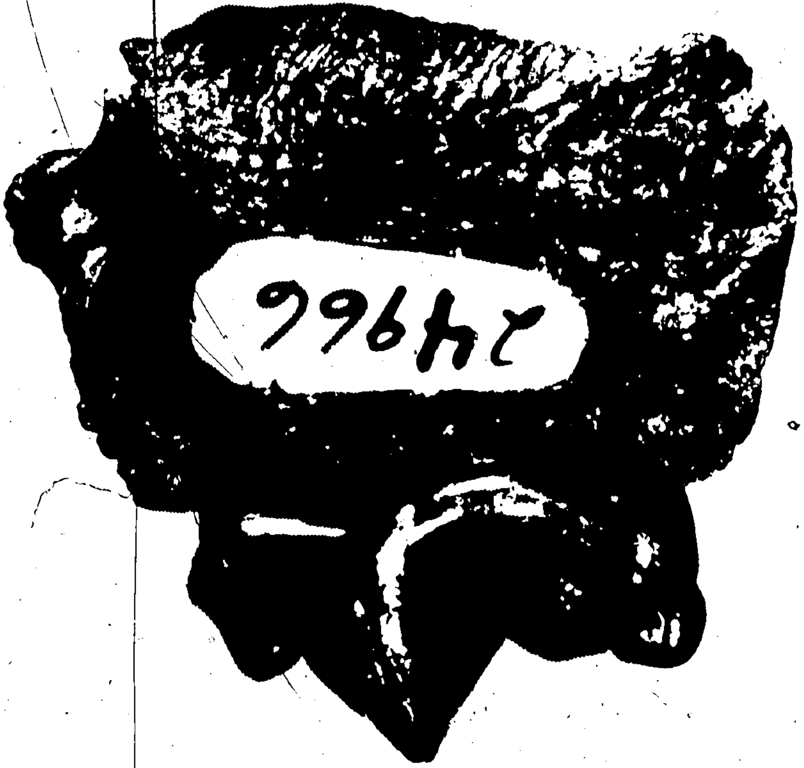
Felis (Lynx) canadensis (Canada lynx)

Two specimens of the Canada lynx (Figures 46A-B, Tables 48-49) have been collected from Pleistocene deposits in the Old Crow Basin. These are the first records of this species from ice age sediments in the Yukon Territory.

Referred specimens

NMC 24966 from Old Crow Locality 11A is a left maxillary fragment with LP^4. The cusps on the tooth are slightly worn, which, in conjunction with the size of the tooth, indicates that an adult lynx is represented. The tooth is slightly larger than those of six Recent lynx from Canada with which it was compared. Of the Recent specimens, it most closely matches NMC 24161, a male from the Yukon Territory. It is markedly smaller than mountain lion *(Felis concolor)* P^4s seen. Also, the depth from the maxillary-malar suture to the alveolar margin above the paracone of P^4 in the lynx (and NMC 24966) is approximately 40% of that measurement in the mountain lion. The fossil is stained blackish brown.

Figure 46. Left maxillary fragment with LP^4 (NMC 24966, Old Crow Locality 11A) of a Pleistocene Canada lynx *(Felis (Lynx) canadensis)*. A. Lateral view. B. Occlusal view.



A
3 CM

B
3 CM

Table 48. Measurements of a Pleistocene lynx *(Felis (Lynx) canadensis)* maxilla from the Yukon Territory compared to maxillae of Recent lynx and mountain lion *(Felis concolor)* from Canada.

Specimens	Sex	Measurements (mm)*				
		1	2	3	4	5
Felis (Lynx) canadensis.Pleistocene, Y.T.						
NMC 24966 Old Crow Loc. 11A	-	9.0	18.6	8.2	11.8	10.2
Felis (Lynx) canadensis.Recent, Canada						
NMC 34161 Y.T.	♂	9.0	17.3	8.1	11.3	9.0
NMC 34165 Y.T.	♀	7.7	16.6	7.5	10.9	8.8
NMC 34198 Y.T.	♂	9.8	16.5	8.0	11.0	8.6
NMC 34163 Y.T.	♂	9.2	16.4	7.3	11.0	8.9
NMC 32172 -	♂	9.4	15.9	7.7	10.5	8.9
NMC 34164 Y.T.	♂	8.5	15.2	7.7	10.6	8.2
Felis concolor.Recent, B.C.						
NMC 14344	♂	18.7	24.3	12.4	16.0	13.6
NMC 11269	-	24.5	24.1	13.0	15.6	12.1
NMC 29264	♂	20.7	23.0	12.3	15.2	12.9
NMC 11507	♀	18.9	22.4	11.8	15.1	11.4
NMC 29263	♂	21.7	21.9	10.3	14.0	12.0
NMC 11508	♀	22.[illegible]	22.1	11.8	13.9	10.8

* 1 - Depth from maxillary - malar suture to alveolar margin of P^4 above the paracone.
2 - P^4 length.
3 - P^4 width across protocone.
4 - Length from posterior margin of P^4 metacone to the anterior margin of P^4.
5 - Height of P^4 metacone.

Table 49. Measurements of a Pleistocene lynx (*Felis (Lynx) canadensis*) mandible from the Yukon Territory compared to mandibles of Recent lynx from Canada.

Specimens	Sex	Measurements (mm)*	
		1	2
Felis (Lynx) canadensis. Pleistocene, Y.T.			
NMC 20322 Old Crow Loc. 29		17.5	8.2
Felis (Lynx) canadensis. Recent, Canada			
NMC 32172 -	♂	18.1	8.1
NMC 34198 Y.T.	♂	16.3	7.4
NMC 34161 Y.T.	♂	16.1	7.5
NMC 34164 Y.T.	♂	15.1	7.1
NMC 34165 Y.T. (young)	♀	12.8	6.9

* 1 - Depth of mandible below posterior root of M_1.

2 - Thickness of mandible below posterior roo of M_1.

NMC 20322 from Old Crow Locality 29 is a right mandibular fragment containing a posterior part of the metaconid of RM_1. It matches Recent specimens of the lynx in size and in all characters that are preserved. Notable similarities are the very gradual upward sweep of the anterior margin of the ascending ramus, the deep masseteric fossa extending anteriorly to a point below the posterior root of M_1, the extremely flat medial surface of the mandible, and the size and position of the mandibular foramen. Among Recent Canadian specimens to which it was compared, the fossil is closest to a male, NMC 32172. The ramus is stained brown and shows signs of surface oxidation. The tooth fragment is darker.

Discussion

The Yukon fossils are considered to be of pre-late Wisconsin age. Geist (1953, p. 172) has briefly mentioned ("Lynx-rare") remains of this species from Pleistocene sediments near Fairbanks, Alaska, but they have not been described. The only Canadian record, apart from the Yukon fossils, is from Sangamon interglacial deposits at Medicine Hat, Alberta (Stalker and Churcher 1970). Remains of Wisconsin age have also been found in Idaho, Wyoming and Utah. Lynx fossils are rarely found in North America.

The origins and dispersal history of the lynx are difficult to understand without more and better evidence. At present, it seems most likely that the ancestor of the Canada and Eurasian lynx is the Issoire lynx *(Felis (Lynx) issiodorensis)* of the Villafranchian of Europe and possibly China. Evidently it had reached southern North America by early Pleistocene (late Blancan) time across the Bering Isthmus, for "*Felis* aff. *F. (Lynx) issiodorensis*" is reported in the Cita Canyon fauna of Texas by Hibbard (Skinner *et al.* 1972, p. 128). Compared to modern lynx it has a long face and body, and short legs. Perhaps the typical hunting methods and body of the northern lynx began to evolve in the middle Pleistocene when hares *(Lepus)* first entered Europe (Kurtén 1968, pp. 81-82). As the earliest certain finds of the Eurasian and Canada lynx are of Eem (Sangamon) interglacial age, I speculate that lynx arose in the coniferous forests of western Beringia during the middle Pleistocene, whence they dispersed westward to Europe and eastward across the Bering Isthmus during the Illinoian glaciation. The problem is complicated by the fact that large lynx-like felid remains are known from the Borchers fauna (Aftonian interglacial) of Kansas, and the Mullen II fauna (early Illinoian glacial) of Nebraska (Kurtén, personal communication 1976). It is conceivable that modern lynx stemmed from them, but too little is known about these forms.

Felis (Lynx) canadensis is found only in northern North America, particularly in the broad boreal forest belt extending across Canada from the Yukon Territory to Newfoundland. It is common throughout the Yukon. It may occur well north and south of its normal range when hare populations are lowest in the boreal forest. The Canada lynx is a medium-sized cat with a short body, long legs with broad padded feet, a stubby tail and a thick coat. These cats prefer to live in dense boreal forest with thick undergrowth an[illegible] falls, and their fossils are probably indicative [illegible]at type of paleoenvironment. They are generally solitary and nocturnal. For shelter they construct rough beds under rocky ledges or windfalls. Sometimes they use caves. Their populations fluctuate greatly, depending upon the abundance of hares, with peaks about 10 years apart. About three-quarters of their diet is made up of snowshoe hares *(Lepus americanus)*, which evidently were fairly common in the Old Cro[illegible] Basin during the late Pleistocene. Birds, such as ducks and ptarmigan, and voles make up most of the rest of their diet. Besides people, lynx have few predators except for mountain lions and wolves. In the forest they can escape wolves by climbing trees.

Felis (Puma) cf. *concolor* (mountain lion)

A single specimen of what appears to be a large mountain lion or cougar (Figure 47A-B, Table 50) has been collected from Yukon Pleistocene deposits. At the present time, mountain lions are occasionally seen within the southern border of the Yukon Territory (Youngman 1975, p. 153).

Referred specimen

NMC 24958 from Old Crow Locality 11A is an RP_4 lacking the roots. The complete crown seems to have been broken off leaving the roots in the mandible. All cusps are all worn, which in conjunction with the relatively large size of the tooth, suggests that an adult is represented. There is no evidence that the tooth differs in any characteristics from P_4s of living mountain lions, but it averages about 30% larger in all measurements than Recent specimens with which it was compared. The height of the principal cusp is particularly great (approximately 40% larger) in relation to those of Recent mountain lions examined. NMC 24958 is much smaller than P_4s of the American lion *(Panthera leo atrox)*, but no dP_4s were available for comparison. The morphological features of the specimen indicate its affinities with the mountain lion; the size difference seems worth noting

Figure 47. Crown of an RP_4 (NMC 24958, Old Crow Locality 11A) tentatively referred to a Pleistocene mountain lion (*Felis (Puma)* cf. *concolor*). A. Lateral view. B. Occlusal view.

A

3 CM

B

3 CM

Table 50. Measurements of a Pleistocene mountain lion *(Felis (Puma)* cf. *concolor)* P_4 from the Yukon Territory compared to P_4s of recent mountain lions from British Columbia.

Specimens	Sex	Measurements (mm)*			
		1	2	3	4
Felis (Puma) cf. *concolor*. Pleistocene, Y.T.					
NMC 24958 Old Crow Loc. 11A	–	19.1	11.5	10.9	13.4
Felis (Puma) concolor. Recent, B.C.					
NMC 11269	–	17.5	8.9	10.8	8.2
NMC 14344	♂	16.7	8.5	11.9	8.3
NMC 11508	♀	16.1	7.4	9.7	7.3
NMC 29264	♂	16.0	8.3	11.9	8.4
NMC 11507	♀	15.6	7.8	9.8	7.6
NMC 29263	♂	14.4	7.5	10.7	7.8

* 1 – P_4 length.

2 – P_4 width.

3 – Basal length of principal cusp of P_4.

4 – Height of principle cusp of P_4.

however, and the fossil may represent another species within the same subgenus *(Puma)*, such as the giant mountain lion *(Felis (Puma) inexpectata)*. Therefore, pending the recovery of more complete fossils, NMC 24958 is tentatively referred to *Felis (Puma)* cf. *concolor*. The specimen is stained black.

The Yukon fossil is almost certainly pre- late Wisconsin in age. This species has not been recorded previously from Pleistocene deposits of Canada or Alaska.

The mountain lion appears to be related to the larger, rangier giant mountain lion *Felis inexpectata*, which is known from the early Pleistocene (late Blancan) faunas of Cita Canyon and Blanco, Texas, and Curtis Ranch, Arizona, through the middle Pleistocene (Kansan) faunas of Mullen II, Nebraska, Cumberland Cave, Maryland and Conard Fissure, Arkansas. *Felis concolor* is fairly common in the late Pleistocene. It first appears in the late Illinoian fauna of Santa Fe River IIA (Webb 1974, Figure 2.2, Table 2.1) in Florida, continues through the Sangamon interglacial (Reddick IA, Florida; Cragin Quarry, Kansas), and has been reported from many sites of Wisconsin age from California to Florida and Idaho to Maryland (B. Kurtén, personal communication 1976). Presumably the species evolved during the Illinoian glaciation. Evidently late Pleistocene mountain lions were larger on the average than those found in the same areas today (Merriam and Stock 1932, p. 207; Anderson 1968, p. 46), and it is worth noting that mountain lions are larger in size toward the northern limits of their range at the present time (Kurtén 1973, p. 4), which may help to explain the unusually large size of the Old Crow specimen.

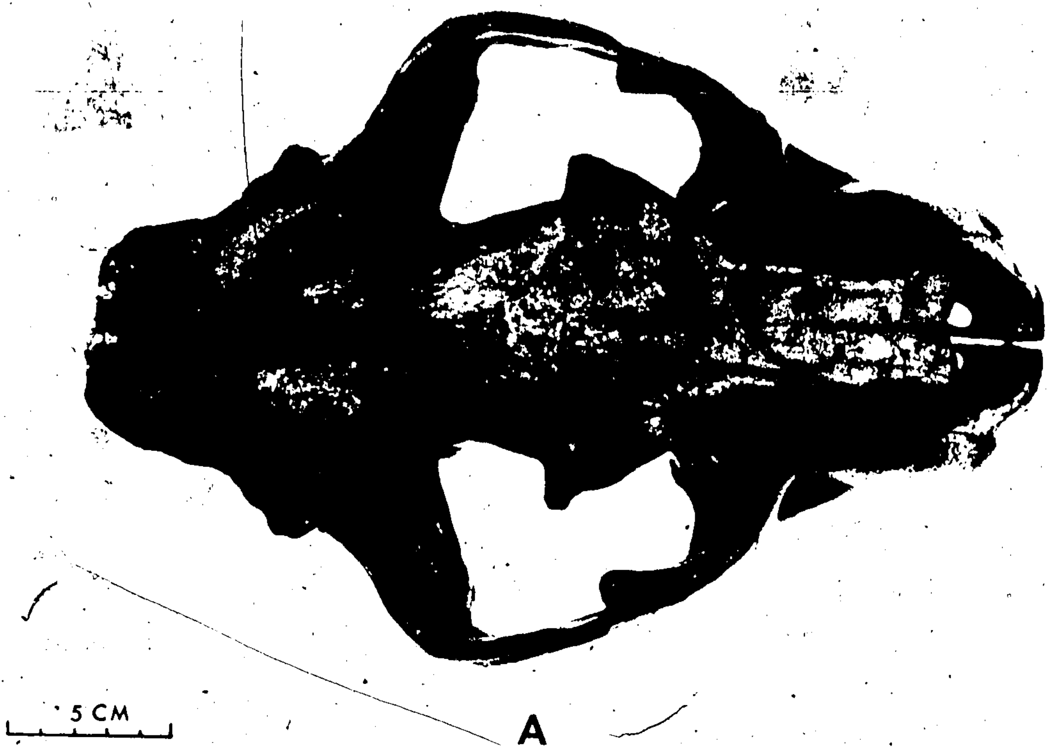
The mountain lion, which is confined to America, h[illegible]f the most extensive distributions of any mammal in the Western Hemisphere. It originally occurred from Pacific to Atlantic (and this was apparently true during the late Pleistocene) and from the southern border area of the Yukon Territory to Patagonia in South America. Mountain lions are fairly large cats, which are known to have reached 8 feet (2.4 m) in total length and approximately 270 pounds (120 kg) in weight. They have long tails, and their well developed hind legs aid them in pouncing on prey. They occupy a wide variety of habitats so their fossils are not particularly useful as paleoenvironmental indicators. It seems to me, however, that they are not well adapted to surviving prolonged cold in relatively open areas - a thought suggested by their long tails, short coats and present range south of the tundra. Therefore, it seems plausible that the fossil NMC 24958 would date to an interglacial rather than a glacial time in the Pleistocene of the Yukon. Cougars, like lynx, are generally solitary and nocturnal animals with keen senses. They are excellent climbers. Their lairs are usually caves or rock crevices, but they may shelter beneath overhanging banks or trees. Mountain lions stalk and feed primarily on large mammals, particularly white-tailed or mule deer. They also eat wapiti, moose, mountain sheep, porcupines, and many other species. Under extreme circumstances they will kill humans. Except for people, who often shoot them to protect livestock, mountain lions have few predators.

Panthera leo atrox (American lion)

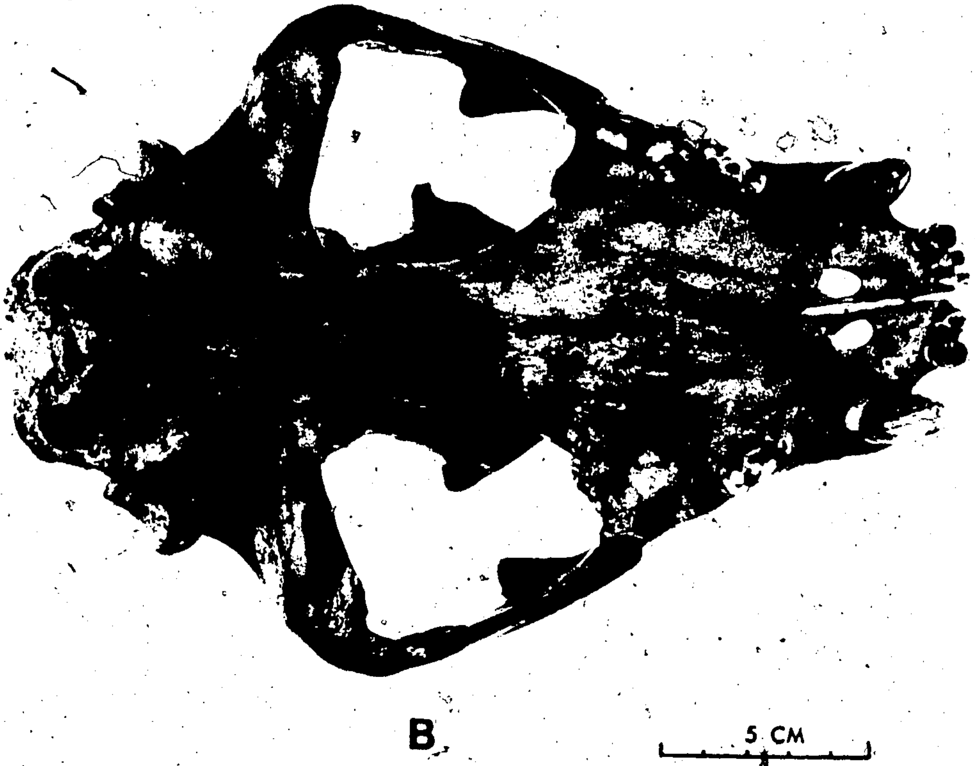
Remains of the American lion (Figures 48A-B, 49A-C, 50, Tables 51-54) are occasionally found in the Pleistocene deposits of the Yukon Territory. They are readily identifiable by their large size, and it is easy to see characters in most bones of the skeleton that differ from those of the scimitar cat *(Homotherium)* and the sabertooth cat *(Smilodon)* (Merriam and Stock 1932). The first American lion remains from Canada and the Yukon Territory were recorded in 1969 (Harington 1969). Since

Figure 48. Cranium (NMC 13742, Dawson Locality 10) of a Pleistocene American lion *(Panthera leo atrox)*.

A. Dorsal view. B. Ventral view.



A



B

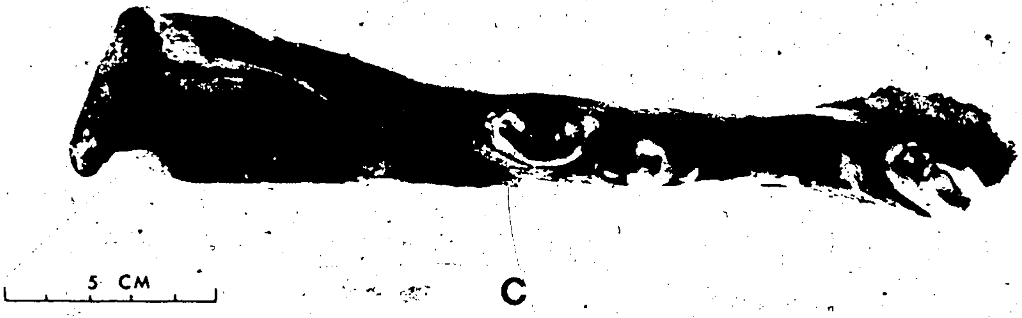
Figure 49. A. Right lateral view of cranium and articulated right mandible (NMC 13472, Dawson Locality 10) of a Pleistocene American lion *(Panthera leo atrox)*.

B. Right lateral view of right mandible with RC_1, and RP_4-RM_1 (NMC 13472, Dawson Locality 10).

C. Occlusal view of right mandible NMC 13472.

A

B



C

Figure 50. Restoration of an American lion (*Panthera leo atrox)* attacking a Yukon wild ass (*Equvs (Asinus) lambei)*. Ink sketch by Bonnie Dalzell.

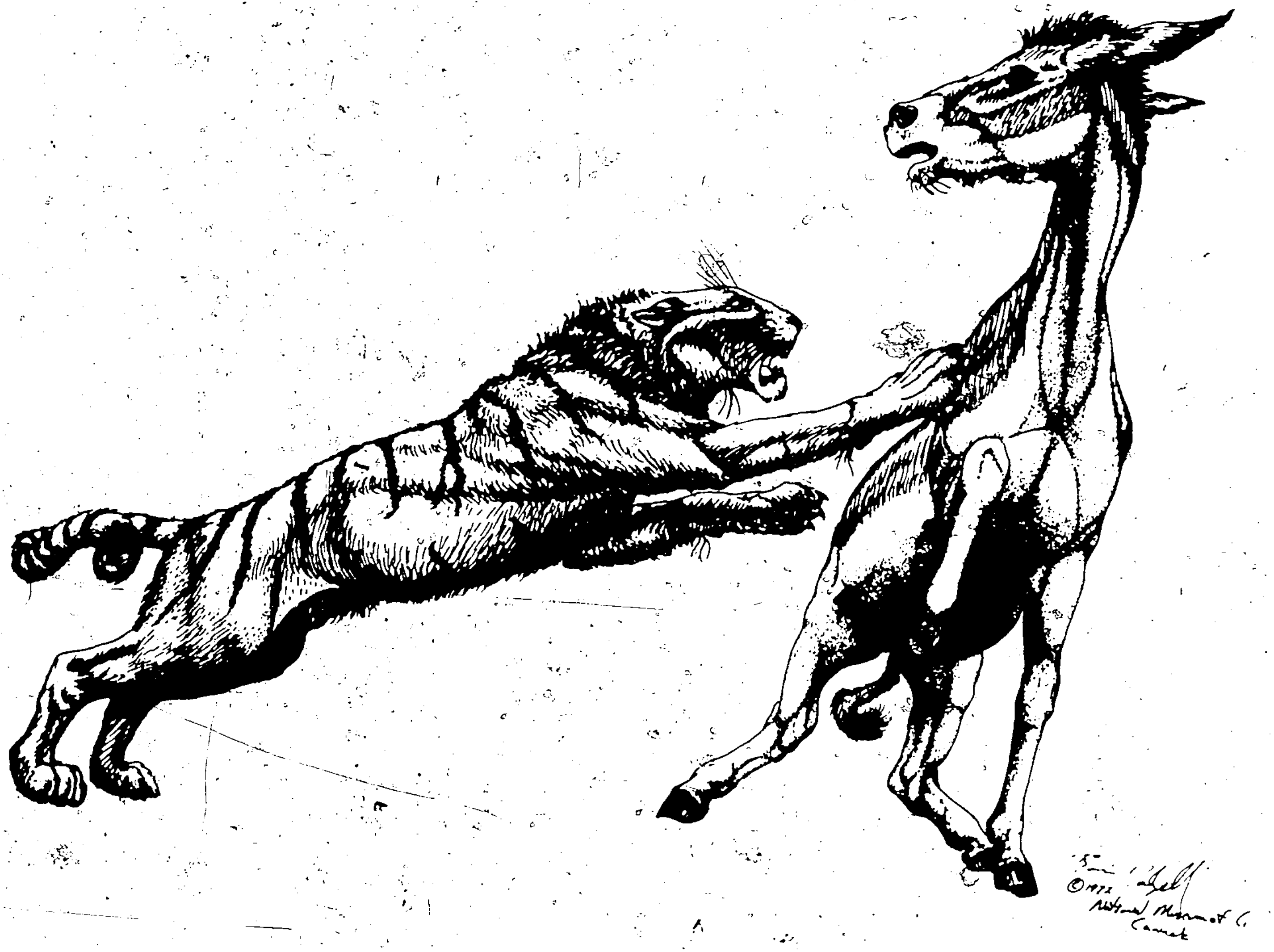

©1972 National Museum of C.
Canada

Table 51. Measurements of Pleistocene American Lion (*Panthera leo atrox*) crania from the Yukon Territory compared to those of Pleistocene American lions from R. cho La Brea, California.

Specimens	Measurements (mm)*																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Panthera leo atrox, Pleistocene, Y.T.																	
NMC 13742 Dawson Loc. 10	293.8	278.2	319.0	148.6	83.8	70.4	53.0	94.8	70.3	107.8	66.4	214.3	87.0	132.5	29.6	130.3	63.7
NMC 12230 Dawson Loc. 7	-	-	-	-	101.1	-	-	-	77.2	114.0	72.4	253.4a	-	-	28.8	144.2a	71.4
NMC 29013 Dawson Loc. 16	-	-	-	-	93.3	-	-	-	-	-	67.2	-	-	-	27.2	146.1	65.2
Panthera leo atrox, Pleistocene, Rancho la Brea, Calif. (Merriam and Stock 1932, p. 173)																	
M	353.1	331.6	396.2	176.4	94.7	97.1	62.3	115.9	84.9	114.2	78.8	250.4	89.5	126.8	26.9	146.5	69.6
OR	290-424.3	269-404.7	310.3-467.5	142.9-212	80-112.5	79.2-114	47a-73	98-141.4	68.8-106.6	99-132	71-89	203a-304.3	76-108.4	110-147.8	21.1-35.9	122.8-173.6	58.4-73.6
N	17	18	16	16	16	13	16	18	15	14	17	15	16	17	18	14	17

ndylobasal length.
2 - Basal length.
3 - Total length.
4 - Palatal length.
5 - Posterior of glenoid cavity to posterior of condyles.
6 - Nasal length.
7 - Width of nasal opening.
8 - Rostral width at canines.
9 - Least width between orbits.
10 - Width across postorbital processes.
11 - Width at postorbital constriction.
12 - Zygomatic width.
13 - Posterior palatal width between inner roots of upper carnassials.
14 - Width across posterior alveoli of upper carnassials.
15 - Width across bulla.
16 - Mastoid width.
17 - Width across condyles.

Light copy

Table 52., Measurements of Pleistocene American lion *(Panthera leo atrox)* upper dentitions from the Yukon Territory compared to those of Pleistocene American lions from Rancho La Brea, California.

Specimens	Measurements (mm)*									
	1	2	3	4	5	6	7	8	9	10
Panthera leo atrox. Pleistocene, Y.T.										
NMC 13742 Dawson Loc. 10	23.0	15.8	8.2	24.3	13.2	34.8	17.9	14.4	13.8	98.5
NMC 24234 Old Crow Loc. 22	-	-	-	-	-	38.4	18.9	14.5	15.0	-
Panthera leo atrox. Pleistocene, Rancho La Brea, Calif. (Merriam and Stock 1932, p. 177)										
M	28.9	21.2	8.7	27.1	13.9	39.4	20.1	15.0	15.1	118.6
OR	25.2-36.8	18.0-25.7	7.3-11.4	23.9-30.6	12.0-16.2	35a - 45.0	18.3-22.9	12.4-17.0	13.9-16.5	101.2-139.4
N	11	11	16	14	15	15	16	15	14	16

* 1 - C^1 length.

2 - C^1 width.

3 - Length P^2 alveolus.

4 - P^3 length.

5 - P^3 width.

6 - P^4 length.

7 - P^4 width.

8 - P^4 length of paracone.

9 - P^4 length of metacone blade.

10 - Alveolar length C^1-P^4.

Table 53. Measurements of Pleistocene American lion (*Panthera leo atrox*) mandibles and lower dentitions from the Y[illegible]rritory compared to those of Pleistocene American lions from Rancho La Brea, California.

	Measurements (mm)*																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Panthera leo atrox, Pleistocene, Y.T.																				
NMC 13742 Dawson Loc. 10	218.6	70.8	42.2	47.5	20.2	95.0^{+}	42.4	-	15.9	20.4	14.6	-	-	25.0	12.0	12.3	27.5	13.5	116.7	76.0
NMC 29014 Dawson Loc. 16	248.0	79.7	42.4	50.3	22.3	123.2^{+}	54.1	58.3	22.1	26.2a	17.2	-	-	25.9	11.8*	12.4	-	-	126.3	71.7
NMC 29167 Sixtymile Loc. 3	259.9	81.2	50.2	55.8	24.9	126.6	50.5	61.7	22.5	29.3^{+}	21.4	18.7	10.6	-	-	-	28.9	14.8	133.5	79.1
NMC 15433 Old Crow Loc. 14N	-	-	-	-	-	-	-	-	-	27.9	18.8	-	-	-	-	-	-	-	-	-
Panthera leo atrox, Pleistocene, Rancho La Brea, Calif. (Merriam and Stock 1932, pp. 176-177)																				
M	241.0	78.4	50.3	54.1	24.9	121.7	51.6	60.1	22.4	26.8	20.0	19.5	11.1	29.1	14.3	13.3	29.7	14.9	137.2	78.2
OR	206- 318	67.2- 99.3	38.9- 60.7	46.0- 67.1	20.0- 36.9	96.3- 150.0	42.0- 66.4	44.5a- 74.9	18.4- 27.2	21.8- 30.4	15.1- 22.0a	17.0- 21.6	8.9- 13.2	25.8- 32.3	12.0- 16.9	11.9- 15.0	26.9- 33.9	13.0- 17.5	116.4- 156.7	68.3- 89.0
N	16	16	16	16	16	15	16	16	16	11	11	15	15	16	16	16	16	16	14	16

* 1 - Length from symphysis to condyle.
2 - Length of anterior border of symphysis.
3 - Mandibular depth at anterior end of P_4.
4 - Mandibular depth below posterior end of M_1.
5 - Thickness of mandible below posterior end of M_1.
6 - Height of ascending ramus (angle to coronoid process).
7 - Height from angle to condyle.
8 - Width of condyle.
9 - Maximum depth of condyle.
10 - C_1 length.
11 - C_1 width.
12 - P_3 length.
13 - P_3 width.
14 - P_4 length.
15 - P_4 width.
16 - P_4 length of principal cusp.
17 - M_1 length.
18 - M_1 width.
19 - Alveolar length C_1-M_1.
20 - Alveolar length P_3-M_1.

Table 54. Measurements of Pleistocene American lion (*Panthera leo atrox*) forelimb bones from the Yukon Territory compared to those of Pleistocene American lions from Rancho la Brea, California.

Specimens	Measurements (mm)*							
	Humerus				Ulna			
	1	2	3	4	5	6	7	8
Panthera leo atrox.Pleistocene, Y.T.								
NMC 11706 (humerus) Dawson Loc. 28 } same individual	32.5	54.6	90.6	29.1	-	-	-	-
NMC 11707 (ulna) Dawson Loc. 28 } same individual	-	-	-	-	47.0	62.9	42.5	17.9
NMC 27478 (humerus) Old Crow Loc. 62	34.8	41.8	88.8	29.2	-	-	-	-
NMC 25191 (ulna) Dawson Loc. 16	-	-	-	-	48.4	-	38.8	21.2
NMC 16801 (ulna) Old Crow Loc. 14N	-	-	-	-	51.7	-	39.6	25.3
Panthera leo atrox.Pleistocene, Rancho la Brea, Calif. (Merriam and Stock 1932, Tables 42, 44)								
M	36.8	60.3	100.1	32.8	61.4	78.8	50.9	22.9
OR	33.0-41.4	53.4-70.0	85.7-111.3	29.5-36.0	48.0-69.7	68.5-87.8	42.5-57.7	20.7-25.0
N	9	9	9	9	7	7	7	7

*1 - Midshaft width.
2 - Midshaft depth.
3 - Distal width.
4 - Minimum anteroposterior diameter of articulating surface for ulna.
5 - Greatest width of greater sigmoid cavity.
6 - Depth from posterior border to top of coronoid process.
7 - Shaft depth at proximal end of tendon scar.
8 - Shaft width at proximal end of tendon scar.

then, several specimens have been collected from the Dawson, Sixtymile and Old Crow areas. Some of the more complete fossils are described.

A few preliminary remarks seem necessary before describing the specimens. There has been a dispute over the affinities of the American lion. Leidy (1853, p. 320), in his description of the type specimen "*Felis atrox*" (the anterior half of a mandible from Mississippi), mentioned several points in which he considered it was closer to a lion than a tiger. Merriam and Stock (1932) gave the first detailed description of the species, basing it on an abundant sample of good specimens from the Rancho La Brea tar pits in California. Primitive features of the species, such as relatively small brain size, and structural similarities to both the lion and tiger, suggested to them that it approached the ancestral group from which the large cats may have been derived. It is surprising that Merriam and Stock (1932, pp. 190-195) did not refer this large American cat to the Eurasian cave lion, considering the results of their comparisons. They (Merriam and Stock 1932, pp. 186-187) apparently refrained from this because of a lack of knowledge then concerning Pleistocene faunal relationships of North America and Eurasia. Evidently they knew of no cave lion remains closer to North America than the Urals. Because of this, and a report of "tiger" remains from northern Siberia, they thought a closer relationship between the Rancho La Brea animals and the tiger, rather than the lion, might be implied from the zoogeographical data alone. Also, they apparently expected that an ancestral form might be found in the North American Tertiary. Simpson (1941) remarked that *"Panthera atrox"* is not a lion and might be called a giant jaguar (a term first used by Freudenberg in 1910), specifically distinct from the South American jaguar, *Panthera onca*, but nevertheless related to it. This opinion held sway among American paleontologists until recently, when more detailed morphological and zoogeographical studies have clearly demonstrated that this large American cat is a lion, closely allied to, if not consubspecific with the Eurasian cave lion (Harington 1969, pp. 1282-1286; Vereshchagin 1971; Hemmer 1974).

Referred specimens

NMC 13742 from Dawson Locality 10 is a rather small, complete cranium with all teeth except LI^1, both P^2s, LP^3 (the anterointernal root is still in its socket) and both M^1s. The palatine and lacrimal bones below the orbits are damaged. A right mandible associated with the cranium lacks only the incisors, RP_3 and bone on the superior and posterior margins of the coronoid process. The teeth of this skull are well worn, particularly the upper incisors and the shearing surfaces of the carnassials, which, combined with complete fusion of the frontal suture, the basioccipital - basisphenoid suture, and the strong development of the sagittal crest, indicate that an adult is represented. The palatal bones are misleading with regard to age determination, for obviously they have sprung apart after the animal's death, probably as a result of drying after the specimen was released from the permafrost. The relatively slender canines, and smallness of the cranium and mandible may be indicative of a female (Stock 1965, pp. 39-40). The specimen is tan with a dark gray surface mottling (manganese?). These fossils came from near the interface of a gold-bearing gravel somewhat more than 5 inches (13 cm) thick and an overlying 25 to 50-foot (7.6 to 15.2 m)-thick unit of organic silt or muck. Evidently the lion represented by NMC 13742 died near the locality where it was found.

NMC 12230 from Dawson Locality 7 is a cranial fragment posterior to the nasals. Zygomatic arches are lacking except for most of the right zygomatic process of the temporal. Mastoid and paroccipital processes are heavily worn or missing, and the supraoccipital is broken off. The specimen is of average size for the American lion. Fusion of the basioccipital - basisphenoid suture (see Miller 1968, p. 5), and the marked development of the sagittal crest suggest that the specimen represents an adult male. Signs of surface erosion show that the specimen was transported for a short distance. The fossil was collected near the interface of the gravel and muck at Quartz Creek. It has been described previously (Harington 1969, p. 1277).

Another posterior cranial fragment, NMC 29013, was collected from Dawson Locality 16. It is similar to NMC 12230 except that bone anterior to the postorbital processes is missing. Only the stub of the temporal process of the left zygomatic arch is preserved. The sagittal crest is well developed.

NMC 24234 from Old Crow Locality 22 is an LP^4 slightly larger than that preserved in NMC 13742, and of approximately average size compared to a sample from Rancho La Brea. The vestigial cusp of the protocone is evident, as is an extensive facet on the lingual surface of the paracone and metacone. The cementum on the three roots of this tooth is stained rusty brown, while the enamel is ivory colored with a grayish mottling, as seen in teeth from the Dawson Are. It may be of late Wisconsin age.

NMC 29014 from Dawson Locality 16 is a right mandible lacking the incisors, the tip of the canine and RM_1. The tips of the coronoid and angular processes are lacking. Part of a groove-like wear facet made by RC^1 is seen on the posterolateral surface of the lower canine. Wear is moderate on the principal and posterior cusps of RP_4.

NMC 29187 from Sixtymile Locality 3 is a left mandible lacking the incisors, the tip of the canine (like NMC 29014 it also shows a groove-like facet made by the upper incisor), and most of the crown of LP_4. The metaconid blade of LM_1 is heavily worn and its anterior portion appears to have been broken, then worn. It is the largest of the three mandibles described, but is only of average size relative to American lion mandibles sampled from the tar pits of Rancho La Brea. Pitting around the alveolar margins, the high degree of wear on the teeth and the massive canine suggest that an old male is represented. A slight peculiarity of the specimen is that there are two posterior mental foramina instead of the single foramen usually found beneath the anterior root of P_3. The specimen is pale buff in color.

NMC 15433 from Old Crow Locality 14N is an lC_1 with a broken root tip and a 20 mm long x 5 mm wide groove-like wear facet on the posterolateral surface. It is stained blackish brown and has approximately eight ridge-like bands girdling the cementum of the root, which may be annuli. The characteristic ridge running from the cingulum to the tip of the enamel on the anteromedial surface is present. The tooth is blackish brown and may be of pre- late Wisconsin age. Generally, the teeth of American lions from the Yukon Territory are smaller than those from farther south (Rancho La Brea).

NMC 11706 from Dawson Locality 28 is a right humerus lacking the proximal end. It is smaller than an American lion humerus (UCMP 2051) from Rancho La Brea with which I compared it, but has the same morphological features. It was found with and articulates with the ulna NMC 11707.

NMC 11707 from the same locality is a right ulna, lacking the distal end, which articulates with NMC 11706. The surfaces of both bones are bright orange brown, and are covered with clearly defined rootlet impressions, not inconsistent with decay in a grassy loess-steppe environment. These specimens have been described in greater detail and illustrated (Harington 1969, p. 1280, Plate III).

NMC 27478 from Old Crow Locality 62 is the distal half of a left humerus that compares closely in size and in all morphological features with NMC 11706.

NMC 25191 from Dawson Locality 16 is a right ulna lacking the extremities. It is stained brown. NMC 16801 from Old Crow Locality 14N is the proximal part of a right ulna lacking the olecranon region. It is stained dark brown and may be of pre- late Wisconsin age.

A right metatarsal IV (LUM 1. 176) from Dawson Locality 32 has been described by Harington and Clulow (1973, p. 700). Probably it is of late Wisconsin age.

Discussion

Evidently American lions were widespread in the Yukon part of the Eastern Beringian refugium. Most of the specimens from near Dawson and Sixtymile are probably of late Wisconsin age. Except for NMC 24234, the Old Crow fossils are deeply stained and are likely pre-late Wisconsin in age.

American lion fossils have been reported from many parts of Alaska such as the Fairbanks area (Guthrie 1968b), Lost Chicken Creek near the Yukon - Alaska border (Whitmore and Foster 1967), and the Kaolak River near the arctic coast (Harington 1969, pp. 1280-1282). Probably most of these specimens are of Wisconsin age. A specimen mentioned as "*Felis* sp. (large cat)" from the loess at Gold Hill near Fairbanks may represent the American lion. If so, it would probably be of Illinoian age (Péwé 1975a, p. 96).

The only Canadian records, apart from the Yukon fossils, are from near Bindloss (Harington 1971) and Medicine Hat in southern Alberta (Stalker and Churcher 1970). The Medicine Hat material is from deposits of Sangamon interglacial age.

In the United States, the earliest (probably Illinoian) record of *P. leo atrox* is from American Falls, Idaho. Specimens of Sangamon interglacial age, or early Wisconsin to Sangamon age, are known from Cragin Quarry, Kansas and Easley Ranch, Texas, respectively. Fossils of this species have been collected at many localities of Wisconsin age in the United States, and from Tequixquiac, Mexico (Freudenberg 1910) and the Talara tar-seeps, Peru (Lemon and Churcher 1961).

Probably central Asia was the dispersal centre of the genus *Panthera* (Thenius 1967, p. 138). The earliest known large cat having both lion and tiger-like characters is *Panthera* sp. from the Villafranchian (Bed II) deposits at Olduvai Gorge, East Africa (Ewer 1965, p. 21). This cat seems to have been very closely related to *Panthera leo fossilis* of the early middle Pleistocene of Europe (Mauer, Mosbach, Scharzfeld and Obrigheim), which probably gave rise to the cave lion *Panthera leo spelaea* and, I think, the American lion *Panthera leo atrox*, which are characterized by more efficient crushing teeth (Schütt 1970, pp. 213-214). The cave lion first occurred in Europe during the middle to late Pleistocene (Schütt 1970) and evidently lived there continuously until the last glaciation (Kurtén 1968, pp. 85-87). *"Panthera youngi"*, with affinities to both the cave lion and American lion, appeared in northeastern China (Choukoutien Locality 1) during the late middle Pleistocene. I suspect that this cat is very close to the transition between *P. leo fossilis* and the "*spelaea* group" (the northern Holarctic lions including *P. leo spelaea* in Europe and Siberia and *P. leo atrox* in America; the other group being the "*leo* group" of the southern Palearctic, Ethiopian and western Oriental regions (scheme slightly modified from that of Hemmer 1974, p. 271)).

Panthera leo atrox ranged from northern Alaska to northwestern Peru, and from California to Florida (Harington 1969, Figure 1; Harington 1971, Figure 1). It has a temporal range extending probably from the Illinoian glacial, and certainly from the Sangamon interglacial, to the end of the Wisconsin glacial. The only direct radiocarbon date of the American lion from Beringia is on tendon from a tibia from Alaska, which yielded a date of 22,680 ± 300 years B.P. (SI-456), indicating the species was there near the peak of the late Wisconsin glaciation. Many of the Yukon specimens appear to be of similar age. The most recent remains seem to be from Jaguar Cave, Idaho, where hearths containing its bones have been radiocarbon dated at 10,370 ± 350 years B.P. (Kurtén and Anderson 1972, p. 22).

In summary, the cave lion *P. leo spelaea* was common in eastern Siberia during the late Pleistocene (from the Illinoian glaciation to the close of the Wisconsin glaciation). Its remains have been reported from the Yensei River in the west of that region to the

Alazeya River in the east (Vangengeim 1961, p. 141) – about 1,000 miles (1,600 km) west of the nearest known specimen of *P. leo atrox* from the Kaolak River in northern Alaska. That distance is perhaps of little significance considering the wide-ranging habits of the cave lion, its adaptability to cool climatic conditions, and the breadth of the land connection between Siberia and Alaska during the late Pleistocene glaciations. The presence of bison, horse and mammoth herds on the grassy Bering Isthmus probably made it very attractive to lions. Therefore, the ancestral stock *(P. leo spelaea)* that gave rise to *P. leo atrox* probably crossed the Bering Isthmus from Siberia to North America during the Illinoian glaciation. Lions had penetrated the North American Plains by late Illinoian or early Sangamon time. As the Wisconsin ice spread, American lions were isolated in refugia to the north (Eastern Beringia) and south. Toward the end of the Wisconsin glaciation they ranged the southwestern half of the United States, penetrating as far south as Mexico and Peru. Some barrier, probably rather dense forests, seems to have prevented their movement into the northeastern United States and eastern Canada. The large lions of northern Eurasia and America became extinct at the close of the Wisconsin glaciation, probably following the decline of their large prey.

American and cave lions seem to have been larger than most living lions. Intriguing evidence indicates that these "*spelaea* group" lions had a faintly striped coat. A rather detailed wall engraving of a cave lion by a Paleolithic artist at Combarelles, France (Koby 1941, Figure 8) suggests that it had pale stripes and a slight mane. Probably it had a thick coat too - perhaps like the Amur tiger - as an adaptation to cold northern climates (Cornwall 1968, p. 1311). Gromov (1935, pp. 166-167) has described a small mammoth tusk figurine of a man wearing the whole skin of an animal with a long tail and head covering the wearer's head from the upper Paleolithic site at Mal'ta in the Soviet Union. The surface of the skin is striped, and Gromov suggests that the only animal pelt that could be depicted is that of a cave lion.

Probably the "*spelaea* group" lions were much like the modern lion in preferring open grassland and parklands. Their fossils are generally found with remains of other Pleistocene mammals (e.g. on the New Siberian Islands; at Lost Chicken Creek, Alaska; Gold Run Creek, Yukon Territory and Rancho La Brea, California) with those habitat preferences. They seem to have been well adapted to an arctic steppe environment. Probably heavy forests covering much of eastern North America during the late Pleistocene prevented

American lions from flourishing there.

Presumably American lions were gregarious and hunted in groups like African lions. They may have sheltered in caves, rock fissures or steep canyons, lining their dens with dried leaves or grass like Amur tigers (Stroganov 1969, p. 491) – large cats that have likewise adapted to cold climates. According to their anatomical structure, American lions were at least as fleet as African lions which are able to reach speeds of 30 miles (48.3 km) per hour in bursts when hunting (Boorer 1971, p. 91). Perhaps they were best adapted to feeding on the American bison (e.g. *Bison crassicornis* and *Bison latifrons*). Probably they also hunted wild asses and horses, such as *Equus (Asinus) lambei* and *Equus scotti*. Perhaps people were their only predators, although they undoubtedly had numerous competitors among the other large carnivores of the North American late Pleistocene, such as the short-faced bears, brown bears, wolves and wolverines. Remains of American lions among refuse in an archeological site at Jaguar Cave, Idaho, suggest that Paleo-Indians may have hunted or eaten them.

Homotherium serum (American scimitar cat)

Only three specimens from Pleistocene deposits of the Yukon Territory are referred to *Homotherium serum* (Figures 51A-C, 52A-C, Table 55). Evidently the scimitar cat was found in both Old Crow and Dawson areas, but was rarer in this part of Eastern Beringia than the American lion *(Panthera leo atrox)*. The first specimen from Canada and Eastern Beringia was reported in 1970 (Harington 1970, p. 39). It extended the known range of the species over 2,000 miles (3,218 km) northward.

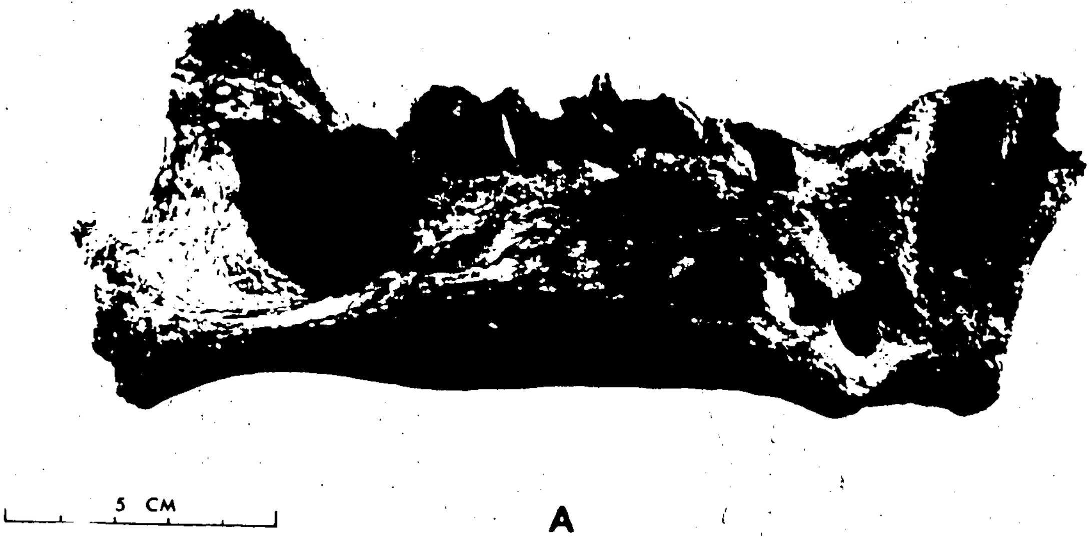
I have found no clear evidence that the saber-tooth cat, *Smilodon*, occupied the Yukon Territory during the Pleistocene. Its presence in Alaska has been mentioned by Geist (1953, p. 172), who merely states: "Saber tooth Tiger - uncommon", and later (Geist 1956, p. 201) "...only rare occurrences of camel and sabertooth cat are reported." Guthrie (1968b, p. 353) indicates that remains of *Smilodon* sp. were collected at Cripple Creek near Fairbanks, but in a colored wall chart accompanying a later publication, Guthrie (1972) illustrates and identifies *Homotherium serum* as the only "saber-toothed cat." Despite these reports, R. Tedford (personal communication 1976) informs me that he has not seen fossils of *Smilodon* in the extensive Frick

Figure 51. Right mandible with damaged RP_4-RM_1 (NMC 12457, Old Crow Locality 21) of a Pleistocene American scimitar cat (*Homotherium serum*).

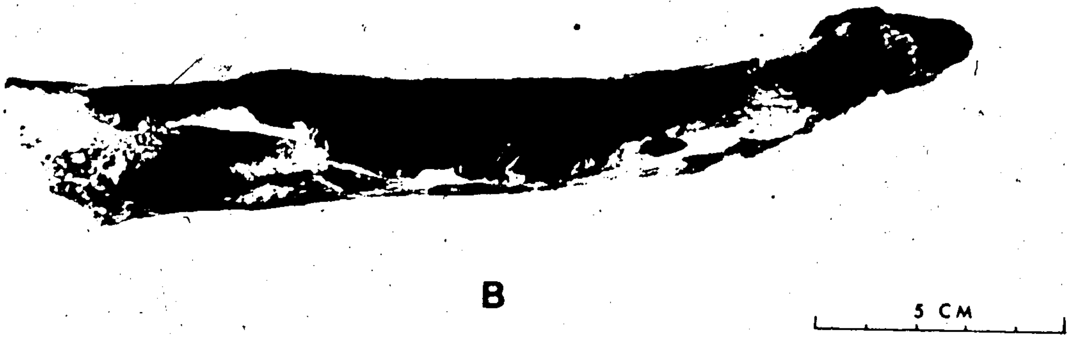
A. Lateral view.

B. Occlusal view.

C. Medial view.



A



B

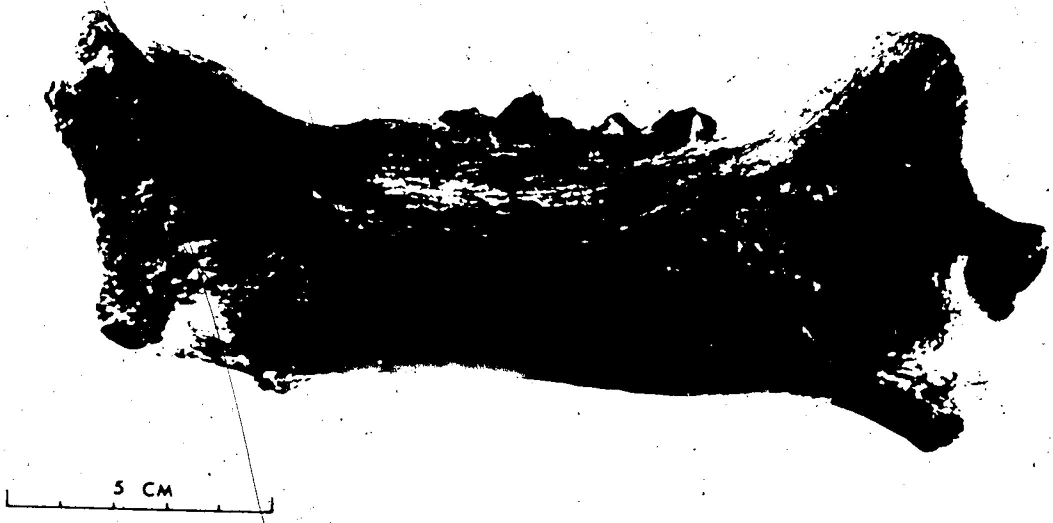


Figure 52. Distal end of a damaged right humerus (NMC 7758, Dawson Locality 9) of a Pleistocene American scimitar cat *(Homotherium serum)* (left) compared to a damaged right humerus of a Pleistocene American scimitar cat (TMM 933-2206, Friesenhahn Cave, Texas) (right).

A. Anterior view.

B. Medial view.

C. Posterior view.


A
B
5 CM
C

Table 55. Measurements of a Pleistocene scimitar cat (Homotherium serum) mandible from the Yukon Territory compared to mandibles of American scimitar cats from the Pleistocene of Texas, Homotherium latidens from the Pleistocene of England, [illegible] from the Pleistocene of Texas, and the sabretooth cat (Smilodon sp.) from the Pleistocene of California.

Specimens	Measurements (mm)*												
	1	2	3	4	5	6	7	8	9	10	11	12	13
[illegible], Pleistocene, Y.T.													
NMC 12457 Old Crow Loc. 21	47.0	48.2	21.1a	50.2	79.2	65.9	53.2	32.7+	45.0+	24.0	[illegible]	[illegible]	[illegible]
[illegible], Pleistocene, Texas, Friesenhahn Cave (Meade 1961, Table 1)													
M	41.9	42.9	18.3	41.2	77.7	62.9	47.6	32.9	51.5	19.2	[illegible]	[illegible]	[illegible]
OR	38.0- 49.7	39.5- 47.5	17.7- 19.8	38.[illegible]- 45.[illegible]	71.0- 83.0	58.0- 67.0	47.2- 43.[illegible]	28.5- 43.6	43.0- 65.5	18.2- 20.4	[illegible]- [illegible]	[illegible]- [illegible]	[illegible]- [illegible]
N (includes right and left mandibles of TMM-933-1)	5	7	8	6	6	5	[illegible]	4	5	9	6	[illegible]	[illegible]
[illegible] (cast), Pleistocene, England, [illegible] ([illegible], personal communication 1969)													
Catalog [illegible] [illegible]	43.4	48.3	21.9**	43.5	[illegible].3**	-	55.6**	-	45.0	21.5	[illegible]+	[illegible]	[illegible].3+
[illegible], Pleistocene, Texas, Cita Canyon (Meade 1965, Table 1)													
[illegible]	43.7	-	-	-	62.0	72.5	48.9	42.0a	-	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible].0*		-	-	-	65.0	46.5	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	32.3	-	-	-	[illegible].0	56.0	[illegible]	29.0	-	[illegible]	[illegible]	[illegible]	[illegible]
Smilodon sp. Pleistocene, Calif. Rancho La Brea (Merriam and Stock 1932, Table 5)													
M	33.9	40.3	21.4	33.8	76	73.2	-	-	-	[illegible]	14.3	[illegible]	[illegible]
OR	27.3- 40.4	30.0- 45.[illegible]	18.7- 25.0	30.7- 44.0	53.0- 76.3	68.3- 89.0	-	-	-	[illegible]- 32.3	12.0- [illegible]	[illegible]- 33.9	[illegible]- [illegible]
N	25	25	25	25	25	16	-	-	-	16	[illegible]	[illegible]	[illegible]

* 1 - Minimum mandibular depth at diastema.
2 - Mandibular depth below posterior end of M_1.
3 - Mandibular thickness below M_1.
4 - Depth, angle to summit of condyle.
5 - Depth, inferior border of angle to apex of coronoid process.
6 - Alveolar length P_3-M_1.
7 - Alveolar length P_4-M_1.
8 - Diastema length (C_1-P_3 alveoli).
9 - Alveolar length C_1-P_4.
10 - P_4 length.
11 - P_4 width.
12 - M_1 length.
13 - M_1 width.

** Measurements taken from a scaled photograph.

collection of Pleistocene mammal remains from Alaska housed in the American Museum of Natural History. Presumably, the records of *Smilodon* from the Fairbanks area were actually based on *Homotherium* fossils. This does not mean that *Smilodon* will never be reported from Pleistocene deposits of Eastern Beringia.

Referred specimens

NMC 12457 from Old Crow Locality 21 is a right mandible with partly damaged RP_4 and RM_1 and partial sockets for RP_3, the canine and incisors. Most of the blade of RP_4 is broken away. The anterior jaw flange and the angle and condyle of the mandible are lacking. The apex of the coronoid process appears to have been slightly eroded. The high degree of wear on RM_1 and the relatively large size of the mandible suggest that an old individual is represented. Morphological features of the specimen that characterize *Homotherium serum* are: (a) masseteric fossa more highly developed than in the sabertooth cat, *Smilodon*, or the American lion, *Panthera leo atrox*, and reaching maximum inflection at its anterior extremity; (b) coronoid process low and rounded as in *Smilodon*, not high and overhanging the condyle as in the American lion; (c) a flange was present on the anterolateral part of the mandible as in *Smilodon* and unlike the American lion; (d) the least depth of the mandible below the diastema is greater than in *Smilodon*. (e) length of the diastema between alveoli for C_1 and P_3, and the C_1-P_4 length, are clearly less than in *Smilodon*; (f) P_4 and M_1 are narrower than those of *Smilodon* or *Panthera leo atrox*; (g) P_3 is present as in *Homotherium serum*: it is usually absent in *Smilodon*. The socket indicates that P_3 in the Yukon specimen had two fused roots as in *H. serum* (Churcher 1966, p. 269) and *Ischyrosmilus johnstoni* from earliest Pleistocene (late Blancan) deposits at Cita Canyon, Texas (Mawby 1965, p. 577); (h) a posterior mental foramen is well developed near the inferior margin of the mandible below M_1 as in *H. serum* (Meade 1961, Plate 1c): it is not apparent in *Smilodon* or the American lion as illustrated by Merriam and Stock (1932), and this part of the type mandible of *Ischyrosmilus johnstoni*, unfortunately, is missing (Mawby 1965, Figure 2). NMC 12457 is larger in most measurements than mandibles of *H. serum* from Friesenhahn Cave, Texas recorded by Meade (1961), but is very close in size and shape to *H. latidens* from England. It appears to be within the general range of measurements for *Ischyrosmilus johnstoni*, but more careful comparisons are required to understand the affinities of these two scimitar cats.

NMC 12457 differs from other scimitar cat mandibles I have seen in the confluence of the two anterior mental foramina. Usually these foramina are well separated. Perhaps this confluence has resulted from a shortening of the mandible anterior to P_3. Pending further evidence, this feature is not considered to be of taxonomic significance; nor is the rather large size of the mandible compared to other *H. serum* specimens from Texas. Clines are detectable among other large cats such as the mountain lion, in which body size increases toward the northern limits of the species' range. In this case increased size could also be a function of the relatively old age of the individual. The mandible is stained dark brown, suggesting that it was permeated by mineral-bearing groundwater during a relatively warm period prior to formation of permafrost in the area during the late Wisconsin. I infer that the mandible is of late Pleistocene and probably pre- late Wisconsin age.

NMC 24216 from Old Crow Locality 66 is a fragment of an LC^1 or "scimitar" that was originally located between the tip and the uppermost exposed part of the canine. The specimen is only 49.7 mm long. Part of the slightly convex anterior margin of the canine fragment is serrated as in *Homotherium* and *Smilodon*.

The posterior margin and lower tip of the tooth are lacking. Its transverse diameter is 10.4 mm and its estimated anteroposterior length is about 28 mm. These proportions best fit the canines of *H. serum*, which are more compressed laterally and smaller than in *Smilodon*. The fossil is tentatively referred to *Homotherium serum*. It is stained black and appears to be of pre- late Wisconsin age.

NMC 7758 from Dawson Locality 9 consists of the distal two-thirds of a right humerus, lacking part of the lateral condyle and the proximal part of the medial epicondylar region. The anterior surface of the distal articulation is damaged, and deep subparallel gnaw marks are seen on the proximal end of the broken shaft on the lateral surface. They are opposed by shallower, subparallel marks having the same orientation on the medial surface. I think they were made by a medium to large carnivore, such as a fox, wolverine or wolf. The origin of the marks on the lower part of the shaft is less certain. There, shallower marks on the anterior surface are parallel to deeper slashes posterior to the entepicondylar foramen. It is an unusual coincidence that gnaw marks, evidently made by rodents in this case, appear on similar parts of a right humerus of

Homotherium serum (TMM 933-2206) from Friesenhahn Cave, Texas, which was borrowed for comparative purposes. NMC 7758 averages 8% smaller than TMM 933-2206.

Features shared by NMC 7758 and TMM 933-2206 that seem to be characteristic of *Homotherium serum* humeri, but which are not evident on humeri of *Smilodon* (UCMP 28154) and *Panthera leo atrox* (NMC 11706) are: (a) structural slenderness and lightness, seen particularly in the narrowness and shallowness of the shaft: sabertooth cat and American lion humeri are more robust, especially in midshaft depth; (b) the gradual meeting (the angle of juncture is more acute) of deltoid and median ridges, which occurs relatively higher on the anterior surface of the shaft. Also, the surface between the converging ridges is bevelled inward rather than outward as in the sabertooth cat and American lion; (c) the relative straightness of the lateral condyloid crest when viewed from behind, compared to its slight convexity in the sabertooth cat and American lion; (d) the slip of bone enclosing the entepicondylar foramen is situated closer to the anterior surface of the humerus than in the sabertooth cat and American lion; (e) the apparent prominence of the lateral epicondyle and the poorer development of the muscle scar above it, compared to those features in the sabertooth cat and American lion. However, a larger series of humeri of each species would probably show more variability in some of these features. Recent breaks on NMC 7758 show that the interior bone of the humerus is quite fresh in appearance. The specimen is probably of late Wisconsin age.

The history of NMC 7758 is interesting. It was purchased by D.D. Cairnes in 1911 for the Geological Survey of Canada. It is part of a larger collection of Yukon Pleistocene mammals comprising the following species: *Mammuthus primigenius* (woolly mammoth), *Equus (Asinus) lambei* (Yukon wild ass), *Rangifer tarandus* (caribou), *Ovis ?dalli* (Dall sheep) and *Bison crassicornis* (large-horned bison). An entry in L.M. Lambe's original catalog states that the material came from "NO. 1 {claim}, Discovery Pass {Pup?}, Last Chance Creek, Yukon, all about 35 feet {10.7 m} from the surface and within a distance up and down the creek of 50' {15.2 m}." Lambe misidentified the specimen as the distal end of the right humerus of a deer, and it was displayed for many years in the National Museum of Canada as "Humerus of Deer".

Discussion

In summary, the American scimitar cat is known from both Dawson and Old Crow areas of the Yukon Territory. Deeply stained specimens from the latter area suggest that the species lived in the Yukon prior to the late Wisconsin glaciation, while the Dawson specimen indicates that it survived there until late Wisconsin time. The species probably lived in central Alaska during the late Pleistocene, but the Alaskan fossils have not yet been described.

This species or a closely related form occurs in middle Pleistocene faunas of Irvington, California, Inglis IA, Florida, and Gililand, Texas. Evidently the American scimitar cat was widespread in the late Pleistocene, for there are records from Oregon, Kansas, Tennessee, Oklahoma and Texas, in addition to the Yukon and probably Alaska. Although widespread, it seems to have been a relatively rare carnivore in the North American Pleistocene. Yet, an extremely interesting concentration of material has been preserved in Friesenhahn Cave, Texas.

The evolution and dispersal history of the American scimitar cat are difficult to understand, because it has various possible derivations. The following scheme is put forward as a hypothesis for testing. *Nimravus* of the early Miocene (Arikareean) of North America, having scimitar teeth (i.e. highly flattened, sharp upper canines rather than the rounder, longer "dirk" teeth of the sabertooth cats such as *Smilodon*), but lacking anterior flanges on the mandible, may have been ancestral to *Machairodus*, which appears to be a good generalized ancestor for the Pleistocene scimitar cats of the genus *Homotherium*. *Machairodus* occurred in the Pliocene of North America, Eurasia and Africa, and was characterized by scimitar teeth, and sometimes by anterior flanges on the mandible.

There seems to have been a primary radiation of *Homotherium* during the earliest Pleistocene from an advanced *Machairodus* stock in either North America or Eurasia, which led to a dominance of the greater scimitar cat, *Homotherium sainzelli* (= *Epimachairodus crenatidens* or *Homotherium crenatidens*), in Europe from Villafranchian to Waalian (?Nebraskan) time, and of *Ischyrosmilus johnstoni* in the early Pleistocene of North America. I stress the point that *Ischyrosmilus* and *Homotherium* are probably congeneric and that *I. johnstoni* could even be a junior synonym of *H. sainzelli*. Both were long-limbed rather slender animals with deep, massive mandibles. The relatively short, flattened scimitars and high narrow carnassials are similar. There are many points of resemblance in the crania, including the form of the mastoid process, the shape of the auditory bulla, the keel and depressions of the basioccipital and the division of the sagittal crest (Mawby 1965, p. 584). Evidently *H. sainzelli* gave rise to a more advanced group of scimitar cats *(H. latidens)* during late Günz (?late Nebraskan) time in Europe. They were characterized by scimitar teeth and small to medium-sized mandibular flanges like *H. sainzelli* and *Ischyrosmilus*, and spread rapidly about Kansan time to Java *(H. zwierzyckii*: Djetis beds*)*, China (*H. ultimum*: Choukoutien) and via the Bering Isthmus to North America *(H. serum)*. The main difference between the earlier and later scimitar cats seems to have been the smaller size of the scimitars in the latter group (Kurtén 1968, p. 76).

I follow Kurtén (1968, p. 76) in emphasizing the great similarity between *H. latidens* of Europe and *H. serum* of North America. Certainly their mandibular dimensions are close. *H. latidens* survived in England until the last glaciation and *H. serum* lived in North America until the late Wisconsin. Undoubtedly the ultimate extinction of the scimitar cats followed the extinction of the large prey, such as mammoths, that they were specialized in hunting.

Homotherium serum was widely distributed in North America from Kansan to Wisconsin time, ranging from Atlantic to Pacific in the United States and from Texas to the northern Yukon Territory. The American scimitar cat was the size of a lion, being characterized by long, powerful forelimbs, weaker hind limbs (Mawby 1965, p. 585), and a bob-tail like the lynx. Its "scimitars" were short compared to *Smilodon*, greatly flattened and razor-sharp.

Mazák (1970, p. 360) argues persuasively that a stone statuette about 16 cm long from upper Aurignacian deposits (approximately late Wisconsin, see Bordes 1968, Figure 73) in the cave of Isturitz in southern France depicts the lesser scimitar cat, *Homotherium latidens*, which, as has been mentioned, was probably very similar to the American scimitar cat. The head is big and the lower jaw is deep in the area of the flange, the body is short and powerful, the legs are strong (unfortunately the extremities are missing) and the tail is short and stump-like. A scaled-down outline of the skull of *H. latidens* fits remarkably well within the form of the head of the Isturitz statuette (Mazak 1970, Figures 2, 3). Other features such as the well developed upper legs and short body and short tail also fit what is known of the scimitar cat skeleton. According to the statuette, the scimitars of *Homotherium* were hidden by the lower lip when its mouth was closed and did not bite outside the lower lip.

The American scimitar cat seems to have had no particular physical geographical habitat preference, as can be seen from its broad distribution. Perhaps its main requirement was the presence of slow-moving, thick-skinned prey like mammoths, mastodons and ground sloths. Numerous skeletons of American scimitar cats of all ages, including cubs, found in late Wisconsin deposits of Friesenhahn Cave, Texas, show that caves were sometimes used as dens (Meade 1961, p. 27). Evans (1961, p. 19) mentions that more than 441 isolated teeth of young mammoths were found in the cave, compared to only 14 of adults, indicating that scimitar cats concentrated on killing young Pleistocene elephants, often dragging them into the cave afterward. American mastodon *(Mammut americanum)* remains are also present in the cave: again, they are almost entirely young individuals. Presumably the attack of the scimitar cats would have involved stalking the young elephants, a quick pounce, powerful forelegs clinging tightly to the prey and razor-like scimitars slashing vital parts. Attacks may have been made at dusk. Like the American lion, the American scimitar cat probably had few predators.

Family Phocidae

Phoca cf. *(Pusa) hispida* (ringed seal)

In 1973 on the western margin of Pauline Cove, Herschel Island, I collected a seal bone approximately 15 feet (4.6 m) above sea level in addition to marine mollusc shells (a complete pelecypod and part of a coiled shell were collected) and wood. All of these specimens are deeply iron-stained. Careful examination of the exposure revealed that the bone, shells and wood had almost certainly been derived from an oxidized organic layer 30 feet (9.1 m) above sea level. The bank at that point was approximately twice that high. The sediments in the lower half of the section are mainly sandy silt and appear to be a sequence of coastal marine deposits. I suspect that the organic sediments are of Sangamon interglacial age, but much more stratigraphic work is required before sound conclusions can be reached on this subject. V. Rampton (personal communiction 1976), who has studied the stratigraphy of the island and the region, suggests a pre- early Wisconsin interglacial age for these organic sediments.

Referred specimen

NMC 25149 from Herschel Island Locality 5 is the base of a left scapula of a small seal. Although only 45 mm of bone is preserved distal to the glenoid cavity, and th spine is damaged, the positions of the remaining features and the size of the fossil are closely comparable with thos of scapulae of the ringed seal, *Phoca (Pusa) hispida*, which presently lives in the area. Because the specimen is rather incomplete it seems best to refer it to *Phoca* cf. *(Pusa) hispida.* Maximum length and width measurements at the "neck" of the scapula are 20.2 mm long x 11.8 mm wide.

Discussion

Ringed seal remains found on Baillie Islands, Northwest Territories, about 250 miles (402 km) to the east of Pauline Cove, could range in age from Pleistocene to Recent (Harington 1971a, p. 82). Bones of this species were also collected from raised beach deposits near Alert on northern Ellesmere Island. Presumably they are of postglacial age. A relatively complete skeleton of a ringed seal was excavated *in situ* near Hull, Quebec in deposits of Champlain Sea age (perhaps 11,000 years old) (Harington and Sergeant 1972).

The following summary of the origins and dispersal history of the ringed seal is mainly based on recent work by Repenning *et al.* (1976 MS. p. 35). Marine mammals including the ringed seal have been reported from various Pleistocene strata in western Alaska. Some are from beach deposits of apparent Sangamon interglacial age, which are raised well above present sea level.

Some Paratethyan seals of 10 to 13 million years ago, such as *Phoca pontica* and *P. pannonica*, are similar to living seals of the subgenus *Pusa*. Recently discovered material of *Phoca pontica* supports the suggestion that this type of seal was ancestral to *Pusa*. The distribution of the three living species is difficult to explain zoögeographically. *Phoca (Pusa) caspica* lives in the Caspian Sea, a remnant of Paratethys, supporting further the ancestral position of *Phoca pontica*. *Phoca (Pusa) sibirica* lives in Lake Baikal in central Asia, whereas *Phoca (Pusa) hispida* occupies the Arctic Ocean, extending into the North Pacific and North Atlantic, including the Baltic Sea and lakes Saimaa and Ladoga. In Canada, ringed seals have adapted to living in freshwater in Netilling Lake, Baffin Island. A definite trend is the adaptation of this group to cooler waters, which enabled it to disperse northward. Most likely *Pusa* moved into the Arctic Ocean about 3 million years ago.

At present, the ringed seal is the commonest and most widely distributed arctic seal. It is the smallest of the pinnipeds averaging only 4.5 feet (1.4 m) in length. Adults have dark coats with a pattern of white rings, which accounts for the specific name. Ringed seals are found wherever there is suitable land-fast ice for breeding, and they are good paleoenvironmental indicators of such conditions. During the winter they maintain breathing holes under the ice. Young are born on the fast ice in a den which the females hollow out in the snow over breathing holes, and most pups are born near the beginning of April (Mansfield 1967, p. 21). The shrimp-like crustaceans *Parathemisto* and *Mysis* are the most important food of the ringed seal, and it is interesting to note that the geographical ranges of *Parathemisto* and the ringed seal virtually coincide (Harington and Sergeant 1972, p. 1047). This species is most important to the Eskimo economy. It is heavily hunted by man for pelts and food.

Order Proboscidea

Family Mammutidae

Mammut americanum (American mastodon)

The first record of the American mastodon from Yukon Pleistocene deposits was a molar tooth received by Tyrrell in 1902 from Gold Run Creek near Dawson. Obalski (1904, p. 216) saw mastodon remains in the Dawson Area. Although Maddren (1907, p. 7) considered Obalski's observation to be incorrect, Gilmore (1908, p. 30) stated that there were two definite records from branches of the Indian River. Other specimens from both Dawson and Old Crow areas have been found since. They include six nearly complete molar teeth (Figure 53A-B, Table 56) and several tooth fragments that are preserved in the National Museums of Canada collection.

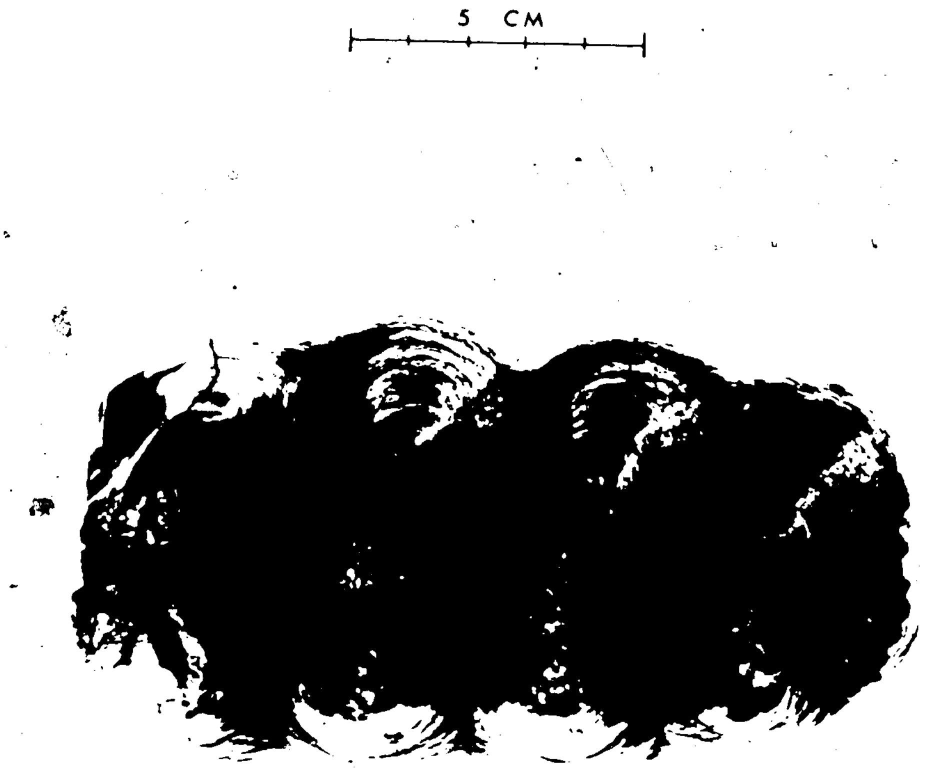
Placer miners in the Dawson Area commonly use the term "mastodon" to describe remains of any fossil elephant. This can give people not familiar with their terminology a distorted idea of the relative abundance of mastodon to mammoth fossils recovered. According to numbers of elephant molar teeth collected in the Yukon, I estimate that less than 5% are of the American mastodon, the remainder almost entirely representing the woolly

Figure 53. An RM_3 lacking most of the roots (NMC 14252, Old Crow Locality 13) of a Pleistocene American mastodon (*Mammut americanum*).

A. Lateral view (posterior of tooth is to the left).

B. Occlusal view (posterior of tooth is to the right).

A



B

Table 56. Measurements of Pleistocene American mastodon (*Mammut americanum*) molar teeth from the Yukon Territory compared to those of American mastodons from other parts of North America.

Specimens	Measurements (mm)*		
	1	2	3
Mammut americanum Pleistocene			
M^3s			
NMC 333 McQuesten Creek (River?), Y.T.	150.0	94.8	69.2
NMC 8060 Dawson Loc. 20, Y.T.	164.3	97.0	-
AMNH 14293 Fulton, Indiana**	168.4	93.6	-
M^1s			
NMC 8147 Bonanza Creek, Dawson area, Y.T.	83.4	74.9	-
NMC 26601 Old Crow Loc. 11A, Y.T.	81.2	61.3	39.2
AMNH 10666 Walnut, Illinois***	86.8	75.2	-
M_3s			
NMC 14252 Old Crow Loc. 13, Y.T.	146.1	78.6	53.8+
NMC 15352 Old Crow Loc. 14N, Y.T.	-	72.0+	56.5
F:AM 27009 Fairbanks area, Alaska (Osborn 1936, p. 177)	187.0	101.0	-
F:AM 23335 New Mexico (Osborn 1936, p. 175)	184.0	-	-
AMNH 21920 New York (Osborn 1936, p. 175)	181.0	-	-
AMNH 2595 Shawangunk, New York (Osborn 1936, p. 175)	155.0	-	-

* 1 - Maximum length.
2 - Maximum width.
3 - Height of highest cusp from cingulum below (heavily worn teeth not measured).

** Measurements calculated from a scaled figure (Osborn 1936, p. 188, Figure 134).

*** Measurements calculated from a scaled figure (Osborn 1936, p. 173, Figure 120).

Light copy

mammoth *(Mammuthus primigenius)*. The American mastodon was definitely not a common element in the Yukon Pleistocene fauna, and Frick (1930, p. 77; 1933, p. 631) has noted its rarity in the Pleistocene fauna of Alaska.

Referred specimens

In 1902, J.B. Tyrrell received an RM_3 (USNM 5101, not 5102 as published by Gilmore in 1908) that had been collected beneath 25 feet (7.6 m) of muck and gravel on claim 14, Gold Run Creek (Dawson Locality 33). Tyrrell sent the specimen to W.H. Osgood for examination and it was ultimately deposited in the Smithsonian Institution. I am grateful to C.E. Ray for checking the identification of this specimen (Harington and Clulow 1973, p. 701).

NMC 8060 is a nearly complete, but heavily eroded RM^3, which was collected on Sulphur Creek (Dawson Locality 20) by D.D. Cairnes. The margins of the posterior lophs are lacking and a well developed conelet is seen on the medial side of the valley between the metaloph and tritoloph (for terminology see Osborn 1936, p. 141). NMC 13717 from Old Crow Locality 11A is from the anterointernal region of RM^3. Medial parts of the well worn protolophs are preserved. The enamel is black, while the roots are dark brown. NMC 28004 from Old Crow

Locality 66 is a small part of the anterior surface of the crown of RM^3. It is stained dark brown. M^3s from the Yukon compare closely in shape and size with the M^3 of an American mastodon from Fulton, Indiana (AMNH 14293).

In 1933, H.S. Bostock collected a complete LM^3 (NMC 8707) from the junction of Independence and Hunker creeks (Dawson Locality 11). It was found beneath 60 feet (18.3 m) of frozen muck overlying gold-bearing gravels. The specimen is currently on display and is not available for measurement.

NMC 333, from an unspecified locality on McQuesten Creek {River?} south of Dawson, is a nearly complete LM^3 that was collected by D.D. Cairnes in 1913 (Lambe 1914, p. 299). The lophs show very little wear. In the medial side of the valley between the protoloph and metaloph is a patch of cementum-like material. R.A.A. Johnston (Lambe 1914, p. 299), who analyzed the substance, said it consisted of struvite (a hydrous phosphate of ammonium and magnesium) intermixed with small quantities of organic matter. A series of at least nine ridges girdling the roots of this tooth appear to be annular rings. It may be profitable to section and stain a series of roots of American mastodon molars in an effort to obtain an idea of the longevity of these animals. Of course the number of the particular tooth that was sectioned would have to be considered in relation to its number in the replacement sequence. The crown of NMC 333 is buff, while the roots are stained dark brown. NMC 23240 from Old Crow Locality 42 is a fragment from the anterior surface of the crown of LM^3. It is stained black.

NMC 26601 from Old Crow Locality 11A is a nearly complete LM^1 with slightly worn cusps. The posterointernal margin of the tooth is damaged. The specimen closely matches the same tooth of an American mastodon illustrated by Warren (1852, Plate VI). It is black, suggesting a pre- late Wisconsin age. NMC 8147 from Bonanza Creek near Dawson is a nearly complete, heavily worn LM^1. The tooth is colored buff with oxidized patches.

NMC 11697 from Dawson Locality 19 is a badly damaged LM_3. Most of the protolophids and the internal metalophid are lacking. The roots are long, showing more than 20 rings from the cingulum to a point near the base. Most of the enamel on the crown is black.

NMC 14252 from Old Crow Locality 13 is an RM_3.

The tips of four of the lophids are damaged, the remainder being moderately worn. The small pentalophid is serrate. The roots are almost entirely missing. The specimen is stained dark brown. NMC 15352 from Old Crow Locality 14N is an RM_3. Most of the roots and the protolophids and the tip of the lateral metalophid are broken off. Wear is slight on the surface of the complete lophids. The pentalophid is poorly developed. "Struvite" is seen in the valleys of the molar.

NMC 29267 from Old Crow Locality 44 is an RM_3 lacking most of the protolophids and the lateral metalophid. It measures 72.6 mm across the tritolophids. The enamel is mottled grayish black and the roots are brown. The fossil was collected by W.N. Irving 3 m above stream level, and although it was not definitely in place, I suspect that it was derived from Unit 2 and that it may be of ?Sangamon interglacial age. Unit 2 marks a time of spruce invasion and probably warmer, wetter climate - conditions that would be suitable for mastodons.

Discussion

It seems that most of the American mastodon remains from the Old Crow Basin are of pre- late Wisconsin age. One partial molar may have been derived from ?Sangamon deposits. Fossils from the Dawson Area have a relatively fresh appearance compared to those from the Old Crow Area, suggesting that they may have survived in the former place until the late Wisconsin. None of the specimens from the Yukon - Alaska region has been radiocarbon dated.

In Alaska, mastodon remains have been recovered from sediments at Cripple Creek sump near Fairbanks that are considered by Péwé (Péwé and Hopkins 1968, p. 269) to be of Illinoian age. I suggest that this material is of early or late Illinoian age, as spruce forest, to which this species seems best adapted, would have been scarce in central Alaska during the peak of the Illinoian glaciation (Péwé 1975a, p. 84; 1975b, p. 12). Perhaps the best specimen from Eastern Beringia comprises a partial mandible with teeth, an upper tusk, both radii, ulnae, forefoot bones and the distal end of a femur from an individual mastodon. It was collected from deposits of possible Wisconsin age near Fairbanks (Frick 1933, pp. 631-632; Osborn 1936, pp. 176-177).

In Canada, most mastodons (over 60 specimens) have been found in postglacial deposits of southern Ontario. Scattered teeth have been recovered from Nova Scotia and New Brunswick, and a nearly complete skeleton was collected near Hillsborough in the latter province. Farther west, mastodon teeth have been reported from: Prince Albert, Pilot Butte, and Jansen, Saskatchewan; Edmonton, Cold Lake, Wapiti River, and possibly Pincher Creek, Alberta; Minaker River, 65 miles (105 km) north of Mile 147 on the Alaska Highway, Courtenay area, and Shawnigan Lake, British Columbia. A tooth fragment collected from Lower Carp Lake north of Yellowknife, Northwest Territories is probably of interglacial age (Harington 1971, pp. 81-82).

Major concentrations of American mastodon remains in the United States are from the eastern half of the country and the west coast. The species evidently reached Mexico (Hibbard 1955, p. 54, Plate 2, Figure 2).

Mastodonts (*sensu* Tobien 1973, p. 57 = Mammutidae (Simpson 1945, p. 133)) evolved in the early Oligocene in Africa, migrated to Eurasia during the early Miocene and entered North America via the Bering Isthmus during the late Miocene or early Pliocene (Clarendonian). The first zygodont mastodonts entering North America at that time belonged to the genus *Miomastodon*. Evidently during the middle Pliocene in the Old World, as well as in North America, a parallel transition from a *Miomastodon* stock to more specialized zygodonts occurred, leading to

Mammut americanum, which survived in North America until postglacial time (Osborn 1936, pp. 132-133; Tobien 1973, pp. 57, 59). Among the earliest records of *Mammut* from North America are those from the late Pliocene (early Blancan) Hagerman fauna of Idaho, and the early Pleistocene (late Blancan) faunas of Blanco, Texas and Broadwater, Nebraska (Skinner *et al.* 1972, p. 129). Of 28 directly or indirectly radiocarbon-dated specimens of *Mammut americanum* from eastern North America, 80% yielded dates between 12,000 and 9,000 years B.P. (Dreimanis 1968, p. 257).

Mammut americanum was confined to North America, being rarely found in the extreme northwestern part of the continent and Mexico. It was most common in the east, where it found favorable habitat in spruce forests or open spruce woodlands that prevailed there throughout much of the Pleistocene (Dreimanis 1968, p. 257). Obviously these elephants were able to survive in other habitats, such as pine-parkland in the Ozarks of western Missouri (King 1973, p. 560); and Martin and Guilday remark on their presence in Florida well south of the known limits of boreal forest, even during late Wisconsin time. Nevertheless, fossils of *Mammut americanum* are generally valuable as paleoenvironmental indicators of coniferous forest.

Compared to modern elephants and mammoths, American mastodons were squat and long in the body, with straighter tusks. Vestigial tusks were present in the lower jaw. A mounted skeleton from Rancho La Brea has a shoulder height of only 1.9 m (Stock 1965, p. 49). One of the largest mastodons known, the Warren mastodon from New York, was about 2.6 m high at the shoulder (Osborn 1936, p. 179). Mastodons had reddish brown hair. Judge Miller, in describing the discovery and appearance of a skeleton at Shawangunk, New York stated that, - 'around and in the immediate vicinity were locks and tufts of hair of a dun brown, of an inch and a half to two inches and a half long and, in some instances, from four to seven inches in length' (Scott 1962, p. 281). No mention is made of underwool, so presumably American mastodons were not so well adapted to cold tundra climate as were woolly mammoths (*Mammuthus primigenius*).

A glimpse of the American mastodon as it appeared to Paleo-Indians may be gained by looking at the figure of an elephant incised on the surface of a large whelk shell found in a layer of peat near Holly Oak, Delaware. It was collected in 1864 by H.T. Cresson, and was evidently used as a pendant, as two holes bored in one end indicate. The engraving shows a long, squat elephant with a good deal of hair and relatively short, straight tusks. It has been interpreted previously as a mammoth (Meggers 1972, p. 14; Kraft and Thomas 1976, p. 756), but I consider that unlikely. The length of the body from base of neck to base of tail is approximately the same as the length from the top of the back to the feet, which corresponds almost exactly to the proportions of the Warren mastodon (Osborn 1936, Figure 124). In comparison the length of the body in a Columbian mammoth (*Mammuthus columbi* = "*Parelephas jeffersonii*", AMNH 9950) reaches (in relative vertical height) only from the top of the back to the distal end of the humerus (Osborn 1942, Figure 931). The elephant depicted on the pendant lacks the pronounced "knob" on the top of the skull, the steeply slanting back and the highly curving tusks of woolly mammoths engraved by Paleolithic artists on the walls of Les Combarelles (Augusta and Burian 1963, Plate 15) and Rouffignac (Ucko and Rosenfeld 1967, Figures 13, 30). In addition, I suggest that it would be more natural for Paleo-Indians to see mastodons in a moist peaty area of the northeastern United States than mammoths. It is worth noting that among many artifacts and other remains collected in the same area by Cresson and his associates was a mastodon tooth (Kraft and Thomas 1976, p. 756).

Of nine well-preserved American mastodons from New Jersey, New York, Virginia and Ohio, two had food in the mouth (twigs of larch, and resins and tars with a high percentage of spruce pollen and some of pine, grass and composites), and the remainder had stomach contents found within their rib cages - the material consisted of: hemlock and cedar wood, conifer twigs, swamp plants including reeds, and mosses (Dreimanis 1968, Table 2). Seven bushels (247 liters) of plant material evidently composed the stomach contents of a mastodon found at Hackettstown, New Jersey (Hay 1923b, p. 67).

There is good evidence from Friesenhahn Cave, Texas that American scimitar cats *(Homotherium serum)* preyed on young mastodons. Probably sabertooth cats *(Smilodon)* also hunted them. Despite abundant finds of American mastodon remains in late Wisconsin deposits, sites where they have been killed by man are virtually unknown (MacDonald 1971, p. 36).

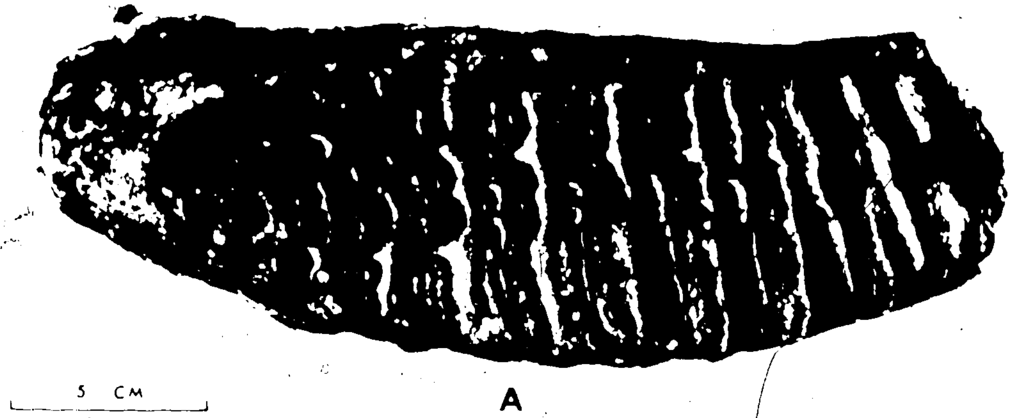
Family Elephantidae

Mammuthus meridionalis (southern mammoth)

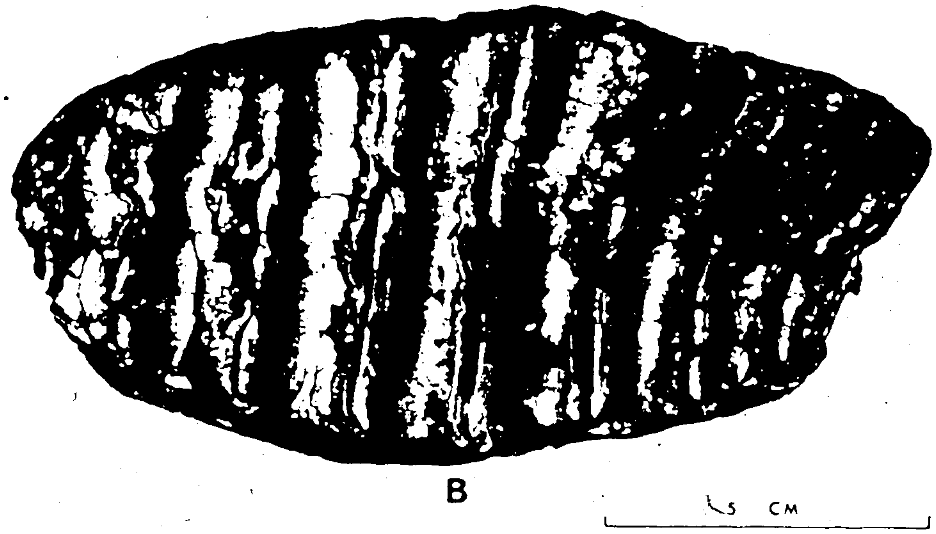
Among hundreds of woolly mammoth *(Mammuthus primigenius)* teeth are a few belonging to more primitive forms. Five well preserved molars (Figures 54A-B, 55A-B, Table 57) from Pleistocene deposits on the Old Crow and Porcupine rivers are best referred to the most progressive stage (Bacton Stage) of the southern mammoth. This species has been reported previously from early to middle Pleistocene sediments in southern North America (Maglio 1973, p. 62), but never before from the northwestern part of the continent, through which they must have passed in their dispersal from Eurasia.

Measurements on mammoth teeth are often difficult to replicate, so in studying this group, I have confined myself to description of some of the more complete lower molars (particularly M_3s) which are most commonly used for taxonomic purposes, and for which Maglio (1973, pp. 8-13) has established clear, standardized metrical procedures and comparative tables. Of the measurements given, I consider the following ones most significant: total number of enamel plates (lamellae); lamellar frequency (the number of plate-cement units within a 100 mm interval); and enamel thickness. These characters are functionally important in the adaptation of mammoths to particular habitats, and have changed rather rapidly throughout the Pleistocene, providing a broadly useful biostratigraphic key.

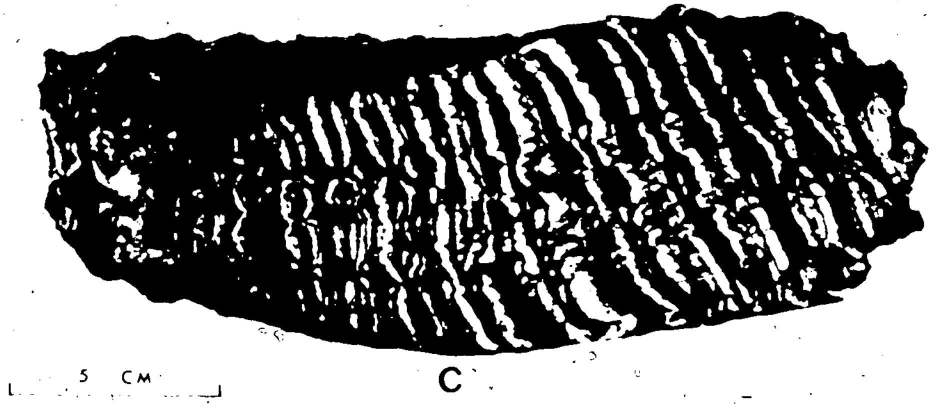
Figure 54. A. Occlusal view of an LM_3 (NMC 14509, Old Crow Locality 22) of a Pleistocene southern mammoth (*Mammuthus meridionalis*). B. Occlusal view of an LM_1 (NMC 13736, Old Crow Locality 11A) of a Pleistocene southern mammoth (*Mammuthus meridionalis*). C. Occlusal view of an LM_3 (NMC 21013, Old Crow Locality 7) of a Pleistocene steppe mammoth (*Mammuthus* cf. *armeniacus*).



A



B



C

Figure 55. Compare with Figure 54.

A. Medial view of NMC 14509.

B. Medial view of NMC 13736.

C. Medial view of NMC 21013.


5 CM
A


649
11A/70.
5 CM
B

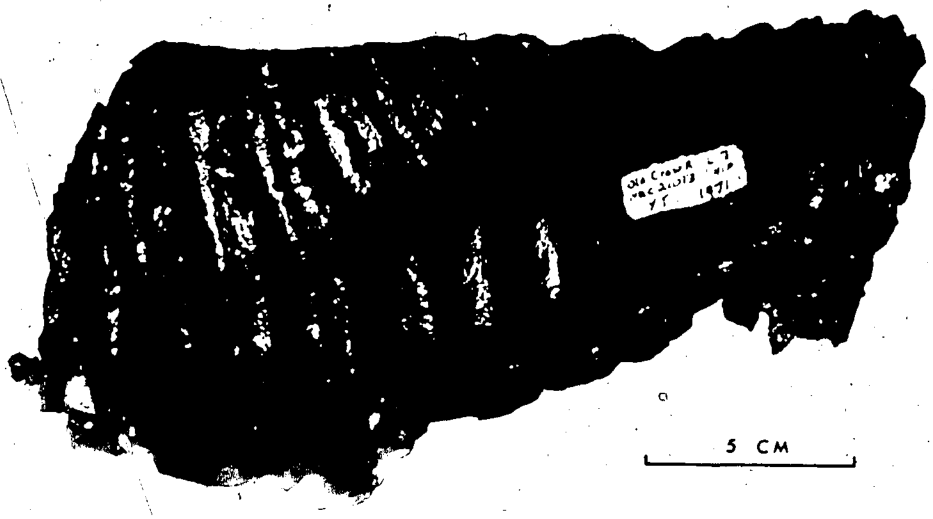

Old Crow R
YT 1971
5 CM
C

Table 57. Measurements of Pleistocene southern mammoth (*Mammuthus meridionalis*) molar teeth from the Yukon Territory compared to those of southern mammoths from Eurasia and North America.

Specimens	Measurements (mm)*						
	1	2	3	4	5	6	7
M_3s							
Mammuthus meridionalis.Pleistocene, Y.T.							
NMC 14509 Old Crow Loc. 20	14e	263.9	89.2	103.0	5.0	2.8	115.5
NMC 17061 Porcupine Loc. 100	14	234.7	73.8	70.9	5.0	2.8	96.1
Mammuthus meridionalis.Pleistocene, Eurasia (Maglio 1973, Table 30)							
M	12.1	266.3	97.2	115.0	4.6	3.4	126.4
OR	10.0- 14	212.0- 306.0	69.1- 119.4	75.0- 152.0	3.5- 5.9	2.4- 4.1	107.8- 165.5
N	19	18	36	17	36	33	14
SD	1.5	27.5	12.4	21.0	0.6	0.4	15.4
V	12.3	10.3	12.8	18.3	12.8	12.0	12.1
Mammuthus meridionalis.Pleistocene, Nebraska (Osborn, 1942, p. 1035)							
CMNH 1359 Angus	14	289.0	84.0	-	5.5	-	-
M_2s							
Mammuthus meridionalis.Pleistocene, Y.T.							
NMC 15540 Old Crow Loc. 20	10e	158.0*	74.2	98.2	6.0	2.4	132.4
Mammuthus meridionalis.Pleistocene, Eurasia (Maglio, Table 30)							
M	9.3	198.7	85.1	97.8	5.1	2.8	121.6
OR	8.0- 10.0	190.0- 209.0	69.0- 97.0	90.9- 111.2	4.6- 6.1	2.4- 3.5	104.6- 141.4
N	6	3	10	5	10	8	5
SD	0.8	9.6	7.9	8.0	0.4	0.4	16.7
V	8.7	4.8	9.2	8.1	8.2	13.9	13.8
M_1s							
Mammuthus meridionalis.Pleistocene, Y.T.							
NMC 13736 Old Crow Loc. 11A	10e	143.0*	70.7	90.6	6.0	2.2	126.2
NMC 20424 Old Crow Loc. 22	10e	153.8*	69.9	74.3*	5.5	2.3	-
Mammuthus meridionalis.Pleistocene, Eurasia (Maglio, Table 30)							
M	9.2	151.6	67.0	94.0	7.0	2.2	130.1
OR	8.0- 10.0	116.8- 185.0	56.5- 73.4	93.1- 94.9	6.6- 7.7	1.9- 2.6	129.4- 130.8
N	4	4	4	2	4	4	2

* Measurements follow those of Maglio (1973).

1 - Plate (lamella) number.
2 - Length.
3 - Width.
4 - Height.
5 - Lamellar frequency (number of plate-cement units in a 100 mm interval).
6 - Enamel thickness (average).
7 - Hypsodonty index ($\frac{H}{W}$ x 100).

Light copy

Referred specimens

NMC 14509 from Old Crow Locality 22 is an LM_3 lacking the ends of the roots. Thirteen of an estimated 14 enamel plates were in wear when the individual represented by the fossil died. The enamel is thick and slightly wrinkled and the plates are widely separated. Among North American mammoth molars figured by Osborn (1942), it appears to be closest to *M. meridionalis* from Nebraska (= "*Archidiskodon meridionalis nebrascensis*"; CMNH 1359), which Lugn and Schultz considered to be of Yarmouth interglacial age (Osborn 1942, p. 1033). The Nebraska specimen also has slightly wrinkled enamel. NMC 14509 is stained brown and has black enamel.

NMC 17061 from Porcupine Locality 100 is a highly oxidized LM_3 lacking the ends of the roots. Most of the first enamel plate has broken away. Of a total of 14 enamel plates, all are in wear, denoting an old individual. The enamel is thick and the plates are widely spaced as in NMC 14509, but wrinkling of the enamel is finer. The relative primitiveness of this molar and signs that it had been covered by highly oxidized matrix suggest to me that the fossil could have been derived from the basal interglacial unit at Porcupine Locality 100, which I consider to be of Yarmouth or earlier interglacial age. Hopefully, mammoth teeth will be found *in situ* at this exposure in the future. The tooth is rusty brown with black enamel. Probably both NMC 14509 and 17061 would have had slightly thinner enamel measurements and slightly higher lamellar frequency readings if they had not been so heavily worn. In any case, the following M_2 and M_1 specimens tend to confirm the presence of southern mammoths in the northern Yukon Territory during the Pleistocene.

NMC 15540 from Old Crow Locality 20 is an RM_2 lacking the ends of the roots. I estimate that it had 10 plates, all of which were being worn when the animal died. Probably two anterior plates are missing and the occlusal surface of the seventh is damaged. The enamel is thick and has a few coarse plications. The tooth is dark brown with thick, black enamel.

NMC 13736 from Old Crow Locality 11A is a moderately worn LM_1 lacking the tips of the roots. Of a total of 10 enamel plates, all are worn but the posteriormost. The anterior of the specimen, particularly the lateral part, and the posterior of the tooth have been damaged. The molar is characterized by thick enamel and widely separated plates. It is deeply oxidized, approaching a reddish-brown color, and has black, finely wrinkled enamel.

Traces of indurated medium sand matrix are cemented to the lateral surface of the roots.

NMC 20424 from Old Crow Locality 22 is an LM$_1$, with relatively thick surrounding cementum. The roots are lacking, and I estimate that two anterior plates are missing. The posterior part of the tooth is slightly damaged. The enamel plates are comparatively thick, having extensive "lakes" of dentine. Of an estimated total of 10 plates, all are worn. The specimen is rust to brown in color with grayish-black enamel.

Discussion

The dark staining of the Yukon specimens indicates their probable pre- late Wisconsin age, and their primitive morphological characteristics suggest an early to middle Pleistocene age. Unfortunately, none was found in place, although NMC 17061 may have been derived from the oxidized deposits of ?Yarmouth or earlier interglacial age at Porcupine Locality 100. Perhaps *Mammuthus meridionalis* would have been comfortable during that period in the northern Yukon in an environment with affinities to a boreal forest - aspen parkland margin, where forest cover (spruce, birch, pine and sporadic hazel), and open heath areas may have been common (Lichti-Federovich 1974, p. 4). These fossils are more primitive from an evolutionary viewpoint than mammoth teeth from the Mindel (?Kansan) Olyor Suite of the Kolmya Lowland in Siberia, for Sher (1971) indicates that an M_3 (GIN 835-214/27) has 22-23 enamel plates with a lamellar frequency averaging 7, and an enamel thickness of 1.8-2.5 mm. In my opinion, those characteristics best fit *Mammuthus armeniacus.*

Although no fossils of the southern mammoth have yet been recorded from Alaska, undoubtedly the species lived there once. *Mammuthus* cf. *meridionalis (= "Mammuthus* cf. *haroldcooki".)* has been recorded from late Aftonian interglacial deposits at Wellsch Valley, Saskatchewan, and *M. meridionalis (= "Mammuthus imperator haroldcooki")* is known from Kansan age sediments at Medicine Hat, Alberta (Stalker and Churcher 1972, Tables 2, 3).

Mammuthus had its origins in sub-Saharan Africa, being part of an early Pliocene radiation of the Elephantinae on that continent. *M. subplanifrons*, the earliest known species, spread rapidly into eastern and southern Africa. By the late Pliocene, a more progressive species *(M. africanavus)* began moving northward, simultaneously giving way to emerging populations of *Loxodonta* and *Elephas* in sub-Saharan Africa. In the early Villafranchian the *M. africanavus* stock that gave rise to the southern mammoth had entered southern Europe, probably across the Gibraltar Isthmus. *Mammuthus meridionalis* (Laiatico Stage) is first recorded from scattered localities in Italy and the Netherlands. By the close of the Pliocene, a more progressive southern mammoth (Montavarchi Stage) had spread throughout Europe and had reached England (Maglio 1973, p. 117), which was part of continental Europe then (Frenzel 1968). Thus, the trend in this group was toward better adaptation to cold climate, and exploitation of the expanding northern grasslands. The most advanced stock (Bacton Stage) of the southern mammoth had reached the Taman Peninsula in the Soviet Union during the Cromer (?Aftonian) interglacial (Kahlke 1973, p. 12), and evidently had crossed the Bering Isthmus to North America at the beginning of the Pleistocene about 2 million years ago.

Perhaps one of the earliest records in North America is from Wellsch Valley, Saskatchewan, where *M. meridionalis* may have lived about 1.7 million years ago according to paleomagnetic evidence (A. MacS Stalker, personal communication 1976). It evidently persisted on the Canadian plains until Kansan time, as indicated by material from Medicine Hat, Alberta. A number of specimens from Idaho, Kansas, Nebraska, and Oklahoma (originally called *"Archidiskodon hayi"*, *"Archidiskodon haroldcooki"*, and *"Archidiskodon meridionalis nebrascensis"*) are among the earliest elephants known from North America. The specimen from Bruneau, Idaho is about 1.36 million years old according to potassium-argon dates (Maglio 1973, pp. 61-63, 117-118).

Mammuthus meridionalis had a Holarctic distribution from Europe, where it survived from Villafranchian to Cromerian (?Aftonian) time, to North America, where it seems to have lived between Nebraskan and Kansan time. Probably the southern mammoth looked more like the modern Asiatic elephant *(Elephas maximus)* than the African species *(Loxodonta africana)*. Its back was horizontal or arched, rather than sloping. The tusks were large and curved upward. Its shoulder height was approximately 3.5 to 3.7 m. A good idea of the appearance of the southern mammoth can be gained from an illustration based on a mount of the Angus, Nebraska skeleton (Osborn 1942, Figure 927). A complete skeleton from Durfort in southern France is displayed in Paris. Kurtén (1968, p. 134) considered that the southern mammoth was not highly specialized but occupied savannas, bush steppes and woodlands. It was probably not successful in arid steppe environments. Therefore, it seems to be of little use as a paleoenvironmental indicator other than signifying moderately warm, moist conditions. The molar teeth of this species, with their widely spaced lamellae suggest that it was able to feed on succulent grasses and shrubs. Perhaps scimitar and dirk-toothed cats were among predators of the young or disabled.

Mammuthus cf. *armeniacus* (steppe mammoth)

Four lower molars from Pleistocene deposits of the Old Crow Basin, and another enclosed in most of a mandible from the Dawson Area (Figures 54C, 55C, 56, Table 58) have characteristics lying between those of the southern mammoth *(Mammuthus meridionalis)* and the woolly mammoth *(Mammuthus primigenius)*. They have more enamel plates, closer lamellae and thinner enamel than *M. meridionalis*, probably indicative of a dry grassland adaptation. Two kinds of steppe mammoths with similar teeth are known: (a) those that evolved from *M. meridionalis* in the grasslands of southern North America, which are called the imperial *(M. imperator)* and the Columbian *(M. columbi columbi*, and *M. columbi jeffersoni* - a more advanced stage) mammoths; and (b) those that evolved from *M. meridionalis* in Eurasia, which are called *Mammuthus armeniacus*. I consider that the Yukon specimens

Figure 56. Restoration of a steppe mammoth *(Mammuthus armeniacus)* as it may have appeared in the northwestern Yukon during a Pleistocene glacial phase. Ink sketch by Charles Douglas.

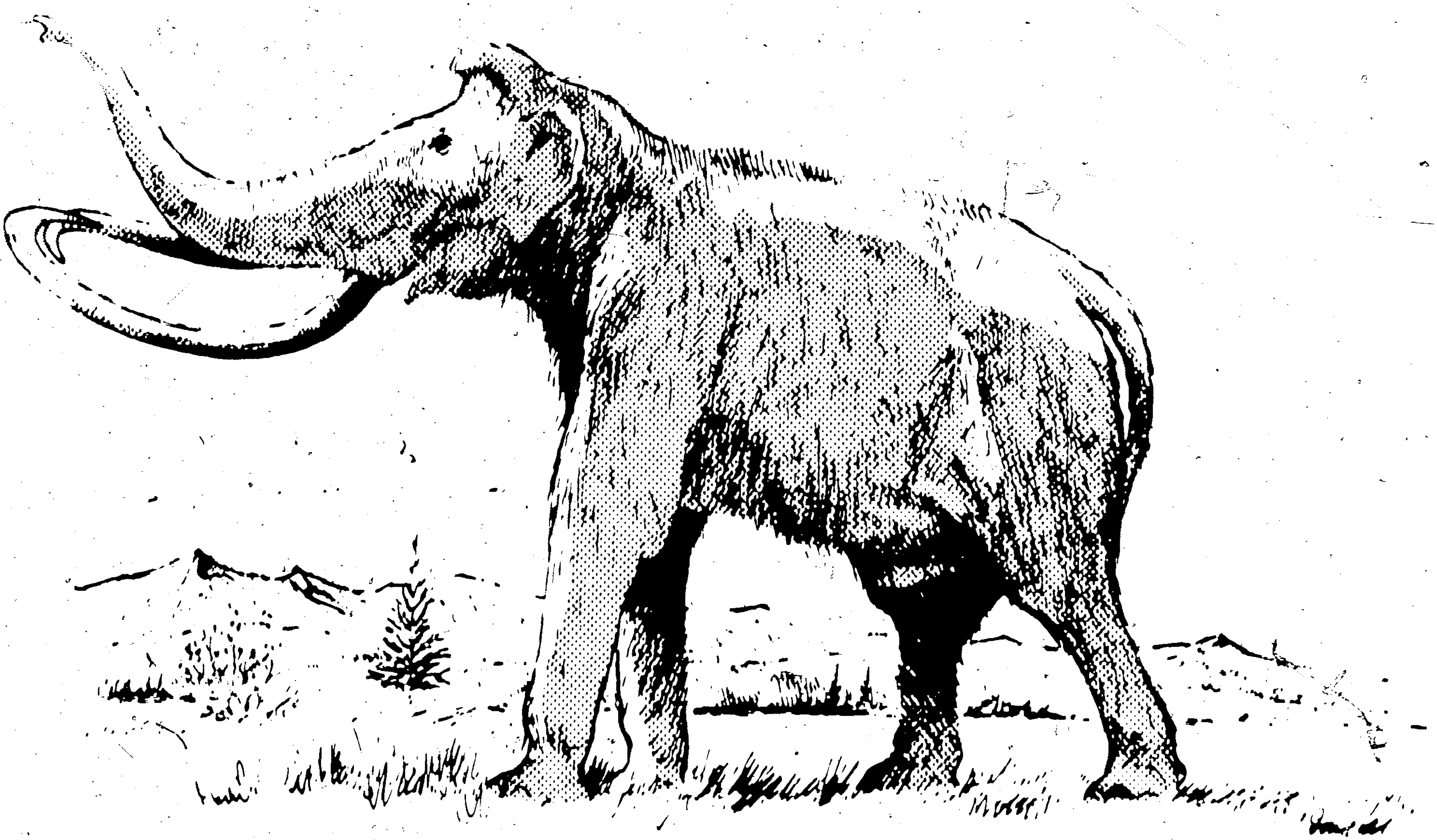


Table 58. Measurements of Pleistocene steppe mammoth (*Mammuthus* cf. *armeniacus*) M_3s from the Yukon Territory compared to those of steppe mammoths (*Mammuthus armeniacus*) from Eurasia.

Specimens	Measurements (mm)*						
	1	2	3	4	5	6	7
Mammuthus cf. *armeniacus*. Pleistocene, Y.T.							
NMC 21013 Old Crow Loc. 7	16e	216.0+	78.6	108.6	6.0	2.9	138.2
NMC 29270 Dawson Loc. 8	16e	265.0e	94.8	-	5.0	2.2	-
NMC 20560 Old Crow Loc. 32E	9.5+ (15e)	-	82.3	79.7	6.0	2.2	96.8
NMC 13737 Old Crow - locality unknown	10+ (16e)	-	74.9	80.2	6.5	2.4	-
NMC 14029 Old Crow Loc. 5	14+ (20e)	-	120.6	118.2	6.5	1.9	97.8
Mammuthus armeniacus. Pleistocene, Eurasia (Maglio 1973, Table 31)							
M	18.3	298.2	87.6	139.8	6.3	2.3	165.9
OR	15.0-21.0	236.0-340.0	70.0-113.0	96.0-160.0	5.0-7.2	1.8-3.0	133.2-206.6
N	15	14	21	21	22	20	16
SD	2.0	32.8	11.5	17.9	0.6	0.3	21.9
V	10.8	11.0	13.1	12.9	10.3	13.8	13.2

* Measurements follow those of Maglio (1973).

1 - Plate (lamella) number.
2 - Length.
3 - Width.
4 - Height.
5 - Lamellar frequency (number of plate-cement units in a 100 mm interval).
6 - Enamel thickness (average).
7 - Hyposodonty index ($\frac{H}{W}$ x 100).

may represent either or both of these groups and have described them as *Mammuthus* cf. *armeniacus* largely as a matter of convenience.

Unfortunately there is no authoritative study explaining how the teeth of the North American steppe mammoths differ from those of the Eurasian species. The confusion of nomenclature in the later North American mammoths is succinctly stated by Maglio (1973, p. 62). Therefore, I use the term *M.* cf. *armeniacus* in the broadest possible sense to describe these teeth that are transitional between those of the southern elephant and the woolly mammoth. It is a practical measure too, for Maglio (1973, Table 31) has provided a handy yardstick for comparison. The Yukon specimens fit rather well within the size limits of *M. armeniacus*, except NMC 14029, which is broader than any of 21 M_3s sampled by Maglio. Zoogeographically, it would have been feasible for either *M. armeniacus* to migrate from Eurasia to Eastern Beringia via the Bering Isthmus in the middle Pleistocene, or for *M. imperator* and/or *M. columbi* to reach it from southern North America during a non-glacial phase or phases of the middle to late Pleistocene.

Referred specimens

NMC 21013 from Old Crow Locality 7 is an LM_3

lacking most of the roots. Of an estimated 16 enamel plates, 14 were in wear when the animal died. The first plate is broken away; most of the second and the posteriormost plates are damaged. The enamel is plicated and pearl gray in color; the remainder of the tooth is stained brown.

NMC 29270 from Dawson Locality 8 is a complete, well worn RM_3 in place in a mandible that lacks most of the right ascending ramus, and the posterior half of the left ramus. Part of the socket for LM_3 and a piece of its root are preserved. Thirteen or 14 of an estimated 16 plates are worn. The tooth and mandibular bone are fresh-looking, like other fossils of late Wisconsin age from the area. If this specimen is of Wisconsin age, then it likely represents the Columbian mammoth. I intend to have part of the mandibular bone radiocarbon dated. The enamel is whitish.

NMC 20560 from Old Crow Locality 32E is an LM_3 lacking the anterior part. Most of the roots are missing and much of the cementum has broken away from the lateral surface. Median enamel loops are clearly developed on plates 6 and 7 counting from the posteriormost one that is worn. Of an estimated total of 15 plates, 9½ are preserved. The enamel is finely wrinkled and is gray in color. The rest of the tooth is dark brown.

NMC 13737 from an unknown locality on Old Crow River is the anterior part of an RM_3. An estimated six posterior plates are missing, and of the 10 present, the greater part of the anteriormost plate is worn away. The enamel is pearl gray and finely plicated.

NMC 14029 from Old Crow Locality 5 is an RM_3, which has been damaged on the lateral margin of the five anterior plates. Much of the posterior portion of the tooth is missing, as are most of the roots. There may have been about 20 plates altogether: only about 14 are preserved. The tooth is remarkable for its breadth, said to be characteristic of the imperial mammoth of North America (Maglio 1973, p. 62).

Discussion

All of the Old Crow fossils are stained brown and are probably of pre- late Wisconsin age. It is interesting to note that the enamel on these specimens is paler than the black enamel of the *M. meridionalis* molars described previously. Perhaps, in this case, the degree of permineralization of the enamel is indicative of the difference between early Pleistocene and middle to late Pleistocene teeth. The fresh appearance and relative completeness of NMC 29270 from Quartz Creek near Dawson suggests that a few steppe mammoths shared the Wisconsin arctic steppe environment with more abundant woolly mammoths. As steppe mammoths have not been reported from Alaska, these records appear to be the first for Eastern Beringia.

Mammuthus armeniacus is clearly derived from the southern mammoth *Mammuthus meridionalis*, being transitional morphologically and stratigraphically between the latter and the woolly mammoth. Among the earliest *M. armeniacus* specimens recognized are those from the Cromer Forest Bed of England and Mosbach I, Germany, which are approximately of Cromerian (?Aftonian) interglacial age. As Kurtén (1968, p. 136) has remarked: "So it is to some extent a matter of taste where the boundary between the species is drawn; what is important of course is that we have evidence of the direct emergence of the steppe mammoth by gradual transformation from a steppe race of the southern elephant." During the Mindel (?Kansan), *M. armeniacus* was a characteristic member of Eurasian middle Pleistocene faunas, and has been recorded from Spain to northeastern Siberia (Kahlke 1973). A few relatively primitive mammoth teeth from Mindel (?Kansan) deposits in the Kolyma Lowland are best referred to this species. Certainly, these wide-ranging mammoths were not far from Eastern Beringia at that time. Early in the Riss (Illinoian) glacial the transition between *M. armeniacus* and *M. primigenius* occurred.

With regard to the North American steppe mammoths, *Mammuthus imperator* first appeared during the middle Pleistocene in the western part of the continent. It is distinguishable from its ancestor *M. meridionalis* by its greater number of molar plates and more hypsodont molars. *Mammuthus columbi* arose from *M. imperator* sometime prior to the Illinoian glaciation. It was the dominant North American mammoth of the late Pleistocene, being mainly restricted to southern North America where it was very abundant (Hibbard 1955b; Skeels 1962, p. 117). The name "*Mammuthus jeffersoni*" is sometimes applied to the more advanced type that was common on the American plains during the Sangamon and Wisconsin phases, but I prefer to consider it a northern subspecies of *M. columbi* (e.g. *M. columbi jeffersoni*) following Aguirre (1969, p. 1374). The species became extinct about 11,000 to 10,000 years ago (Harington *et al.* 1974, p. 298).

M. armeniacus ranged from Spain to Siberia, being the dominant mammoth of the Eurasian middle Pleistocene. *M. imperator* and *M. columbi* were the most common mammoths in southern North America from the middle to late Pleistocene. Any or all of these species could have reached Eastern Beringia during the Pleistocene. In size, *M. armeniacus* exceeded all other mammoths, reaching a shoulder height of 4.5 m in the largest recorded specimens. The tusks were moderately curved, extending up to 5 m in length (Kurtén 1963, p. 136). *M. columbi* was about 3.4 to 3.6 m in height. It may have had a hairy coat, considering its adaptation to cool grasslands, but there is no direct evidence on this subject. Its tusks curved gently downward, outward and inward. Data on the probable habitat of the Columbian mammoth have been summarized by Harington *et al.* (1974, pp. 298-301). Skeels (1962, p. 118) points out that *M. columbi jeffersoni* has teeth most like those of the living Asiatic elephant, which is almost exclusively a grazer. She adds that this mammoth may have supplemented its normal grass diet in winter by feeding on alder, willow and birch. Of the predators known to have occupied the Yukon during the Pleistocene, perhaps the scimitar cat *(Homotherium serum)* would have been best adapted to preying on these steppe mammoths

(Evans 1961, p. 19; Meade 1961, p. 27). Paleo-Indians hunted the Columbian mammoth (Harington, *et al.* 1974, p. 298).

Mammuthus primigenius (woolly mammoth)

A sample of 9 lower molar teeth (Figure 57, Tables 59-60) have been selected to demonstrate the presence of the woolly mammoth in the Yukon Pleistocene. Specimens have been collected from many parts of the Yukon Territory including the Old Crow Area, Dawson Area, Porcupine River, Rock River, Sixtymile Area, and Herschel Island. A description of various skeletal elements of this species from Gold Run Creek (Dawson Locality 32) has been given previously (Harington and Clulow 1973, pp. 705-708).

With horse and bison, woolly mammoth fossils are among the most common from ice age deposits in the Yukon. One of the most interesting finds during the course of this study was the discovery of much of an articulated skeleton on the Whitestone River (Locality 43). The mandible of the Whitestone mammoth is on display with that of a juvenile of the same species in the National Museum of Natural Sciences in Ottawa. It

Figure 57. Occlusal view of the anterior part of a mandible containing M_3s (NMC 17659, Whitestone Locality 43) of a Pleistocene woolly mammoth *(Mammuthus primigenius)*.


b
5 CM

Table 59. Measurements of Pleistocene woolly mammoth (*Mammuthus primigenius*) M_2s and M_3s from the Yukon Territory compared to a sample measured by Magliô (1973; Table 32).

Specimens	Measurements (mm)*						
	1	2	3	4	5	6	7
M_3s							
Mammuthus primigenius.Pleistocene, Y.T.							
NMC 15264 Old Crow Loc. 22	25	258.3	80.5	121.2	10	1.6	150.6
NMC 1552 Old Crow - locality unknown	24	325.0	93.2	137.3	9	1.7	147.3
NMC 15263 Old Crow Loc. 22	20e	247.4	94.2	98.3^{+}	8.5	1.9	-
NMC 17659 Whitestone Loc. 43	22	294.8	93.0	95.3^{+}	8	1.8	-
NMC 9926 Dawson Loc. 12	20e	255.0	96.2	119.8	8	1.9	124.5
NMC 773 Dawson - locality unknown	22e	322.0	109.1	118.3^{+}	7	1.8	-
NMC 28957 Johnson Ck.	22	236.4	83.3	131.7	8.5	1.6	156.1
Mammuthus primigenius.Pleistocene (Maglio 1973, Table 32)							
M	21.8	267.4	87.6	137.8	8.5	1.5	159.7
CR	20.0- 25.0	207.0- 320.2	65.0- 100.0	123.0- 184.1	6.8- 10.2	1.3- 2.0	137.8- 189.2
N	5	5	8	8	8	8	8
SD	1.9	44.1	10.9	20.9	1.1	0.3	10.6
V	8.8	16.5	12.5	15.2	13.2	15.1	12.4
M_2s							
Mammuthus primigenius.Pleistocene, Y.T.							
NMC 26740 Old Crow Loc. 12E	18	176.5	75.0	119.6	10	1.3	159.4
NMC 20374 Old Crow Loc. 22	17	163.7	64.3	111.0	9.5	1.5	172.6
Mammuthus primigenius.Pleistocene (Maglio 1973, Table 32)							
M	15.3	174.3	67.0	121.9	9.2	1.3	197.0
OR	15 - 16	147.0- 185.0	43.0- 85.0	100.0- 136.0	7.6- 11.4	1.0- 2.0	159.8- 232.6
N	7	5	10	7	9	8	6
SD	0.5	15.5	12.8	11.4	1.2	0.3	29.8
V	3.2	8.9	19.1	9.3	13.5	26.0	15.1

* Measurements follow those of Magliô (1973).

1 - Plate (lamella) number.
2 - Length.
3 - Width.
4 - Height.
5 - Lamellar frequency (number of plate-cement units in a 100 mm interval).
6 - Enamel thickness (average).
7 - Hypsodonty index ($\frac{H}{W}$ x 100).

Table 60. Radiocarbon dates on woolly mammoth (*Mammuthus primigenius*) remains from Siberia (mainly after Heintz and Garutt 1965).

Species	Age (years B.P.)	Laboratory Number	Locality	Remarks
Mammuthus primigenius	29,500 ± 3000 32,650 ± 2500 31,500 ± 2000 44,000 ± 3500	T-170	Sanga-Yuriak R., Yakutia	Analyses were done on skin and fat from a female mammoth.
" "	31,750 ± 2500 44,000 ± 3500	T-299	Berezovka R., Yakutia	Analyses of dried blood and fat from a male, the famous Berezovka mammoth.
" "	>33,000 35,800 ± 2700	T-172	Mokhovaya R.	Analyses of skin, fat and sinew.
" "	35,800 ± 1[illegible]	T-171	Lena R. delta	Analysis of skin and fat of a male.
" "	>30,000	Y-633	Lena R. delta	Analysis of skin from the same specimen at the Radiocarbon laboratory at Yale University.
" "	26,000 ± 1600	MO-215	Lena R.	Analysis of material from a carcass (Kind 1967, p. 182).
" "	30,250 ± 1800 33,500 ± 1000 33,500 ± 1000	T-298	Gyda R.	Analysis of skin and fat. The second and third results were given HCℓ, and HCℓ and NaOH washes, respectively.
" "	11,450 ± 250	T-297	Mamontova R., Taimyr. Pen.	Analysis of skin, fat and sinew of a male.
" "	12,000 (approx.)	-	" "	Analysis of soft parts of the same mammoth in 1954 by A.V. Trofimov of the Geochemical and Analytic-chemical Institute, USSR Academy of Sciences.

will be described elsewhere. It is worth noting that many woolly mammoths seem to have died when they were young, for a few dozen milk molars (not fully worn) have been recovered from ice age deposits in the Yukon.

Referred specimens

NMC 15264 from Old Crow Locality 22 is a complete LM_3. It has a total of 25 enamel plates, 17 of which were in wear at the time of the animal's death. A piece of mandibular bone is lodged between the two anterior-most roots. The enamel is gray, while the rest [illegible] he tooth is brown. NMC 17659 from Whitestone Locality 43 is the nearly complete anterior half of a mandible containing both M_3s. Nineteen of 22 plates of LM_3 were in wear when the animal died. The enamel is gray, and the rest of the tooth is brown. The specimen was found near the Whitestone mammoth and, like it, may be of mid-Wisconsin age. NMC 9926 from Dawson Locality 12 is an LM_3. The occlusal margins of the anterior six plates are damaged. Of an estimated 20 plates, 18 were in wear. The enamel is white and the rest of the tooth is light tan. It is probably of late Wisconsin age.

NMC 1552 was collected from an unknown locality on Old Crow River. It is a partly worn (15 of 24 plates were in wear) RM_3. The enamel is black, the remainder of the tooth being dark brown. NMC 15263 from Old Crow Locality 22 is an RM_3 with damaged roots. The anterior two plates are heavily eroded. Of an estimated 20 plates, approximately 16 were in wear. The enamel is gray, and the rest of the tooth is dark brown. NMC 773 from an unknown locality in the Dawson Area is an RM_3. Of an estimated 22 plates, 17 were in wear. The enamel is white, and the rest of the tooth is brown. NMC 28957 from Johnson Creek in the Old Crow Basin is an RM_3 with 22 plates, 14 of which were in wear. Most of the anterior-most plate is missing. The enamel is grayish and the rest of the tooth is brown.

NMC 26470 from Old Crow Locality 12E is a complete LM_2. Of 18 plates, 11 were in wear when the animal died. The enamel is grayish and the rest of the tooth is brown. NMC 20374 from Old Crow Locality 22 is an RM_2 lacking the anterior roots. Of 17 plates, 15 were in wear. The enamel is gray and the rest of the tooth is stained dark brown.

Discussion

Tooth fragments referable to *Mammuthus* sp. have been found in place in the upper organic subunit of the basal clay, and in the fossiliferous zone (Unit 2) of

Locality 44 in the Old Crow Basin. Therefore, although mammoths are known to have occupied the region from the ?late Illinoian to ?Sangamon time, the exact species is doubtful at present. The darkly stained teeth described here are probably of pre- late Wisconsin age, and NMC 9926 from the Dawson Area is likely to be of late Wisconsin age. In 1975 a fragment of bone from the orbital region of a woolly mammoth was collected in the Sixtymile Area which still has traces of flesh adhering to it. This specimen is of probable late Wisconsin age. Bone from the Whitestone mammoth, which can be readily identified as *Mammuthus primigenius*, gave a radiocarbon date of 30,300 ± 2,000 years B.P. (I-3576), indicating presence of woolly mammoths in the northern Yukon during mid-Wisconsin time.

The woolly mammoth has been recorded in several places farther south in Canada. Most of a skeleton was excavated from clay beneath peat near Muirkirk, Ontario (Lambe 1898, p. 137). Organic material with a woolly mammoth tooth buried deeply in gravels near Woodbridge, Ontario yielded a radiocarbon date of 45,000 ± 900 years B.P. (GSC-1181), indicating a mid-Wisconsin age for the mammoth (Churcher 1968, p. 219). Leith (1949, p. 137) and Young (1966, p. 96), in reviewing ice age elephant finds in Manitoba, concluded that most represent the woolly mammoth. There is no information on the age of these fossils.

Important to our understanding of the time of entry of the woolly mammoth into North America are fossils from Medicine Hat, Alberta. There, its remains are identified from sedimentary units considered to be of early Wisconsin and late Wisconsin age (Stalker and Churcher 1970). In British Columbia, woolly mammoth fossils have been identified from the Cariboo and Peace River districts. Radiocarbon analysis of a molar of *M. primigenius* from terrace gravels near Taylor in the Peace River area yielded a date of 27,400 ± 580 years B.P. (GSC-2034). Therefore, tundra-adapted mammoths lived in the Peace River region during an interval [illegible]re ice of the last glaciation covered it. They apparently reoccupied the region after the Wisconsin ice retreated, if a radiocarbon date of 7,670 ± 170 years B.P. (I-2244) on a tusk from moraine deposits at Portage Pass is correct (Harington 1976 MS.).

Remains probably referable to the woolly mammoth have been recorded from various parts of the Northwest Territories including: Tununuk near the mouth of the Mackenzie River, where bone from a specimen yielded a radiocarbon date of 19,440 ± 290 years B.P. (I-8578); the Baillie Islands; and Cape James Ross on Melville Island. The latter specimen is a tusk of an elephant (Proboscidea cf. *Mammuthus*), which yielded a radiocarbon date of 21,900 ± 320 years B.P. (GSC-1760). It is difficult to explain the presence of mammoths in this part of the Queen Elizabeth Islands during the peak of the Wisconsin glaciation. Perhaps the tusk was rafted along by glacial or sea ice. This is the most northerly mammoth record for North America (Harington 1976 MS.).

Woolly mammoth remains are occasionally f in the northern part of the conterminous United Sta such as in late Wisconsin deposits of the Appalachians (Guilday 1971, p. 252), yet it is often difficult to separate the northern subspecies of the Columbian mammoth (*M. columbi jeffersoni*) from *M. primigenius* because of the similarity of their teeth due to convergent evolution. Aguirre (1969, p. 1376) considers mammoth molars dredged up from the Atlantic continental shelf (Whitmore *et a* 1967, p. 1477) to lie within the range of *M. columbi columbi* and *M. columbi jeffersoni* (which in thickness of enamel and some other traits, overlaps with *M. primigenius*). He concludes that "a mixed assemblage in the continental shelf is possible."

In Alaska, woolly mammoth fossils have been recorded from many sites such as the arctic coast, St. Lawrence Island, St. Paul Island, Unalaska, Lost Chicken Creek, and particularly the Fairbanks area. Dessicated flesh from a partial carcass found 85 feet (25.9 m) below the surface on Fairbanks Creek, yielded a radiocarbon date of 21,300 ± 1,300 years B.P. (L-601), which seems reasonable despite the fact that the specimen was preserved in glycerine. Hair from the skull of a woolly mammoth from Dome Creek gave a date of 32,700 ± 980 years B.P. (ST-1632) (Péwé 1975a, p. 99), which is very close to that of the Whitestone mammoth from the Yukon. Although the genus *Mammuthus* is known from Illinoian sediments in central Alaska, there are no definite records of *M. primigenius* in Alaska prior to the Wisconsin glaciation.

Among the Pleistocene vertebrate faunas of northeastern Siberia, an early type of woolly mammoth first occurs in the Utka Beds of the Kolyma Lowland, which appear to be of Riss II (late Illinoian) age (Sher 1971). The species is also known from late Pleistocene (Illinoian to Wisconsin?) deposits on the southern tip of Bolshoi Lyakhov Island in the New Siberian Islands (Vangengeim 1961, p. 55). A late type of the woolly mammoth is recorded from the early Wisconsin Iedoma Suite and the late Wisconsin Alioshka Suite in the Kolyma Lowland (Sher 1971). Remains have also been found in Wisconsin faunas from Proliv Dmitriya Lapteva and the Berelekh River (Vereshchagin 1974, pp. 3-12). A tusk from the main fossiliferous unit at the latter site yielded a radiocarbon date of 12,240 ± 160 years B.P. Other radiocarbon dates on Siberian woolly mammoth remains are provided in Table 60. Apparently this species died out in Siberia between 12,000 and 11,000 years ago.

Woolly mammoths were present in Europe from the Riss II (late Illinoian) to the close of the Würm (Wisconsin) glaciation. Evidently Scandinavia was a refuge for the species during the Eem (Sangamon) interglacial (Heintz 1955, p. 73; 1962, p. 208).

As indicated previously, the woolly mammoth was derived from the steppe mammoth *(M. armeniacus)* in Eurasia toward the end of the Riss II (late Illinoian) glaciation. It appears about the same time in Europe and northeastern Siberia. The earliest forms still resembled their steppe-dwelling ancestors. In later forms a series of progressive changes occurred: molar plates became more numerous and crowded; molar enamel decreased in thickness; tusk curvature increased; and body size was reduced Kurtén 1968, pp. 136-137). Such changes provided advantages in masticating the tougher tundra vegetation, and probably the decrease in body size (accompanied [illegible] reduction of extremities such as the ears and trunk) and development of a thicker pelt enabled them to survive under increasingly cold conditions.

The late form of *M. primigenius* first appeared in the early part of the Würm (Wisconsin) glaciation in Siberia. Evidence from Medicine Hat, Alberta suggests that the woolly mammoth first reached North America from Siberia via the Bering Isthmus during the early Wisconsin, although a late Illinoian crossing is still possible. The critical evidence on this matter probably still lies in the ground in Alaska and the Yukon Territory. The species spread rapidly during the mid-Wisconsin reaching eastern Canada about 45,000 years ago, and evidently becoming extinct in North America some 8,000 years ago.

Woolly mammoths were Holarctic in their distribution probably, originating in and spreading from north central Eurasia westward to England and Spain, and eastward to the tundra or tundra-like regions of northern North America including the Appalachians and the Atlantic coastal region of the northern United States (Hay 1923b, pp. 131-132). The species was common in Eastern Beringia during the last glaciation.

A great deal is known about the appearance of this species as a result of the discovery of some well preserved carcasses from the permafrost of Siberia, and from many detailed carvings, engravings and murals in caves by Paleolithic artists in southwestern Europe. These mammoths were about 3 m high at the shoulders — smaller than most late Pleistocene members of the genus, and about the size of modern Asiatic elephants. Perhaps their most remarkable features were: the long, hanging hair consisting of coarse, dark reddish, brown guard hairs and fine, muskox-like underwool (Ryder 1974, p. 190); large elaborately curved tusks; a high, peaked head which appears knob-like in many cave depictions; a high hump resulting from the long spines of the cervical vertebrae, possibly accentuated by fat deposits and thick hair; a steeply sloping back; relatively small ears; and a trunk shorter than those of living elephants (Kurtén 1968, pp. 137-138).

The habitat of the woolly mammoth is clearly indicated by its physical appearance and food habits.

All evidence points to its adaptation to cold climatic conditions, and generally, it can be considered as a reliable paleoenvironmental indicator of tundra, tundra-boreal forest margin, or cold loess-steppe.

Stomach contents found with frozen carcasses reveal an abundance of grasses, sedges and other boreal meadow and tundra plants, along with a few twigs, conifer cones, and pollen of high-boreal and tundra trees. Sixty species of plants have been determined from the stomach contents of the well known Berezovka mammoth — one of the best preserved woolly mammoths (Farrand 1961, Table 1). Food in the stomach of this mammoth weighed about 33 pounds (15 kg) (Augusta and Burian 1962, p. 18). I think it possible that woolly mammoths could have been migratory to some extent, feeding on grasses, sedges and willows of the tundra during the summer and autumn, and moving toward the tree-line in winter, where heavy shrubs and stunted trees may have provided fodder. The question is debatable.

How the species adapted to water shortage in winter is unknown. To conserve water physiologically during winter conditions, it would seem reasonable that their winter droppings would have been dry, perhaps like muskox, moose or caribou pellets, only larger. Yet, to my knowledge no recognizable fossil droppings have been reported. Did they break ice on ponds or streams to get at water, or did they obtain sufficient liquid by taking in snow with their normal food? Many fundamental questions concerning the survival of large elephants in the arctic have yet to be answered.

Scimitar cats may have preyed on the young, but the adults would have been formidable adversaries. The[illegible]easing evidence that Paleolithic hunters kill[illegible]y mammoths in great numbers in Eurasia, particularly in the Ukraine, where the species was of basic economic importance (Pidoplichko 1969; Klein 1973). In the Old Crow Basin of the Yukon, mammoth limb bones often show signs of breakage by man. Special techniques were probably developed there for making and using mammoth bone tools (Harington *et al*. 1975, p. 47). In Alaska, two fluted points were found *in situ* 60 feet (18.2 m) from the surface in frozen muck. One of them was directly associated with bones of a young "mastodon" {presumably a woolly mammoth - CRH} (Rainey 1940).

Order Perissodactyla

Family Equidae

Equus cf. *(Plesippus) verae* (large horse)

Remains of horses are the most common vertebrate fossils recovered from the Yukon Pleistocene deposits. Several thousand specimens (mainly teeth, metapodials, carpals, tarsals and phalanges) from Dawson, Old Crow and other areas are in the Quaternary Zoology collection.

E. Ann Holland of the University of Toronto began a statistical study of the horse specimens in this collection in 1973. Pending the results of her more detailed study, I will summarize my views of the kinds of horses that occupied the Yukon Territory during the Pleistocene mainly by reference to a series of complete metapodials. Generally speaking, metapodial length is related to length of stride and speed, while metapodial stoutness varies directly with the size and weight of the horse. The possible phylogenetic value of horse metapodials has been mentioned by Forsten (1973, p. 3), and a few detailed metric studies have been carried out on late Cenozoic horses (e.g. Willoughby 1948, Howe 1969). Scattergrams relating total length to proximal width of metapodials seem to offer a useful method of separating various species of horses, zebras and wild asses, and this method (Lundelius and Stevens 1970, Figure 3; Harington and Clulow 1973, Figure 28) is applied here to complete Pleistocene horse metapodials from the Yukon in an attempt to indicate the various kinds of horses represented in collections from that region (Figure 60A-B).

Fossils of large horses (Figures 58A-B, 59A-D, 60A-B, 62B-D, Tables 61-62) are most commonly found in the Old Crow Basin of the Yukon. Unfortunately no significant cranial or mandibular specimens with teeth have been recovered yet, although many separate teeth belonging to this species have been collected. Generally, the molars are large, and the upper molars are often characterized by complex enamel folding (particularly on the posterior margin of the prefossette and the anterior margin of the postfossette). The complexity of the enamel is not entirely a function of age, for well-worn teeth often show this feature (e.g. NMC 20830 and 19034 from Old Crow Localities 29 and 66 respectively; Figure 62B-C). Also, hypostylar fossettes (see Quinn 1955, Figure 1) are commonly seen (e.g. NMC 20830; Figure 62C) in upper molars of the large horses of the Yukon Pleistocene. Similar features are noted in *Equus (Plesippus) idahoensis* of the late Pliocene

Figure 58. Comparisons of metapodials of large horses from the Pleistocene of the Yukon Territory. A. Posterior views (from left to right): right metatarsal lacking the distal end (NMC 16524, Old Crow Locality 12) of a Pleistocene giant horse *(Equus sp.)*; right metatarsal (NMC 15080, Old Crow Locality 69) of a Pleistocene large horse *(Equus cf. (Plesippus) verae)*; right metacarpal (NMC 16324, Old Crow Locality 65) of a Pleistocene large horse *(Equus cf. (Plesippus) verae)*; right metacarpal (NMC 13660, Old Crow Locality 11A) of a Pleistocene large horse *(Equus cf. (Plesippus) verae)*. B. Anterior views (from left to right): NMC 16524; NMC 15080; NMC 16324; NMC 13660.


11A/70
B
5 CM
A

Figure 59. A. Posterior view of a right metatarsal (NMC 25265, Sixtymile Locality 2) of a Pleistocene large horse *(Equus* cf. *(Plesippus) verae)*.

B. Posterior view of a right metatarsal (NMC 26038, Sixtymile Locality 2) of a Pleistocene large horse *(Equus* cf. *(Plesippus) verae)*. Note the light color of these metatarsals compared to the darkly stained metapodials from the Old Crow Basin (Figure 58).

C. Dorsal view of a third phalanx (NMC 13655, Old Crow Locality 11A) of a Pleistocene large horse *(Equus* cf. *(Plesippus) verae)*.

D. Ventral view of NMC 13655. Note the large size of this hoof.

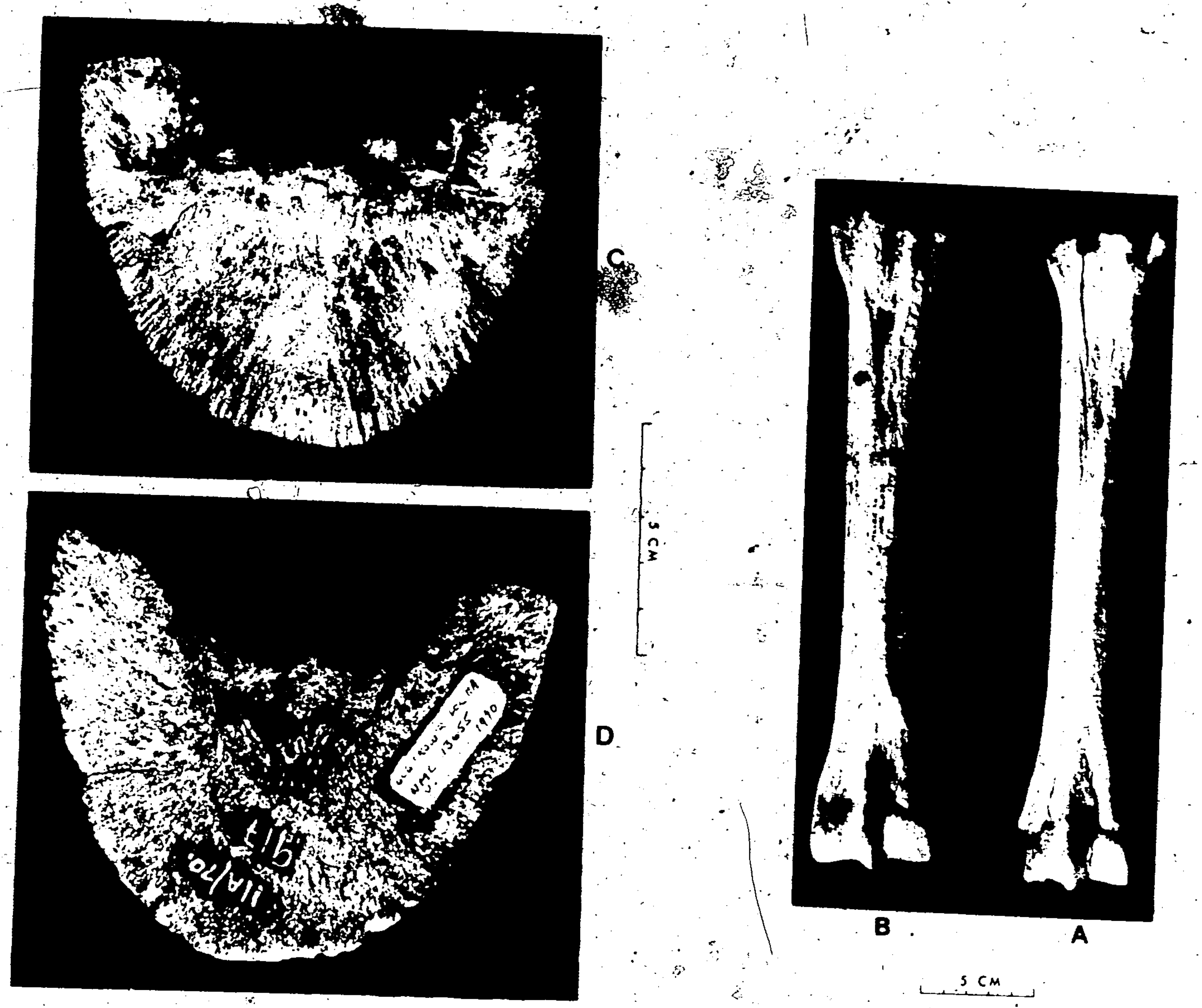
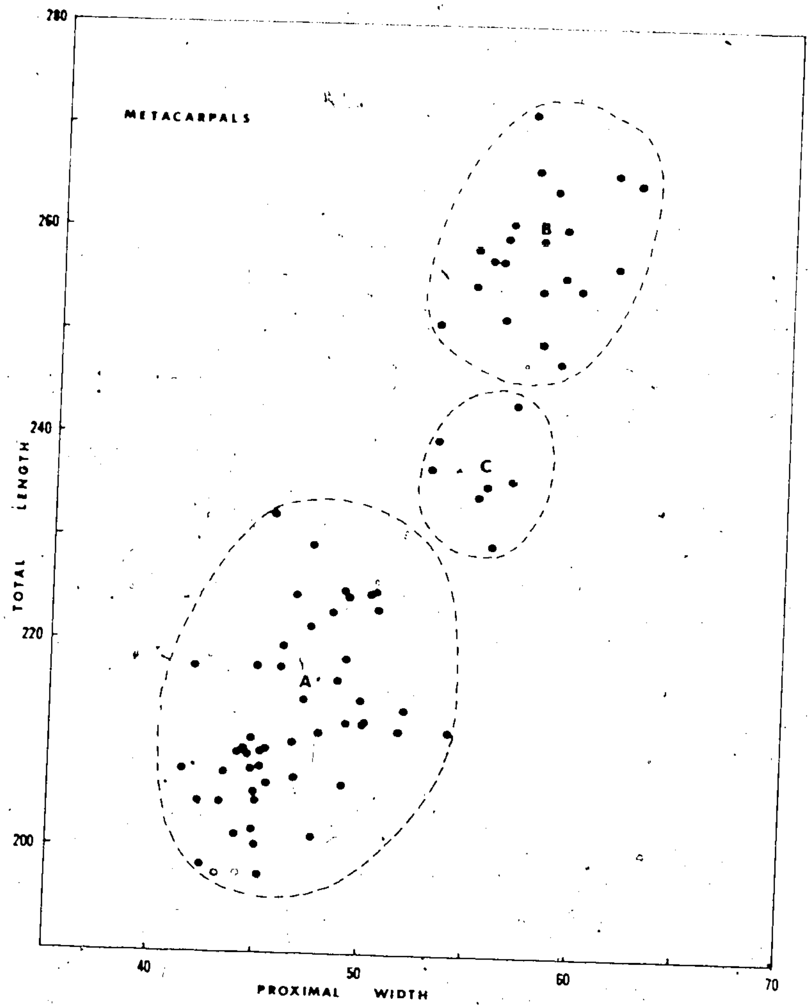
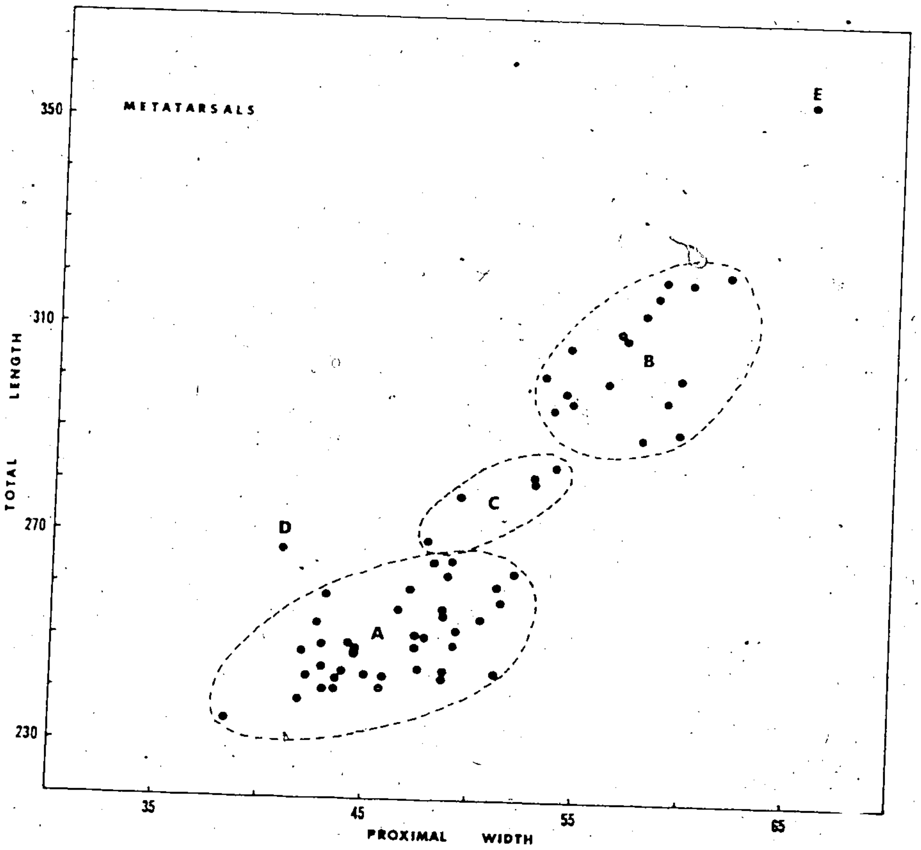

C
D
5 CM
B
A
5 CM

Figure 60. A. Scattergram of total length in relation to proximal width of Yukon Pleistocene horse metacarpals referred to: A. Yukon wild ass *(Equus (Asinus) lambei)*; B. large horse *(Equus* cf. *(Plesippus) verae)* C. medium-sized horse *(Equus* cf. *scotti)*.

B. Scattergram of total length in relation to proximal width of Yukon Pleistocene horse metatarsals referred to: A. Yukon wild ass *(Equus (Asinus) lambei)*; B. large horse *(Equus* cf. *(Plesippus) verae)*; C. medium-sized horse *(Equus* cf. *scotti)*; D. kiang-like wild ass *(Equus (Asinus)* cf. *kiang)*; E. giant horse *(Equus* sp.*)*.


METACARPALS
TOTAL LENGTH
PROXIMAL WIDTH
280
260
240
220
200
40
50
60
70
A
B
C

A


METATARSALS
TOTAL LENGTH
PROXIMAL WIDTH
350
310
270
230
35
45
55
65
A
B
C
D
E

B

Table 61. Measurements of Pleistocene large horse (*Equus* cf. *(Plesippus) verae*) metatarsals from the Yukon Territory compared to those of Pleistocene *E. (P.) verae* from Siberia and Pliocene *E. (P.) idahoensis* from the United States.

Specimens	Measurements (mm)* 1	2	3	4	5	6	7
Equus cf. *(Plesippus) verae*, Pleistocene, Y.T.							
NMC 18910 Old Crow Loc. 29	271.5	57.3	38.4	39.4	31.6	53.0	
NMC 16424 Old Crow Loc. 65	266.0	57.6	38.5	40.4	23.2	57.2	[illegible]
NMC 23243 Old Crow Loc. 84	265.8	61.4	42.2	40.6	29.6	56.2	44.8
NMC 19?0 Old Crow Loc. 11A	264.9	62.5	41.1	44.5	30.3	58.[illegible]	[illegible]
NMC 18162 Old Crow Loc. 29	264.1	58.5	39.0	39.0	30.1	53.[illegible]	
NMC 14355 Old Crow Loc. 15	260.9	56.4	40.0	39.0	32.0	–	[illegible]
NMC 20493 Old Crow Loc. 20	260.3	57.9	38.4	38.1	26.2	56.[illegible]	42.[illegible]
NMC 28298 Old Crow Loc. 136	259.5	56.2	37.5	40.2	32.2	52.9	[illegible]
NMC 16905 Old Crow Loc. 42	259.3	57.9	37.8	40.3	29.9	53.9	
NMC 20759 Old Crow Loc. 29	258.3	54.7	37.0	38.5	26.1	50.0	41.[illegible]
NMC 23?68 Old Crow Loc. 42	257.2	55.5	35.8	38.5	28.3	55.5	39.7
NMC 14658 Old Crow Loc. 25	257.1	56.0	37.0	37.7	27.5	55.5	39.9
NMC 26633 Old Crow Loc. 11	256.9	63.0	37.5	42.3	30.9	57.3	–
NMC 20555 Old Crow Loc. 32E	255.8	59.0	39.0	38.0	29.0	56.0	40.5
NMC 20617 Old Crow Loc. 22	254.9	54.7	38.2	37.6	28.2	53.7	43.3
NMC 27393 Old Crow Loc. 60	254.5	59.8	40.6	38.4	28.0	57.0	41.1
NMC 20760 Old Crow Loc. 29	254.3	57.8	36.5	38.3	27.1	54.7	41.2
NMC 16732 Old Crow Loc. 14N	251.7	56.2	38.2	39.2	29.2	51.6	42.0
NMC 14186 Old Crow Loc. 12	251.0	53.9	36.9	37.4	28.0	51.7	40.0
NMC 20627 Old Crow Loc. 22	249.1	58.0	37.6	40.1	28.7	55.0	42.2
NMC 20092 Old Crow Loc. 74	247.4	58.9	37.2	38.9	30.9	56.1	44.0
Equus (Plesippus) verae, Pleistocene, Siberia**							
PIN 2998-74	267.1	60.6	38.6	40.5	29.6	53.[illegible]	41.2
PIN uncataloged	261.8	66.7	44.2	43.9	32.6	62.7	43.4
PIN $\frac{835-243}{27}$	260.2	63.9	41.5	43.6	30.4	60.1	44.6
PIN 2998-27	259.8	59.9	39.7	40.7	27.4	56.9	41.2
PIN $\frac{835-529}{52}$	256.7	58.3	39.5	39.2	30.4	55.5	39.8
Equus (Plesippus) idahoensis, late Pliocene, Idaho (Shotwell 1970, Table 22)							
M	265.0	57.0	35.0	–	–	–	–
OR	225.0–280.0	48.0–66.0	32.0–39.0	–	–	–	–
N	9	9	9	–	–	–	–

* 1 – Total length.
2 – Proximal width.
3 – Proximal depth.
4 – Midshaft width.
5 – Midshaft depth.
6 – Distal width.
7 – Distal depth.

** A.V. Sher kindly allowed me to take these measurements from specimens collected by him and preserved in the Paleontological Institute, Academy of Sciences of the USSR, Moscow.

Light copy

Table 62. Measurements of Pleistocene large and giant horse (*Equus* cf. *(Plesippus) verae* and *Equus* sp.) metatarsals from the Yukon Territory compared to those of Pleistocene *E. (P.) verae* from Siberia and late Pliocene *E. (P.) idahoensis* from the United States.

Specimens	Measurements (mm)*						
	1	2	3	4	5	6	7
Equus sp. Pleistocene, Y.T.							
NMC 16524 Old Crow Loc. 12	354.2e	65.6	52.8	43.0	37.5	-	-
Equus cf. *(Plesippus) verae*.Pleistocene, Y.T.							
NMC 21029 Old Crow Loc. 14	321.0	61.8	47.7	41.0	33.8	59.3	44.7
NMC 22939 Old Crow Loc. 12	320.0	58.8	49.3	38.8	33.5	58.9	44.1
NMC 17295 Dawson Loc. 28	319.6	60.1	47.5	37.4	34.2	56.8	44.9
NMC 14486 Old Crow Loc. 22	316.7	58.4	48.0	38.8	32.6	56.5	41.4
NMC 24025 Old Crow Loc. 20	313.4	57.9	48.2	37.5	32.2	55.8	42.9
NMC 27366 Old Crow Loc. 45	309.8	56.7	46.0	37.4	32.0	55.5	41.9
NMC 15080 Old Crow Loc. 69	308.3	57.0	46.9	38.6	34.7	56.9	42.9
NMC 29039 Dawson Loc. 10	306.9	[illegible]	45.9	37.0	33.8	50.2	41.9
NMC 20616 Old Crow Loc. 22	301.3	53.2	44.8	31.2	30.1	52.6	42.7
NMC 27365 Old Crow Loc. 45	300.8	59.7	50.3	36.5	36.7	57.0	42.5*
NMC 27912 Old Crew Loc. 71	300.0	56.1	48.6	38.1	36.0	54.2	42.6
NMC 25265 Sixtymile Loc. 2	298.0e	54.1e	46.4	33.5	35.2	50.3	43.5
NMC 15334 Old Crow Loc. 22	296.4	59.0	47.7	40.3	35.0	58.7	45.5
NMC 27886 Old Crow Loc. 87	296.0	54.5	45.1	34.4	33.6	50.4	41.6
NMC 18980 Old Crow Loc. 29	294.2	53.6	46.0	37.8	35.3	54.9	42.4
NMC 26887 Old Crow Loc. 22	290.4	59.7	46.9	37.4	35.8	56.9	44.0
NMC 26038 Sixtymile Loc. 2	289.6	57.9	46.8	36.4	34.4	54.7	41.2
Equus (Plesippus) verae.Pleistocene, Siberia**							
PIN $\frac{835-552}{34}$	326.0	61.8	52.0	39.8	35.8	58.9	45.0
PIN 2998-131	323.0	61.2	49.9	40.4	34.3	59.7	44.4
PIN 2998-34	313.7	61.9	51.4e	40.4	35.6	58.8	44.2
PIN uncataloged	313.4	60.0	50.2	40.7	36.2	60.0	44.5
PIN $\frac{825-234}{27}$	306.4	53.1	44.8	33.5	29.0	54.1	41.2
Equus (Plesippus) idahoensis.late Pliocene, Idaho (Shotwell 1970, Table 22)							
M	300.0	56.0	47.0	-	-	-	-
OR	298.0-315.0	53.0-59.0	45.0-51.0	-	-	-	-
N	5	5	5	-	-	-	-

* 1 - Total length.
2 - Proximal width.
3 - Proximal depth.
4 - Midshaft width.
5 - Midshaft depth.
6 - Distal width.
7 - Distal depth.

** A.V. Sher kindly allowed me to take these measurements from specimens collected by him and preserved in the Paleontological Institute, Academy of Sciences of the USSR, Moscow.

Light copy

Grand View fauna of Idaho, and lower premolars such as P_4 (NMC 26049; Figure 62D) are closely matched in size and enamel pattern by specimens of *E. (P.) idahoensis* (Shotwell 1970, Figure 41 L,C).

In 1973, during a visit to several Soviet museums, sponsored by the Paleontological Institute of the Academy of Sciences of the USSR, I was able to compare lower forelimb and hindlimb bones of the large horse from the Old Crow Basin directly with similar elements of *Equus (Plesippus) verae* collected by A.V. Sher from the Olyor Suite (Mindel = ?Kansan) in the Kolyma Lowland of northeastern Siberia. They were almost exactly the same - even to their blackish brown staining. An upper molar with its characteristic complex enamel pattern was readily matched by specimens of *E. (P.) verae* in Sher's collection. Therefore, except for NMC 16524, the largest metapodials are referred to a large horse like *Equus (Plesippus) verae*. Further comparisons are required with some of the large North American Pleistocene horses such as *Equus (Plesippus) idahoensis* and *Equus (?Plesippus) giganteus*.

Referred specimens

The following metacarpals (III) are referred: right - NMC 16324 (Old Crow Locality 65), 13660 (Old Crow Locality 11A), 14355 (Old Crow Locality 15), 28292 (Old Crow Locality 136), 26633 (Old Crow Locality 11), 16732 (Old Crow Locality 14N), 20493 (Old Crow Locality 20), 23368 (Old Crow Locality 42), 20555 (Old Crow Locality 32E), 16905 (Old Crow Locality 42), 14658 (Old Crow Locality 25), 20092 (Old Crow Locality 74); left - NMC 27393 (Old Crow Locality 60), 14186 (Old Crow Locality 12), 23293 (Old Crow Locality 84), 20627, 20617 (Old Crow Locality 22), 20759, 18910, 20760, 18102 (Old Crow Locality 29). These specimens are stained brown to blackish brown. NMC 13660 appears to represent an old individual according to development of a ridge of callus along the medial margin where metacarpal II was strongly fused to metacarpal III (see Harington and Clulow 1973, p. 721) - a view supported by the large size of the latter bone. Similarly, NMC 16732 may be old because metacarpal IV is fused to metacarpal III. Exostoses at the proximal end of NMC 23293 are also suggestive evidence that an old individual is represented. NMC 14355 is interesting because of an exostoseal lesion above its distal articulation. NMC 20627 has a "fresh" impact mark 17 mm above the anterior surface of the distal articulation, which seems to have been made about the time of the death of the animal. In part, it may have had to do with the death of the horse. It could be the result of a human blow, or possibly a compression mark made by crushing teeth of a large carnivore. The latter suggestion seems unlikely because no tooth marks are visible on the posterior surface of the bone at the same general level. Could the healing of a similar blow or bite have resulted in the pathological proliferation of bone in the same place on NMC 14355? NMC 20760 has a 10 mm x 9 mm facet on the medial side of the distal articular surface. Parallel striae and dark staining on this facet suggest a saw-like cut may have been made there on fresh bone - possibly by people in the process of butchering the animal. Most metacarpals have total lengths lying between 247 and 272 mm.

The following metatarsals are referred: right - NMC 16524 (Old Crow Locality 12), 21029 (Old Crow Locality 14), 22939 (Old Crow Locality 12), 24025 (Old Crow Locality 20), 15080 (Old Crow Locality 69), 20616 (Old Crow Locality 22), 27365 (Old Crow Locality 45); left - NMC 17295 (Dawson Locality 28), 14486 (Old Crow Locality 22), 27366 (Old Crow Locality 45), 29039 (Dawson Locality 10), 27912 (Old Crow Locality 71), 25265 (Sixtymile Locality 2), 15334 (Old Crow Locality 22), 27886 (Old Crow Locality 87), 18980 (Old Crow Locality 29), 26038 (Sixtymile Locality 2), 26887 (Old Crow Locality 22). All of these specimens are stained dark brown except

NMC 29039 from Hunker Creek, which is light buff and NMC 25265 from Miller Creek, which is tan. Both show grooves of rootlets on their surface, possibly indicating death in a grassland environment. NMC 20616 is very slender compared to the other metatarsals. Most metatarsals range in total length from 288 to 322 mm, averaging somewhat less than four specimens of *E. (P.) verae* (Sher 1971, Table 20).

Measurements of the Yukon metacarpals and metatarsals lie within the general size range of *E. (P.) verae* of northeastern Siberia and *E. (P.) idahoensis* of southern North America (Tables 61-62).

Discussion

Teeth and other elements tentatively referred to this large horse have been excavated *in situ* from the upper organic subunit of the basal clay at Old Crow Localities 11 and 12, and from Unit 2 at Old Crow Locality 44; thus, the species may have lived in the Old Crow Basin from late Illinoian to Sangamon time. The fresh appearance of NMC 29039 from the Dawson Area suggests that the species may have survived until late Wisconsin time there. I know of no other fossils from Canada that can be referred with confidence to this species, although "*Equus* cf. *giganteus*" from mid-Wisconsin sediments at Medicine Hat, Alberta (Stalker and Churcher 1970) is possibly related.

A fundamental problem in making valid comparisons is the lack of a critical, wide-ranging statistical review of North American Pleistocene horses, although Savage (1951, pp. 243-353) has made an admirable attempt to clarify the problem. Scores of species have been named, many based on poor and fragmentary holotypes.

Large horses are rarely mentioned from Pleistocene deposits in Alaska. A third phalanx of "*Equus* sp." from ?Nebraskan sediments at Cape Deceit may belong to an ancestor of *E. (P.) verae* (Harington 1976 MS. p. 87). Guthrie and Matthews (1971, p. 495) note that it "is larger than most of those that were collected from deposits of Illinoian and Wisconsin age in the Fairbanks area of interior Alaska".

()

In northeastern Siberia, large horses of this general type are first represented by "*Equus (Plesippus)* sp." in the early Pleistocene (?Nebraskan) Begunov Suite (Sher 1971), and they may have lived at approximately the same time in western Alaska (Cape Deceit). *E. (P.) verae* first appeared in Siberia about Mindel (?Kansan) time, being the dominant horse then, and later giving way to a large form of *Equus caballus*. Sher (1971) feels that the former species is more closely related to *E. süssenbornensis* of Europe than to coeval central Asian horses of the *sanmeniensis-sivalensis* type. The zebrine horses of Europe, including *E. süssenbornensis* and its possible predecessor *E. stenonis*, lived from the mid-Villafranchian to the Günz II (?late Nebraskan) glacial (Kurtén 1968, pp. 148-149). Referring to *E. (P.) verae*, Sher (1971, p. 152) states, "So far horses of such type are unknown in America, but theoretically it can be supposed that they will be encountered among the later forms of *Plesippus*." Evidence presented here suggests that this kind of horse was present in the Yukon from at least ?late Illinoian to possibly late Wisconsin time. Like *Alces latifrons*, this species seems to have survived in Eastern Beringia long after its extinction elsewhere.

Compared to later evolving caballine horses, this species was large, reaching an estimated 1.7 m at the shoulder. It had relatively long, slender legs and large hooves (Figure 59C-D). Sher (1971, p. 152) suggests that *E. (P.) verae* was adapted to swift movement over open, fairly solid plains (perhaps not so solid as in contemporaneous steppe regions of southern Europe which were occupied by related horses). Rootlet impressions on the surface of some of the metapodials from the Yukon may imply that the horses they represent died in grassland surroundings. I speculate that the unusually large size of this horse, its correspondingly large cheek teeth, and above all, the extraordinary complexity of enamel patterns on their teeth, are indicative of a form rapidly exploiting a fresh environmental niche, consisting of broad plains with relatively tough grassy forage. Why it gave way to smaller, simpler-toothed caballine horses is an interesting question, for the complexity of the molars of woolly mammoths *(Mammuthus primigenius)* apparently better enabled them to survive in large numbers throughout Eurasia until the close of the last glaciation. The large Yukon horses occasionally had pathological problems as indicated by the occurrence of an exostoseal lesion just above the distal articulation of a metacarpal (NMC 14355) from the Old Crow Basin (Choquette *et al*. 1975, p. 1055). In the Yukon Territory, presumably large cats such as the American lion *(Panthera leo atrox)* and perhaps the American scimitar cat *(Homotherium serum)* were their main predators. Wolves may have preyed on these horses occasionally. Likely, people also hunted them, for bones of large Pleistocene horses often show signs of breakage by man (Harington *et al.* 1975, p. 46). Considering the length of their legs and the size of their hooves, mature horses were probably formidable opponents.

Equus sp. (giant horse)

Referred specimen

A single right metatarsal, NMC 16524 from Old Crow Locality 12 (Figure 58A-B, 60B, Table 62), is much larger than any other horse metatarsals recovered from Pleistocene deposits of the Yukon. Although the distal articulation has been broken away leaving a specimen 320.3 mm long, it is not difficult to estimate by means of ratios the length of the missing portion. I consider the total length of this metatarsal to have been approximately 354 mm. That is about 33 mm more than the longest metatarsal in the collection referred to *Equus* cf. *(Plesippus) verae* from the Yukon Territory, and 28 mm more than the longest metatarsal of *E. (P.) verae* from Siberia that I was able to measure (Table 62). The fossil is dark brown on the posterior surface and light brown elsewhere. I can see no qualitative features by which it can be differentiated from the other large horse fossils.

Discussion

Perhaps NMC 16524 represents an unusually large ancestor of *Equus* cf. *(Plesippus) verae*.

Equus cf. *scotti* (medium-sized horse)

Seven metacarpals and five metatarsals (Table 63) represent a horse intermediate in size between the relatively small Yukon wild ass *(Equus (Asinus) lambei)* and the large horse *(Equus* cf. *(Plesippus) verae)*. Among Pleistocene horse metapodials with which I am familiar, these specimens best match those of *Equus scotti*, and they are referred to a horse of that kind. Pending further evidence, I follow Savage (1951, p. 251) in considering *Equus niobrarensis* and *Equus hatcheri* as junior synonyms of *Equus scotti*.

Referred specimens

Seven metacarpals are referred to *Equus* cf. *scotti*: right - NMC 13658 (Old Crow Locality 11A), 26850 (Old Crow Locality 22), 29038 (Dawson Locality 10); left - NMC 28126 (Old Crow Locality 126), 26686 (Old Crow Locality 20), 22861 (Old Crow Locality 22), 14485 (Old Crow Locality 22). All are stained dark brown but the Dawson Area specimen NMC 29038, which is pale tan and has pyrolusite "stars" on its surface. This specimen and NMC 13658 appear to represent relatively old individuals, for in the former, metacarpal IV is fused

Table 63. Measurements of Pleistocene medium-sized horse (*Equus* cf. *scotti*) metapodials from the Yukon Territory compared to those of Pleistocene *E. scotti* from Texas and Saskatchewan.

Specimens	Measurements (mm)*						
	1	2	3	4	5	6	7
Metacarpals							
Equus cf. *scotti*. Pleistocene, Y.T.							
NMC 26686 Old Crow Loc. 20	243.3	56.8	39.9	39.1	30.0	56.0	41.6
NMC 26850 Old Crow Loc. 22	239.9	53.1	34.5	32.3	24.6	49.5	37.0
NMC 29038 Dawson Loc. 10	238.2	53.0	36.2	34.4	27.2	49.1	38.5
NMC 28126 Old Crow Loc. 126	236.0	55.9	38.0	34.2e	27.3	46.3	40.6
NMC 22861 Old Crow Loc. 22	235.9	56.7	38.8	40.0	30.0	52.3	39.6+
NMC 14485 Old Crow Loc. 22	234.4	[illegible]5.1	36.5	35.1	25.7	54.2	41.3
NMC 13658 Old Crow Loc. 11A	229.6	55.9	38.7	38.7	26.6	53.1	37.1
Equus scotti. Pleistocene, Texas.							
Rock Creek (Troxell 1915, p. 620)	244.0	57.3	41.5	41.0	-	57.7	42.7
Equus scotti. Pleistocene, Saskatchewan							
SM-156 Saskatoon Site, Saskatoon	250.5	52.6	38.1	38.5	29.9	48.5	36.4
NMC 26097 Saskatoon Site, Saskatoon	248.0	53.6	38.6	37.9	31.2	50.8+	43.0e
Metatarsals							
Equus cf. *scotti*. Pleistocene, Y.T.							
NMC 17573 Dawson Loc. 30	283.9	53.9	44.6	35.9	36.7	50.7	[illegible]
NMC 17293 Dawson Loc. 7	281.6	53.0	44.5	34.1	32.9	51.2	41.0
NMC 28964 Dawson Loc. 17	280.3	52.9	44.0	33.1	30.7	51.7	40.0
NMC 29067 Sixtymile Loc. 3	277.6	49.3	39.9	29.1	31.2	47.3	36.8
NMC 23392 Old Crow Loc. 11A	269.2	47.8	40.6	32.3	31.2	44.4	35.8e
Equus scotti. Pleistocene, Texas							
NMC 2331 Rock Creek	277.0e	56.7	49.2	37.9	38.1	53.9	39.5e
Equus scotti. Pleistocene, Saskatchewan							
SM-152 Saskatoon Site, Saskatchewan	299.2	50.2	44.4	34.0	33.9	50.3	39.9
NMC 11869 Fort Qu'Appelle	291.7	47.6	42.0	34.6	34.5	46.9	37.5
NMC 12218 Fort Qu'Appelle	289.2	49.8	43.4	34.0	32.8	48.0	35.1
SM-4 Saskatoon Site	264.3	48.5	40.6	33.7	30.8	-	36.2
NMC 12219 Fort Qu'Appelle	275.0	48.1	42.2	31.8	32.2	46.5	37.1
NMC 12144 Fort Qu'Appelle	268.3	43.4	38.3	36.8	30.3	42.4+	[illegible]
NMC 11902 Fort Qu'Appelle	266.2	42.9	40.9	31.3	33.4	43.9+	37.2

* 1 - Total length.
2 - Proximal width.
3 - Proximal depth.
4 - Midshaft width.
5 - Midshaft depth.
6 - Distal width.
7 - Distal depth.

strongly to metacarpal III, and in the latter, bony proliferation indicates that metacarpal II was strongly fused to metacarpal III. NMC 26850 seems to represent a horse in very early maturity or late immaturity for the distal epiphyseal suture is still visible. NMC 14485 has a network of rootlet impressions on its dorsal surface. These metacarpals lie between the series of small Yukon wild ass metacarpals, and that of large horse metacarpals. NMC 26686 matches very closely a metacarpal of *E. scotti* from Rock Creek, Texas, the type locality of this species (Gidley 1900). Specimens of *E. scotti* from Sangamon interglacial or mid-Wisconsin deposits at Saskatoon, Saskatchewan are slightly larger in size than most of the Yukon fossils.

The following metatarsals are referred: right - NMC 28964 (Dawson Locality 17), 29067 (Sixtymile Locality 3); left - NMC 17573 (Dawson Locality 30), 17293 (Dawson Locality 7), 23392 (Old Crow Locality 11A). The last specimen from the Old Crow Area is stained blackish brown like the metacarpal NMC 26686. The remaining specimens from the Dawson and Sixtymile areas are paler - particularly NMC 29067, which appears to be of late Wisconsin age. NMC 17573 is unusual in that it is grayish. It has rootlet impressions on its surface. Probably larger samples of *Equus* cf. *scotti* metapodials would result in their overlapping the size ranges of both the Yukon wild ass and large horse metapodials.

Discussion

This appears to be the first report of a horse like *E. scotti* from Eastern Beringia. The darkly stained specimens from the Old Crow Basin suggest that these medium-sized horses arrived there from the southern plains of North America before the late Wisconsin. The species seems to have been commoner farther south (in the Dawson - Sixtymile region), probably during the late Wisconsin.

Hay (1913b) described a complete horse skull from the Tofty mining district of Alaska under the name *Equus niobrarensis alaskae*. I doubt that this specimen represents *E. niobrarensis (= E. scotti)*. Comparison of good casts of the entire upper dentitions of the types of *Equus niobrarensis alaskae* (USNM 7700) and *Equus (Asinus) lambei* (USNM 8426) with a complete cranium of *E. scotti* (NMC 2381) from the type locality of that species suggests to me that:
(a) USNM 7700 and 8426 are basically similar in conformation, having similar P^2-M^3 alveolar lengths, simple enamel patterns on the occlusal surfaces of the cheek teeth, and facial crests lying relatively close to the alveolar margin of the upper cheek teeth; (b) the approximately 8 mm longer diastema length and greater breadth across I^3s of USNM 7700 relative to USNM 8426 are probably functions of differences in sex and age; the former represents an approximately

6-year-old male (well developed canines and slightly worn incisors), while the latter evidently represents an old female (no canines or canine swellings and heavily worn incisors). Furthermore, USNM 7700 is closely matched by a good cranium of what I consider to be a male *E. (A.) lambei* (NMC 9924) from Hunker Creek in the Dawson Area. It is also interesting to note that Repenning *et al.* (1964, Table 1) have identified remains of a species of small horse rather than a medium-sized horse from Pleistocene deposits in the Tofty mining district – the type locality of *E. niobrarensis alaskae;* (c) USNM 7700 is notably smaller than a similar-aged female (lacking canines with slightly worn incisors) of *E. scotti* (NMC 2381). In alveolar length alone the former is approximately 13% smaller than the latter. The distance from the facial crest to the alveolar margin of the upper cheek teeth is much greater in NMC 2381 than in either USNM 7700 or 8426. Therefore, it appears that medium-sized horses like *E. scotti* have not yet been reported from Alaska, although there is every reason to suspect that they lived there during the late Pleistocene.

In southern Canada, *E. scotti* first appears in deposits of Kansan age at Medicine Hat, Alberta. It is recorded there also in faunas of Yarmouth and Sangamon interglacial age. I refer two metacarpals (UA* 1643, 1644) from Saskatchewan gravels on the south bank of the Battle River, Alberta to *E. scotti* (Reimchen 1968, Table 13). They may be of mid-Wisconsin or earlier age. Evidently the species was common in southern and central Saskatchewan (Fort Qu'Appelle and Saskatoon) during Sangamon or mid-Wisconsin time.

In the Great Plains and Central Lowland provinces of the United States, *E. scotti* occurs in mammalian faunas of Kansan age from Rock Creek and other sites in Texas, from Holloman, Oklahoma and in the Cudahy fauna from both Kansas and Texas. It is also known from the early Illinoian of Kansas, and *E.* cf. *scotti* has been recorded from late Illinoian deposits in that state. During the Sangamon interglacial *E. scotti* and *E.* cf. *scotti* occupied the Slaton area in Texas and the Butler Spring area in Kansas, respectively. *E. scotti* is also known from Wisconsin deposits in Texas (Hibbard 1970, pp. 419-430).

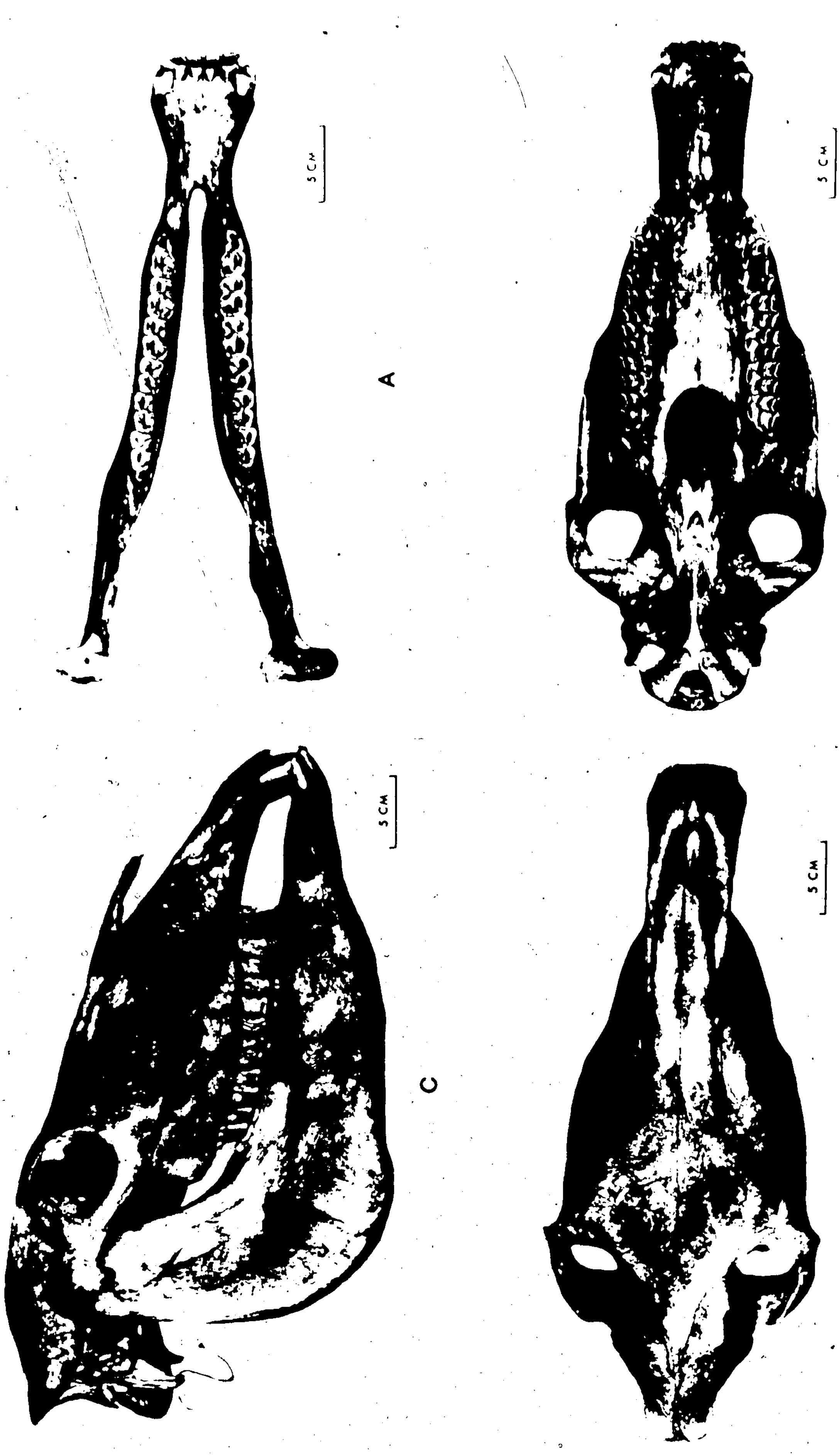
Equus scotti was confined to North America. It first appeared on the western plains and spread rapidly, ranging from Alberta to Texas. Its ancestors are unknown. I speculate that it is related to early caballine horses, which may have originated in northern Asia - a large form *(E. bresanus)* spreading to Europe in the Villafranchian (Kurtén 1968, p. 149) and a smaller form (e.g. *E. scotti,* and *E.* cf. *caballus* (Savage 1951, p. 239)) reaching North America via the Bering Isthmus in Kansan time. Its favored range seems to have been in Texas and Kansas during the middle to late Pleistocene. Apparently it shifted its range northward during the Yarmouth and Sangamon interglacials, perhaps reaching the Yukon during the latter phase. The lack of abundance of specimens of this kind of horse in the Yukon, and the fact that most fossils appear to be a late Wisconsin age, suggests that the species did not survive long there.

Equus scotti was a rather heavy set horse with a large head. Mature mares would have reached a height of about 15 hands (1.5 m). Its hooves were broader than those of living Arabian horses; however, in most characters is is very like modern horses *(Equus caballus)*. The species may have lived in regions of "...luxuriant vegetation with plenty of food and water" (Troxell 1915, pp. 616-617). Rootlet markings on the surfaces of the metacarpal NMC 14485 and the metatarsal NMC 17573 may indicate that it occupied a grassland habitat in Eastern Beringia. It is interesting to note that it is associated with wild asses *(Equus (Asinus)* sp.) in a number of faunas (e.g. early and late Illinoian faunas of Kansas; Sangamon faunas of Slaton, Texas, Cragin Quarry, Kansas, and Medicine Hat, Alberta; and Wisconsin faunas of Texas and the Yukon Territory). Perhaps they had broadly similar habitat requirements, but the wild asses mainly occupied drier portions of their mutual range. Probably large cats such as the American lion *(Panthera leo atrox)* and wolves preyed on *E. scotti*. Man may have hunted this horse, but no obvious kill sites similar to those found in Eurasia have been discovered.

Equus (Asinus) lambei (Yukon wild ass)

This was the dominant species of horse in the Dawson Area during the late Wisconsin. Many fossils comprising most parts of the skeleton, including a few good skulls, have been found there. In addition, remains of this small horse have been collected from the Sixtymile Area, Old Crow Area, and Herschel Island. In order to facilitate comparisons of the Yukon wild ass (Figures 50, 60A-B, 61A-D, 62A, 63A-B, Tables 64-68) with other species of Pleistocene and Recent wild ass, skull measurements are given, in addition to those of the metapodials. Descriptions and measurements of other skeletal elements are provided by Harington and Clulow (1973, pp. 708-724).

Figure 61. A. Dorsal view of mandible (USNM 8426, Dawson Locality 32) of the type of the Pleistocene Yukon wild ass *(Equus (Asinus) lambei)*. B. Ventral view of cranium (USNM 8426). C. Right lateral view of complete skull (USNM 8426). D. Dorsal view of cranium (USNM 8426).


5 CM
A
5 CM
B
5 CM
C
5 CM
D

igure 62. A. Occlusal view of right maxillary fragment with RP^2-RM^3 (NMC 29330, Old Crow Locality 146) of a Pleistocene Yukon wild ass *(Equus (Asinus) lambei)*.

B. Occlusal view of a right upper cheek tooth (NMC 19034, Old Crow Locality 66) of a Pleistocene large horse *(Equus* cf. *(Plesippus) verae)*.

C. Occlusal view of RM^3 (NMC 20830, Old Crow Locality 29) of a Pleistocene large horse *(Equus* cf. *(Plesippus) verae)*.

D. Occlusal view of right lower cheek tooth (NMC 26049, Old Crow Locality unknown) of a Pleistocene large horse *(Equus* cf. *(Plesippus) verae)*.


B
C
D
5 CM
A
5 CM

Figure 63. A. Anterior view of metacarpals (left to right LUM 1.91, 1.105, 1.92, 1.99, 1.100, 1.104, 1.95, 1.103, 1.175, 1.101; Dawson Locality 32) of the Pleistocene Yukon wild ass *(Equus (Asinus) lambei)*, showing apparent bimodal grouping (see Figures 60A-B and Harington and Clulow 1973, Figure 26) into large male? specimens (right) and smaller female? specimens (left). B. Posterior views (from left to right): right metatarsal (LUM 1.106, Dawson Locality 32) of a Pleistocene kiang-like wild ass *(Equus (Asinus)* cf. *kiang)*; left metatarsal (NMC 13477, Dawson Locality 32) of a male? Pleistocene Yukon wild ass *(Equus (Asinus) lambei)*; left metatarsal (NMC 13479; Dawson Locality 32) of a female? Pleistocene Yukon wild ass. *(Equus (Asinus) lambei)*.

A

B

Table 64. Measurements of Pleistocene Yukon wild ass *(Equus (Asinus) lambei)* crania from the Yu

SPECIMENS	PROBABLE SEX	ESTIMATED AGE	Measurements (mm)										
			1	2	3	4	5	6	7	8	9	10	11
Equus (Asinus) lambei.													
USNM 8426 Dawson Loc.32 (type)	♀	Adult	446	245	167	498	129	310	348	102	-	120	72
LUM 1.222 Dawson Loc.32	♀	Adult	471	252	176	533	114	316	371	102	192	121	74
NMC 13485 Dawson Loc.32	-	2½ yrs.	450	246	168	504	125	295	-	101	-	114	-
NMC 17262 Dawson Loc.28	♀	Adult	483	264	176	534	131	321	376	106	195	117	72
NMC 17905 Dawson Loc.32	♂	Adult	496	265e	176	547	139	324	388	129	200	121e	-
NMC 17235 Dawson Loc.28	♂	Old	476	269	172	542	133	325	384	115	204	117	-
NMC 9924 Dawson Loc. 2	♂	Adult	503	275	-	-	131	335	394	122	206	121	81
NMC 17254 Dawson Loc.28	♂	Old	484a	262a	-	542a	133a	322a	383a	118	212	118	-
NMC 13552 Dawson Loc.32	-	Adult	-	-	-	-	-	-	-	-	-	-	-

* 1 - Middle of incisive border to anterior of foramen magnum.
2 - Middle of incisive border to anterior of posterior nares.
3 - Middle of incisive border to naso-premaxillary notch.
4 - Middle of incisive border to posterior of occipital crest.
5 - Middle of incisive border to anterior of PM^2.
6 - Middle of incisive border to anterior of orbit.
7 - Middle of incisive border to posterior of orbit.
8 - Width across mastoid processes.
9 - Width across articulation for lower jaw.
10 - Width between outer faces of M^3s.
11 - Width between outer faces of I^3s.
12 - Minimum distance between orbits (anterior).
13 - Maximum distance between orbits (posterior).
14 - Middle of occipital crest to posterior of orbit.
15 - Palatal width at M^3s (minimum).
16 - Palatal width at P^2s (minimum).
17 - Distance between I^3 and P^2.
18 - Anteroposterior diameter of orbit.
19 - Least width between I^3 and P^2 (on ridge).

ld ass *(Equus (Asinus) lambei)* crania from the Yukon Territory.

	Measurements (mm)*															
3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
7	498	129	310	348	102	-	120	72	-	-	188	65	47	86	54	43
6	533	114	316	371	102	192	12	74	158	214	209	72	50e	89	54	51
8	504	125	295	-	101	-	11	-	157	-	-	61	45	86	-	43
6	534	131	321	376	106	195	117	72	156	209	198	68	46	91	54	44
6	547	139	324	388	129	200	121e	-	159	210	205e	67e	52	106	65	45
2	542	133	325	384	115	204	117	-	164	217	207	72	55	97	63	52
	-	131	335	394	122	206	121	81	166	219	-	71	49	88	63	50
	542a	133a	322a	383a	118	212	118	-	-	223	204	72	52e	98	66	50e
	-	-	-	-	-	-	-	-	158	205†	-	-	43	-	61	-

num.
ares.

crest.

Table 66. Measurements of Pleistocene Yukon wild ass (*Equus (Asinus) lambei*) lower dentitions from the Yukon Territory.

Specimens	Probable Sex	Estimated Age	Measurements (mm)* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Equus (Asinus) lambei.																	
USNM 8426 Dawson Loc. 32 (Measurements from a plaster cast)	♀	Adult	31.6	18.2	26.2	19.4	27.3	19.7	23.0	18.3	26.2	17.5	32.1	16.8	169.2	85.6	83.4
LUM 1.222 Dawson Loc. 32	♀	Adult	34.3	16.3	27.6	18.1	27.4	19.2	23.4	17.6	24.2	17.5	35.5	16.2	171.1	-	-
NMC 9924 Dawson Loc. 12	♂	Adult	38.3	18.5	29.6	19.5	29.0	19.0	26.4	17.9	26.9	17.1	34.5	15.2	190.1	98.9	91.2
NMC 2778 Dawson Loc. unknown	♂	Adult	34.3	18.5	25.4	18.6	25.5	18.4	22.4	18.0	19.0	17.7	32.1	16.0	165.8	94.5	82.4
NMC 17255 Dawson Loc. 28	♂	Old	30.7	19.9	25.7	21.2	25.0	18.7	22.3	19.1	19.4	17.7	32.3	16.1	164.8	81.5	84.3
NMC 17261 Dawson Loc. 23	-	Adult	31.0	17.5	24.2	17.6	25.5	18.9	22.0	17.9	23.9	16.9	31.0	15.4	160.4	82.8	78.2
NMC 7748 Dawson Loc. 9	-	Adult	36.9	18.4	30.8	21.2	28.3	20.7	27.4	19.8	27.5	18.2	33.3	16.2	188.2	98.5	89.3

* 1 - P_2 length.
2 - P_2 width.
3 - P_3 length.
4 - P_3 width.
5 - P_4 length.
6 - P_4 width.
7 - M_1 length.
8 - M_1 width.
9 - M_2 length.
10 - M_2 width.
11 - M_3 length.
12 - M_3 width.
13 - P_2-M_3 alveolar length.
14 - P_2-P_4 alveolar length.
15 - M_1-M_3 alveolar length.

Light copy

Table 67. Measurements of Pleistocene Yukon wild ass *(Equus (Asinus) lambei)* metacarpals from the Yukon Territory.

Specimens	Measurements (mm)*						
	1	2	3	4	5	6	7
Equus (Asinus) lambei, Pleistocene, Y.T.							
NMC 13472 Dawson Loc. 32	232.3	45.4	32.2	28.8	23.9	41.8	31.7
NMC 26009 Dawson Loc. 13	229.3	47.3	32.4	33.4	26.6	46.4	36.4
NMC 11631 Dawson Loc. 32	225.1	50.4	32.2	35.2	27.6	44.9	30.0^{+}
NMC 25190 Dawson Loc. 16	224.3	50.2	-	36.0	26.6	48.8	-
NMC 29070 Sixtymile Loc. 3	224.5	46.6	32.7	41.8	25.5	45.4	36.7
NMC 29071 Sixtymile Loc. 3	224.4	49.1	33.6	34.8	25.9	43.8	34.1
NMC 28495 Old Crow Loc. 143	223.2	50.5	35.2	34.6	25.9	50.3	37.8
NMC 29231 Dawson Loc. 13	223.0	48.3	32.7	33.8	25.7	44.6	35.3
NMC 29073 Sixtymile Loc. 3	221.6	47.3	32.2	32.2	24.2	46.7	35.4
NMC 11630 Dawson Loc. 32	219.6	46.0	30.5	30.8	23.6	42.8	33.9
NMC 13474 Dawson Loc. 32	217.8	44.9	31.1	28.4	22.2	43.0	35.0
NMC 11757 Dawson Loc. 28	217.7	45.9	31.2	33.6	25.6	45.0	35.9
NMC 18040 Old Crow Loc. 11A	216.3	48.7	32.2	35.2	26.0	49.3	38.1
NMC 17267 Dawson Loc. 28	214.5	49.8	33.3	35.9	26.8	46.8	36.4
NMC 17057 Porcupine Loc. 100	212.2	49.2	29.2	33.8	25.2	47.5	36.5
NMC 16233 Old Crow Loc. 48	212.1	49.1	33.6	35.4	25.3	50.3	33.6^{+}
NMC 13663 Old Crow Loc. 11A	211.3	47.9	30.3	32.7	24.4	47.2	36.1
NMC 11758 Dawson Loc. 28	210.7	44.6	28.0	33.5	26.3	44.1	29.8
NMC 13473 Dawson Loc. 32	210.2	46.6	31.7	32.7	26.1	43.8	36.3
NMC 17249 Dawson Loc. 28	209.8	45.3	31.6	30.3	24.2	43.5	34.2
NMC 29197 Dawson Loc. 8	209.7	44.3	30.1	31.9	24.1	40.6	32.5^{+}
NMC 26008 Dawson Loc. 13	209.2	44.0e	27.5^{+}	28.9^{+}	25.1	40.6^{+}	31.5^{+}
NMC 17599 Dawson Loc. 28	209.1	44.4	31.2	31.8	25.8	45.6	35.5
NMC 25939 Dawson Loc. 16	208.0	45.1	31.1	29.7	24.1	43.4	33.1
NMC 17266 Dawson Loc. 28	207.8	41.3^{+}	25.5^{+}	30.9	23.5	40.2	28.4^{+}
NMC 17598 Dawson Loc. 28	207.8	44.7	29.6	29.2	23.7	44.9	33.5
NMC 13475 Dawson Loc. 32	207.3	43.4	29.3	32.7	24.9	44.7	32.3
NMC 17584 Dawson Loc. 13	207.0	4[illegible].2	30.7	31.3	25.3	44.5	32.4
NMC 26723 Old Crow Loc. 20	206.3	49.0	31.6	32.6	23.4	46.4	35.6
NMC 24116 Old Crow Loc. 2	206.2	45.4	30.6	31.6	23.8	44.0e	33.4
NMC 11343 Dawson Loc. 2	205.4	44.9	29.6	30.3	23.3	42.1	33.2
NMC 25254 Dawson Loc. 8	204.8	44.9	31.1	32.9	25.4	44.3	34.2
NMC 11759 Dawson Loc. 28	204.6	42.2	25.9	29.6	22.2	36.1	26.3
NMC 25239 Dawson Loc. 32	204.6	43.2	30.3	30.7	24.2	45.6	34.0
NMC 23362 Old Crow Loc. 95	201.9	44.9	30.7	32.0	22.9	45.8	34.3
NMC 11756 Dawson Loc. 28	201.2	47.6	32.0	31.7	25.2	44.5	33.9
NMC 25247 Dawson Loc. 8	197.5	45.2	28.1	32.0	23.6	45.3	31.7

* 1 - Total length.
2 - Proximal width.
3 - Proximal depth.
4 - Midshaft width.
5 - Midshaft depth.
6 - Distal width.
7 - Distal depth.

| Light copy

Table 68. Measurements of Pleistocene Yukon wild ass *(Equus (Asinus) lambei)* metatarsals from the Yukon Territory.

Specimens	Measurements (mm)*						
	1	2	3	4	5	6	7
Equus (Asinus) lambei.							
Pleistocene, Y.T.							
NMC 25938 Dawson Loc. 16	267.4	49.0	42.4	32.3	29.3	48.2	38.9
NMC 13476 Dawson Loc. 32	265.5	48.2	43.8	32.3	29.4	46.6	38.6
NMC 17563 Dawson Loc. 32	265.0	52.0	45.2	34.8	32.4	51.7	40.5
NMC 2773 Sixtymile Loc. 1	264.4	48.7	41.2	31.5	31.7	45.4	38.3
NMC 23375 Old Crow Loc. 11A	260.1	51.0	41.9	34.5	30.1	50.2	37.4
NMC 17270 Dawson Loc. 28	259.6	47.1	43.9	31.1	33.6	45.9	36.4
NMC 25178 Dawson Loc. 16	258.2	43.1	38.7	28.3	27.9	40.4	30.6
NMC 14667 Old Crow Loc. 26	257.7	51.3	42.9	35.7	37.2	52.3	36.1
NMC 13477 Dawson Loc. 32	256.0	48.6	40.1	34.6	29.9	48.3	36.6
NMC 10467 Dawson Loc. 24	255.9	46.5	39.8	32.3	30.2	46.6	33.3
NMC 25187 Dawson Loc. 16	254.2	50.4	42.6	31.9	31.2	50.9	37.7
NMC 25188 Dawson Loc. 16	253.0	42.6	38.1	27.1	27.1	40.8	32.1
NMC 11752 Dawson Loc. 28	252.0	49.3	40.5	33.4	29.7e	47.3	34.3
NMC 29068 Sixtymile Loc. 3	251.0	47.4	39.0	30.9	29.0	46.0	35.5
NMC 13478 Dawson Loc. 32	249.5	44.2	37.2	30.5	30.1	43.3	35.0
NMC 17511 Dawson Loc. 32	249.0	42.9	35.8	29.3	29.1	43.4	33.7
NMC 17562 Dawson Loc. 32	248.4	44.5	38.5	31.7	29.3	45.6	36.4
NMC 28965 Dawson Loc. 17	248.2	47.3	38.6	32.4	29.1	46.1	35.6
NMC 11754 Dawson Loc. 28	247.4	44.5	37.5	30.6	29.6	43.1	33.7
NMC 13479 Dawson Loc. 32	245.2	44.5	37.6	30.0	28.9	45.8	35.6
NMC 11751 Dawson Loc. 28	244.4	42.9	38.3	31.0	29.8	44.7	34.7
NMC 13664 Old Crow Loc. 2	244.3	47.5	42.0	32.6	29.1	48.5	38.2
NMC 20492 Old Crow Loc. 20	244.1	48.7	42.3	32.5	28.7	50.0	37.6
NMC 26724 Old Crow Loc. 20	243.9	51.2	41.0	32.7	30.3	50.4	37.9
NMC 17585 Dawson Loc. 13	243.2	45.9	36.8	31.6	26.7	47.8	34.9
NMC 28966 Dawson Loc. 17	243.0	42.2	35.0	28.6	29.9	42.5	33.4
NMC 17917 Porcupine Loc. 100	242.9	48.7	41.7	32.1	28.9	45.8	-
NMC 24203 Old Crow Loc. 12	240.7	45.7	40.6	34.6	30.6	46.8	35.2
NMC 17600 Dawson Loc. 28	240.6	43.6	37.3	28.7	30.3	42.7	33.8
NMC 17269 Dawson Loc. 28	240.2	43.0	36.6	27.9	29.5	40.2	31.9
NMC 28968 Dawson Loc. 17	238.3	41.8	37.9	27.8	29.4	41.3	31.8
NMC 11753 Dawson Loc. 28	234.6	38.4	36.2	-	28.7	40.7	30.5

* 1 - Total length.
2 - Proximal width.
3 - Proximal depth.
4 - Midshaft width.
5 - Midshaft depth.
6 - Distal width.
7 - Distal depth.

As part of an attempt to organize sensibly the confused classification of North American Pleistocene horses, Savage (1951, p. 252) referred *E. lambei* to *E.* cf. *caballus*. Quinn (1957, p. 14), in a later revision, referred *E. lambei* to *Onager lambei* and listed additional specimens from Texas that he considered belonged to that species. Groves and Mazák (1967), after completing a comprehensive taxonomic study, placed Asiatic and African wild asses in the genus *Asinus*. They consider the name *Onager* Brisson, 1762 to be invalid, and list the more appropriate name *Hemionus* Stehlin and Graziosi, 1935 as a species, *Asinus hemionus*. Following Stirton (1942, pp. 636-637), I prefer to relegate *Asinus* to subgeneric level (as allowed for by Groves and Mazák (1967, p. 326)) and to consider the type specimen of the Yukon wild ass from Gold Run Creek near Dawson as *Equus (Asinus) lambei*. Thus, regarding the designation of the small, broad-skulled Yukon horse, I am inclined to disagree with Savage, while agreeing fundamentally with Quinn, and altering his nomenclature to conform in essence to that proposed by Groves and Mazák.

Referred specimens

The type specimen (USNM 8426 - not USNM 8226 as mentioned by Hay (1917)) consists of a complete cranium and mandible articulating with it, which evidently belonged to a 12-year-old, or older, female. It was collected in 1903 by John M. Morrison at a depth of 32 feet (9.8 m) on claim 34 of Gold Run Creek (Dawson Locality 32). Hay (1917, p. 435) described and figured the specimen as the type of a new species of small horse *Equus lambei*. In searching the files of L.M. Lambe, I discovered a series of photographs of the type skull, taken for him by the Photographic Division of the Geological Survey of Canada in October 1912. Because of their unusual clarity compared to Hay's illustrations (1917, Plates 56-58), or because they show new views (or both) of this important specimen, a few are included. Although Hay (1917, p. 435) reported that LI^3 and LI_1 ....."have been lost since exhumation", they are present in Lambe's photographs.

Another excellent specimen of *E. (A.) lambei* from Dawson Locality 32 is a cranium with articulated mandible (LUM 1.222) collected in 1968 (Harington and Clulow 1973, Figures 19-22). The cranium is complete except that it lacks the nasals, facial bone anterior to the right orbit, both I^1s, and the tip of the right mastoid process. As the teeth are heavily worn and canines are not present, the specimen probably represents an old female. Thus, in age and sex the skull is comparable to the type specimen USNM 8426. Like the type, protocones on the upper cheek teeth are long. Protocones on the heavily worn M^{3}s are even narrower than those of the type (Hay 1917, p. 440). Groves and Mazák (1967, p. 324) remark that the protocone is generally elongated, especially posteriorly, in the Asiatic wild asses *Equus (Asinus) hemionus* and *Equus (Asinus) kiang*, and this observation applies to the teeth of *E. (A.) lambei*. The teeth of LUM 1.222 are very similar in shape and size to those of USNM 8426, but the cranium is substantially longer. In fact, the cranium of the type is the shortest known for the species. I believe such differences suggest the degree of individual variation that may be expected in the Yukon wild ass.

According to its stage of tooth eruption, the cranium NMC 13485 from Dawson Locality 32 represents an approximately 2½-year-old colt (Harington and Clulow 1973, Figures 23-25). Canine regions are slightly swollen, but no teeth are evident, so NMC 13485 may represent a male or female. I include a detailed description of this specimen because it is chronologically younger than any previously known cranium of this species, and because it demonstrates clearly one stage in the sequence of maturation. Tips of I^{1}s are visible;

dI^2s and dLI^3 are present, but about to be replaced; dRI^3 is lost. LP^1 is present and has a well worn occlusal surface; RP^1 is missing. RP^2 is replacing dRP^2, which is nearly worn to the roots and is slightly worn anteromedially. dLP^2 has been replaced by LP^2, which projects through the gum line and has slightly worn paracones and protocone. P^3s are replacing heavily worn dP^3s. dLP^3 is worn away anteriorly and is almost ground to the roots posteriorly. dP^4s are being replaced. M^1s have well worn occlusal surfaces and project slightly above the level of the M^2s. The occlusal surfaces of the M^2s are only moderately worn, indicating recent eruption. RM^3 may have begun to erupt, but LM^3 has not broken the gum line. Although the latter tooth is present, the former evidently slipped dorsally out of its socket through a damaged area in the cranium and was lost. Most cranial sutures, including the basioccipital - basisphenoid suture, are unfused. Like the type specimen, NMC 13485 has long protocones on the permanent molars, a flat interorbital region, and a pronounced downward slant on the dorsal surface of the cranium between the middle of the braincase and the occipital crest. The occiput when viewed from above has the square, parallel-sided shape seen in *Equus (Asinus)*, rather than the rounded shape common in *Equus (Equus)* (Groves and Mazák 1967, p. 324).

The cranium NMC 17262 from Dawson Locality 28, lacking upper canines and having well worn incisors, probably represents an old female. Protocones on the posterior upper cheek teeth are long, and the enamel pattern on the upper cheek teeth is simple as in the type specimen. The cranium is complete except that the following bone is lacking: the tips of the nasals, the posterolateral part of the right nasal, the interior of the left orbit, most of the left parietal and part of the temporal, parts of the frontals, parts of the auditory bullae, and the tips of the paramastoid processes.

NMC 17905 from Dawson Locality 32 is a cranium lacking the incisors, LC^1, RP^2, LM^1-LM^3, bone of the interior part of the orbits, most of the auditory bullae, and the right paramastoid process. The protocone on RM^3 is long and narrow as in the type specimen: the remainder are markedly shorter. As upper canines are present and the cheek teeth are worn (but still high from roots to occlusal surfaces), probably a mature male is represented. This specimen is 50 mm longer than the type. The bone is stained a rust color and has whitish patches. It tends to be chalky and rather fragile, probably due to long exposure and weathering. RM^2 is relatively small compared to those of most *E. (A.) lambei* seen. This tooth almost exactly matches a brownish stained ?RM^2 (NMC 18415) from Old Crow Locality 29. The latter specimen, which I refer to *Equus (Asinus) lambei*, has maximum crown dimensions of 24.1 mm long x 23.9 wide and has a very long protocone, while the RM^2 of the former is 24.1 mm long x 24.7 mm wide.

NMC 17235 from Dawson Locality 28 is a relatively broad cranium lacking the incisors and P^{3}s. The canines are very heavily worn and the remaining cheek teeth are almost worn to the roots. Most sutures are well fused. Evidently this specimen represents an extremely old male. The tips of the nasals are lacking and the auditory bullae are badly damaged, as is the tip of the left paramastoid process. The dentition is interesting. Apparently RI^3 was lost during life, and its alveolus was nearly completely filled by callus. The alveolar margins of the P^2 sockets are smoothed down, suggesting to me that the P^{2}s were lost well before the animal died. M^{1}s are so heavily worn that hardly any enamel is apparent in the polished occlusal "basins". Another sign of old age is the porosity of the bone near the alveolar margins of the upper cheek teeth. Callus has also filled the areas posterior to the M^{3}s where those teeth have "shrunk forward" (resulting in greatly decreased P^2-M^3 alveolar length) from their situation during early maturity. Although most of the specimens are tan, NMC 17235 seems to have a blackish (manganese?) stain superimposed on top of the tan colored bone.

NMC 9924 from Dawson Locality 12 consists of most of a cranium lacking the dorsal region from a point between the orbits to the anterior part of the premaxillary nasal processes. Only the bone enclosing the roots of the cheek teeth and the upper part of the palate is seen when this part of the cranium is viewed from above. All teeth are present. The incisors are moderately worn and upper canines are present, indicating that the horse represented is an adult male. The occipital or nuchal crest is missing, as are the left lateral portion of the temporal condyle and orbital bone. A complete mandible containing all teeth was found with this cranium. It is the largest skull in the series.

NMC 17254 from Dawson Locality 28 consists of most of a cranium with all cheek teeth, LI^2, LI^3, LC^1, and the socket for LI^1. The cheek teeth, incisors and LC^1 show heavy wear. Probably the specimen represents an old male, but not so old as NMC 17235. Most of the upper part of the cranium anterior to the frontals is missing, including the superior margins of the orbits. The right half of the cranium anterior to RP^2 is lacking. The bone surface is rather grainy due to heavy weathering. Small exostoseal growths occur posterior to M^3s.

The degree of wear on the upper cheek teeth of a fragile cranium (NMC 13552) from Dawson Locality 32 indicates that it represents an adult. The specimen lacks the occipital area, part of the palate, and the region anterior to the cheek teeth. The right tooth row is complete, but the labial faces of RM^1-RM^3 are badly chipped. LP^2-LM^1 are present, but are poorly preserved. The cheek teeth are similar in size and simple enamel pattern to those of the type specimen.

NMC 29350 from Old Crow Locality 146 consists of a right maxillary fragment with RP^2-RM^3. The cheek teeth are moderately worn, so the specimen probably represents an adult. Because it is unusually complete compared to most Pleistocene horse fossils from the Old Crow Basin, because the bone is quite fresh in appearance (like most specimens from the late Wisconsin muck deposits of the Dawson Area), and because it is from the Pleistocene vertebrate locality farthest up the Old Crow River, I consider NMC 29350 is evidence that herds of Yukon wild asses occupied the margins of the Old Crow Basin when it was last filled by Glacial Lake Old Crow during the late Wisconsin.

Other maxillary fragments with teeth have been recorded from Gold Run Creek (Dawson Locality 32). They represent adults according to the degree of wear on the cheek teeth. NMC 13482, a left maxillary fragment with LP^3-LM^3, probably was derived from a slightly younger individual than NMC 11628. The latter specimen consists of a partial palate with nearly complete right tooth row. RP^2, the labial margin of RM^1 and a lingual fragment of LP^4 are missing. Generally speaking, males seem to have consistently larger orbits and are broader across the mastoid processes than females.

It is worth noting that *E. (A.) lambei* mandibles differ from those of Recent horses *(E. caballus)* in the strong convexity of their ventral borders below the premolars. This difference is easily demonstrated by placing mandibles of *E. caballus* and *E. (A.) lambei* upright, side by side on a flat surface. The ventral border of the former species lies close to the surface throughout its length, whereas the anterior part of the ventral border of the latter species rises well above the surface. Descriptions of a few of the most complete mandibles follow.

Measurements of virtually complete mandibles with all teeth, which articulate with the previously described crania (USNM 8426 and LUM 1.222 from Dawson Locality 32, and NMC 9924 from Dawson Locality 12) are included in Table 66. NMC 2778 from an unknown locality near Dawson consists of a complete mandible with teeth excepting LI_1 and RI_1-RI_3. Canines are well developed and incisors are heavily worn, suggesting that the specimen represents a male in late maturity. The tip of the right coronoid process is lacking and the condyles are slightly damaged. This specimen was purchased by D.D. Cairnes of the Geological Survey of Canada about 1916. NMC 17255 from Dawson Locality 28 evidently represents a slightly older male. The anterior cheek teeth are very heavily worn and the margins of the following teeth are missing: the anterior of RP_2, the medial side of RP_4, and the posterior portions of M_3s. Most of the ascending rami are missing.

NMC 17261 from Dawson Locality 28 represents a younger horse than NMC 17255 or 2778. The specimen is a left mandible lacking most of the diastema, the tip of the coronoid process and the medial end of the condyle. NMC 7748 from Dawson Locality 9 is the central part of a right mandible with all cheek teeth. The degree of wear on the cheek teeth indicates that the individual represented was mature at death. NMC 13553 from Dawson Locality 32 is a left mandibular fragment with LP_2-LM_3. It represents a mature individual. This specimen, like NMC 7748, lacks the diastema and ascending ramus.

The following metacarpals (III) are referred: right - NMC 11631, 13475, 25239, 13472, 13474 (Dawson Locality 32), 17599, 11758-59, 17266 (Dawson Locality 28), 11343 (Dawson Locality 2), 17584 (Dawson Locality 13), 25247 (Dawson Locality 8), 29070 (Sixtymile Locality 3), 17057 (Porcupine Locality 100), 24116 (Old Crow Locality 2), 23362 (Old Crow Locality 95), 27406 (Old Crow Locality 129); left - NMC 29197, 25254 (Dawson Locality 8), 17249, 17598, 11756-57, 17267 (Dawson Locality 28), 26008, 29231 (Dawson Locality 13), 25991 (Dawson Locality 10), 25939, 25190 (Dawson Locality 16), 29071, 29073 (Sixtymile Locality 3), 13663, 18040 (Old Crow Locality 11A), 26723 (Old Crow Locality 20), 16233 (Old Crow Locality 48), 28495 (Old Crow Locality 143). NMC 13474 probably represents an individual that died during late immaturity because the suture line is still visible where the distal epiphysis is fused to the shaft. It is one of the few Dawson bones that is dark brown. NMC 11756 and 17267 have metacarpal II fused to them, suggesting that they represent old individuals. Similarly NMC 17584 has metacarpal IV fused to it. Like the large horse *(Equus* cf. *(Plesippus) verae)* metacarpal (NMC 14355) mentioned previously, NMC 13473 has an exostoseal lesion above the distal articulation (Choquette *et al.* 1975, Figures 2, 3). NMC 25190 and 11758 have been heavily gnawed by carnivores near the proximal and distal ends of the shafts, respectively. The following metacarpals have extensive rootlet impressions on their surfaces: NMC 23362, 13472, 29070, 11631, 29071, 17057, 13475, 25254, 25247, 11343, 11759, 17266. Metacarpals vary in total length from approximately 197 to 233 mm.

The following metatarsals (III) are referred: right - NMC 13473, 17562, 17511 (Dawson Locality 32), 17270, 11752, 11751, 17600 (Dawson Locality 28), 28965, 28968 (Dawson Locality 17), 25188, 25178 (Dawson Locality 16), 29068 (Sixtymile Locality 3), 17917 (Porcupine Locality 100), 13664 (Old Crow Locality 2), 26724 (Old Crow Locality 20), 14667 (Old Crow Locality 26); left - NMC 17563, 13477, 13479, 13478 (Dawson Locality 32), 11754, 11753, 17269 (Dawson Locality 28), 25938, 25187 (Dawson Locality 16) 28966 (Dawson Locality 17), 17585 (Dawson Locality 13), 24203 (Dawson Locality 12), 10467 (Dawson Locality 24), 2773 (Sixtymile Locality 1), 23375 (Old Crow Locality 11A), 20492 (Old Crow Locality 20). Most of the specimens are light in color and fairly fresh looking, except for NMC 23375, 24203, 26724, and 13664 from the Old Crow Area, which are stained dark brown, and which may be of pre- late Wisconsin age. Abnormal proliferations of bone occur on the midshaft surfaces of NMC 25187 and 13477. The following metatarsals have clear networks of rootlet impressions on their surfaces: NMC 24203, 17562, 23375, 13477, 28966, 11751 and 25188. Such patterns may be indicative of death in a grassland environment. Metatarsals generally range in total length from 234 to 268 mm.

Discussion

Equus (Asinus) lambei was widespread in the Yukon during the ice age. Some of the fossils from both Old Crow and Dawson areas are suggestive evidence that Yukon wild asses occupied this part of Eastern Beringia before the late Wisconsin. The species seems to have been more abundant in the Dawson Area than in the Old Crow Area during the late Wisconsin, although it was definitely present on the western margin of the basin, probably when the last

Glacial Lake Old Crow was extant. A Yukon wild ass metapodial that I collected *in situ* near the base of the muck and the surface of the gold-bearing gravel on Dominion Creek (Dawson Locality 28) has yielded a radiocarbon date of approximately 15,000 years B.P., which tends to support the idea that Yukon wild asses survived in Eastern Beringia until the late Wisconsin.

Fossils of this species, or species like it, have been found in other parts of Canada. During the early 1970s, I identified *E. (A.) lambei* fossils from Pleistocene deposits in the Northwest Territories: (a) near Tununuk on the Mackenzie River in association with bones of a woolly mammoth *(Mammuthus* cf. *primigenius)* that gave a radiocarbon date of 19,440 ± 290 years B.P. (I-8578); (b) from Richard's Island at the mouth of the Mackenzie River; and (c) from the seafloor near a man-made island ("Immerk") used as an oil well platform (Harington 1976 MS. p. 47). Ass-like horses are not uncommon in Sangamon to postglacial deposits of south-central British Columbia, Alberta and Saskatchewan (Harington 1971a, p. 71; Stalker and Churcher 1970), but they are usually identified as belonging to the Mexican wild ass *(Equus (Asinus) conversidens)*.

In the western United States, species belonging to *Equus (Asinus)* have been recorded from early Pleistocene (Late Blancan) deposits (e.g. "*Equus (Hemionus) calobatus*" from Sand Draw, Nebraska, and "*Equus (Asinus) cumminsi*" from Deer Park, Kansas, and Blanco, Texas (Skinner *et al.* 1972, p. 129)). *Equus (Asinus) conversidens*, the Mexican wild ass, did not appear on the North American plains until Illinoian time (Hibbard 1970, pp. 415, 423).

In Alaska, fossils of small Pleistocene horses have been reported from the Tofty area (Repenning *et al.* 1964, p. 183) - perhaps the type specimen of "*Equus niobrarensis alaskae*" from this region represents a male of *Equus (Asinus) lambei* – and from Lost Chicken Creek (Whitmore and Foster 1967; Harington 1976 MS. p. 75). A horse bone, probably that of a wild ass, from Lost Chicken Creek yielded a radiocarbon date of 26,760 ± 300 years B.P. (SI-355), which suggests that herds were present in that region just before the peak of the Wisconsin glaciation. Remains of small horses have also been recovered along the Ikpikpuk River on the Arctic Coastal Plain (Harington 1976 MS. p. 75). Probably all of those specimens and most of the horse material from the Fairbanks area are referable to the Yukon wild ass. Perhaps Jean Hough has identified one of the geologically earliest specimens of *E. (A.) lambei* in Alaska. It is most of a right mandible with teeth from terrace deposits of ?Illinoian age near Venetie (Péwé and Hopkins 1967, pp. 269-270).

Asiatic wild asses *(Equus (Asinus) hemionus)* lived in Siberia during the middle and late Pleistocene - in some cases with the arctic fox (Vangengeim 1961, p. 117). Remains of small horses, possibly asses like *Equus (Asinus) lambei*, have been collected from late Pleistocene (Illinoian to Wisconsin?) deposits as far north as the New Siberian Islands. They are usually referred to a small subspecies of *Equus caballus* by Soviet paleontologists (Vangengeim 1961, Figure 54b). Vereshchagin (1967, p. 391) states that wild asses were present in eastern Siberia during Paleolithic and Neolithic time. The relationships between Pleistocene horses of Siberia and the Yukon - Alaska region require careful consideration.

The kulan, a variety of Asiatic wild ass *(Equus (Asinus) hemionus kulan)*, has been reported from several European localities in deposits of Riss (Illinoian) to Würm (Wisconsin) age. There is doubt about the exact identification of some of the specimens, however

(Kurtén 1968, p. 151). But Dietrich (1959) found both teeth and limb bones in Würm I-II (mid-Wisconsin) interstadial Rixdorf sediments at Berlin, definitely establishing the presence of *E. (A.) hemionus* there.

Although little is known about the dispersal history of the wild asses, possibly the earliest known species is *Equus (Asinus) stehlini* from the late Villafranchian of Italy (Groves 1974, p. 47; Kurtén 1968, p. 149). Evidently from Eurasia they spread eastward via the Bering Isthmus into southwestern North America during the late Blancan, and southward into Africa. Asses of the basic *Equus (Asinus) hemionus* type apparently first spread widely into the Holarctic northern steppe regions from Europe to the Yukon during the Illinoian glacial. They became the dominant horses of the Beringian arctic steppe during the late Wisconsin (Sher 1971, p. 153; Harington and Clulow 1973, p. 724). *Equus (Asinus) lambei* first occurs in deposits of ?Illinoian age in Alaska, and these Yukon wild asses seem to have lived in the Dawson and Old Crow areas of the Yukon, and in Alaska, in pre- late Wisconsin, as well as late Wisconsin time. Yukon wild asses survived in the Yukon until about 15,000 years ago.

I wish to stress the similarity among the skeletons of *E. (A.) lambei* and its southern and western (Eurasian) relatives, *E. (A.) conversidens* and *E. (A.) hemionus*, respectively. Through the courtesy of C.O. Handley Jr. of the Smithsonian Institution, I have on loan a complete skeleton of a recent Asiatic wild ass *E. (A.) hemionus* (USNM 48493), the parts of which correspond closely to the same elements of the Yukon wild ass. However, the anterior upturn of the mandible, although present, is not so pronounced as it is in *E. (A.) lambei* mandibles described previously. Churcher (1968b, p. 1487) and Stalker and Churcher (1970) indicate the presence of *E. (A.) conversidens* in southern Alberta from Sangamon to postglacial time. The species evidently became extinct there about 8,000 years ago. Therefore, two asses, *E. (A.) lambei* and *E. (A.) conversidens*, lived in western Canada during the late Pleistocene and were separated at times by no more than 1,100 miles (1,770 km). Could these two forms be conspecific and closely related to, if not identical to, the Asiatic wild ass, *E. (A.) hemionus*? The zoogeographic and paleontological data, although somewhat sketchy at present, certainly do not preclude the conspecificity of these wild asses.

The Yukon wild ass formerly occupied the unglaciated areas of Alaska and the Yukon during the late

Pleistocene. It is extinct in America, but the possibility exists - should it be considered conspecific with *E. (A.) hemionus* - that it survives in Eurasia. The subspecies *Equus (Asinus) hemionus hemionus* or the dziggetai, which probably corresponds most closely to the Yukon wild ass, is presently found in southwestern Siberia, Transbaikalia and Dzungaria.

The Yukon wild ass was a small (about 1.3 m high), lightly built horse with a relatively large, broad head and long ears. It was probably buff in color with pale underparts, having a short black mane extending to a broad, dark dorsal stripe and a tail tipped with long black hair. The species was almost certainly capable of developing a thick (perhaps 20 cm long) winter coat, and in May probably looked very much like the excellent photograph of a moulting dziggetai provided by Groves (1974, p. 126).

Perhaps the Yukon wild ass had habits much like the living wild asses, favoring forb steppelands where snow is slight in winter, making grazing easier. The latter animals sometimes migrate long distances, and congregate in herds of up to 300, particularly in winter and summer, splitting up again in spring and autumn.

During most of the year, herds average 5 to 11 animals, consisting of an adult stallion, mares, two-year-olds and yearlings. The family herd is dominated by a stallion, but is usually led along by an old mare. Wild asses are fast (up to 64 km/hr) and can maintain that speed for several kilometres. They readily outdistance modern horses *(E. caballus)*. They swim well and are able to climb rocky mountain slopes swiftly. During hot, dry periods they must drink regularly and watering places determine their summer distribution and daily behavior. However, in spring, when feed is more succulent, they obtain 10 to 15 litres of water daily without drinking.

The commonest items in their diet are sedges (e.g. *Carex*) and grasses, as well as various species of wormwood *(Artemisia* - known to have been common in the dry grasslands of Eastern Beringia during the Illinoian and Wisconsin glaciations) and saltwort *(Salsola)* (Solomatin 1973, Table 6). The commonness of rootlet impressions on many of the Yukon wild ass metapodials is suggestive evidence that the animals occupied grassy tracts. Perhaps this species is a good paleoenvironmental indicator of rather dry, shrub-covered grasslands.

In winter, wild asses may have to scrape through the snow with their hooves to find food. They do not adapt well to deep, long-lasting snow. After heavy snowfalls they head for ravines and canyons where they often feed on shrubs. They are vulnerable to ice, which causes worn and bleeding hooves. During winter blizzards they cease grazing and move toward a sheltered spot in a valley or behind bushes, usually standing with their backs to the wind (Bannikov 1971).

Their speed and well developed senses of vision, hearing and smell help to protect them from predators. It is almost impossible for a person to get closer than 1 to 1.5 km without being noticed. In attack and defence they kick their victims with fore and hind hooves, stomp on them, and rip them with their teeth (Bannikov 1971). In Eastern Beringia during the late Pleistocene, probably only the fastest, craftiest predators such as the American lion and wolf were able to kill them (Figure 50). As yet, there is no evidence that they were hunted by early human occupants of the region.

Equus (Asinus) cf. *kiang*
(kiang-like wild ass)

Remains of these tall wild asses (Figure 63B, Table 69) are rare in Yukon Pleistocene deposits (Harington and Clulow 1973, p. 724).

Referred specimens

A right metatarsal (LUM 1.106) from Dawson Locality 32 is unusually long and narrow compared to specimens referred to *Equus (Asinus) lambei*. The relatively large size of the specimen, and the fact that the epiphyses are fused to the shaft suggest that the fossil was derived from an adult. Comparison of LUM 1.106 with large and small *E. (A.) lambei* metatarsals (e.g. NMC 13477, 13479; Figure 63B) shows that: (a) the nutrient foramen on the posterior surface of LUM 1.106 is situated more distally; (b) facets for metacarpals II and IV are less developed on LUM 1.106, suggesting that they were relatively slender; (c) the distal articular surface of LUM 1.106 is relatively narrow and shallow, indicating the former presence of a smaller hoof; and (d) the non-articular depression on the proximal surface of LUM 1.106 is larger.

When compared in maximum length and proximal width to samples of some Recent and fossil horses, zebras and

Table 69. Measurements of Pleistocene kiang-like wild ass *(Equus (Asinus)* cf. *kiang)* metatarsals from the Yukon Territory and Alaska compared to those of Recent kiangs *(Equus (Asinus) kiang)* from Asia.

Specimens	Sex	Measurements (mm)*						
		1	2	3	4	5	6	7
Equus (Asinus) cf. *kiang*. Pleistocene, Y.T.								
LUM 1.106 Dawson Loc. 32	-	267.4	40.9	-	28.0	28.3	38.5	31.1
Equus (Asinus) cf. *kiang*. Pleistocene, Alaska								
NMC 25820 Lost Chicken Creek	-	269.0	43.4	38.1	28.0	28.4	40.4	32.8
Equus (Asinus) kiang. Recent, Asia**								
AMNH 57212 Right	♂	269.1	42.0	-	28.4	-	38.9	-
Left		267.0	42.0	-	27.3	-	38.6	-
AMNH 57214 Right	♂	270.0	40.5	-	26.5	-	40.5	-
Left		269.2	41.1	-	26.2	-	40.2	-
AMNH 57209 Right	-	269.5	42.0	-	27.7	-	40.4	-
Left		-	42.0	-	27.8	-	40.7	-
AMNH 57211 Right	♀?	266.6	40.4	-	25.8	-	37.8	-
Left		265.4	40.4	-	25.9	-	37.8	-
AMNH 60347 Right	♀?	270.8	40.1	-	27.2	-	37.8	-
Left		271.2	40.5	-	27.0	-	37.7	-
AMNH 57201 Right	♂	275.7	39.2	-	26.4	-	39.0	-
Left		275.0	39.7	-	26.3	-	39.2	-
AMNH 57208 Right	♂	276.0	43.9	-	26.5	-	39.6	-
Left		276.0	44.4	-	[illegible]	-	40.2	-

* 1 - Total length.
2 - Proximal width.
3 - Proximal depth.
4 - Midshaft width.
5 - Midshaft depth.
6 - Distal width.
7 - Distal depth.

** M.F. Skinner kindly provided me with these measurements from specimens preserved in the Mammal Collection of the American Museum of Natural History, New York.

wild asses (*"Equus caballus, E. przewalski, E. grevyi, E. burchelli, E. calobatus, E. francisci, E. hemionus* (the kiang), *E. asinus"*), LUM 1.106 is most similar to specimens of *Equus (Asinus) kiang* (= *"Equus hemionus kiang"*, see Lundelius and Stevens 1970, Figure 3).

In 1974 I collected a left metatarsal (NMC 25820) from Lost Chicken Creek, Alaska of similar size and proportions to LUM 1.106. It is likewise referred to *Equus (Asinus)* cf. *kiang*, and is the first record of a kiang-like wild ass from the Pleistocene of Alaska. Other specimens may exist in the extensive Frick Collection from Alaska in the American Museum of Natural History (M.F. Skinner, personal communication 1974). NMC 25820 is very fresh in appearance, and I suggest that it is of late Wisconsin age. LUM 1.106 and NMC 25820 are best matched among a sample of living kiang metatarsals by AMNH 57212 (male), 57214 (male) and 57209 (sex unknown).

Discussion

Kiang-like asses occupied Eastern Beringia during the late Pleistocene - probably during the late Wisconsin, to be more specific. They seem to have been a much rarer element of the fauna than the Yukon wild asses, although their habits were undoubtedly similar in many ways.

In Canada, the only other specimen attributed to a stilt-legged wild ass is "*Equus ?calobatus*" from Kansan deposits at Medicine Hat, Alberta (Stalker and Churcher 1970), but it has not been described and therefore cannot be compared to the kiang-like wild ass.

In physical structure, *Equus (Asinus)* cf. *kiang* has its closest affinities among southern North American Pleistocene horses with *Equus (Asinus) francisci*. Concerning this matter, Lundelius and Stevens (1970, p. 150) state, "The metapodial elements of *E. francisci* are extremely long and slender, as indicated by the scatter diagram, and are most similar to those of Recent Asiatic asses, especially the kiang, *E. hemionus kiang*. The possibility exists, therefore, that *E. francisci* belongs to a North American kiang-like group. Another possibility, and the one favored by us, is that *E. francisci* is a southern, stilt-legged, ass-like equid which paralleled and surpassed Asiatic asses in metapodial elongation, but which had more generalized patterns of dental enamel and simple lower incisors. This position is supported by lack of close morphologic similarity between dentitions of *E. francisci* and Recent *E. hemionus kiang*." The type specimen of *E. (A.) francisci* (TAMU 2518) is from the Lissie Formation of Texas, which is considered to be of Yarmouth interglacial age. Fossils of this species are also known from the T-2 terrace of the Trinity River at Dallas, Texas, which is possibly of late Sangamon interglacial age. Because metatarsals of *E. (A.) francisci* average 15 mm longer and 7 mm narrower at the proximal end than those of *E. (A.)* cf. *kiang* from the late Pleistocene of Eastern Beringia, and because the latter specimens are well matched among living Asian kiangs, I suggest that they are more closely related to the kiangs of Asia.

Kiangs differ from Asiatic wild asses *(Equus (Asinus) hemionus)*, and probably from Yukon wild asses *(Equus [illegible]nus) lambei)*, in that they are somewhat larger (1.4 m high). Females weigh between 250 and 300 kg, while males often reach 400 kg. The species has a relatively large head, a thick muzzle and neck, a long upright mane, a short body and long limbs. The summer coat is reddish; the winter coat is browner and very long and thick (with underwool). There is a well-marked black dorsal stripe. The underparts are pure white. Kiangs presently occur in Tibet which, faunistically, is mainly a southern extension of the northern temperate zone fauna.

Kiangs live in herds that may vary in size from

5 to 10, occasionally up to 300 or 400. Adult males of 7 to 9 years tend to stay apart from the herds. Kiangs feed on grass and low vegetation, particularly the tough, sharp swamp grass, which would cut the more sensitive mouths of other horses. They put on fat in the "kiang-steppe" (very high, broad plains with xerophyllous vegetation) of Tibet during August and September. In winter, the streams freeze over, and kiangs break the ice with their hooves to get water. Later when the snow comes, they obtain moisture by eating it. They can swim well. Foals are usually dropped in late July or early August in rocky, protected places. Like Asiatic wild asses, kiangs have keenly developed senses. Apart from people, the kiang's only enemy is the wolf. Wolf packs follow the herds and separate young or sick animals, which are chased and overpowered (Groves 1974, pp. 86-96).

Perhaps this review will provide an insight into the habits of the kiang-like wild asses that occupied the Yukon and Alaska during the late Pleistocene. Kiang-like and Yukon wild asses may have been able to live sympatrically because of the greater adaptability of the former to feeding on the toughest plants, which the latter species largely neglected. Maybe "steppeization" of northern Eurasia and North America during the late

Pleistocene glaciations (Vangengeim 1967, p. 284; Hopkins 1967, p. 472) allowed both Asiatic wild asses and kiangs to reach North America via the Bering Isthmus.

Every effort should be made to solve this problem concerning the affinities and dispersal histories of the wild asses which occupied Eastern Beringia during the ice age.

Order Artiodactyla

Family Camelidae

Tribe Camelini (genus and species indeterminate)
(large camel)

The first occurrence of a Pleistocene camel specimen north of the Arctic Circle in North America was reported by J.W. Gidley (1913, p. 1). While collecting Recent mammals for the Smithsonian Institution during the summer of 1912, Copeley Amory, Jr. obtained a small lot of Pleistocene mammal bones from a locality about 50 miles (80 km) upstream from the mouth of the Old Crow River. A single phalanx (NMC 8623 - a plaster cast of the original USNM specimen) of a camel was among the other bones, and was described by Gidley (1913, p. 2) as follows: "While this phalanx, a left of the proximal pair, is characteristically tylopoid and absolutely unmistakeable as regards its group reference, it is not specifically determinable. It agrees approximately in size and proportions with the corresponding element in *Camelop~~s~~ kansasus* {*kansanus?*} Leidy, as that species is at present understood, but is flatter, and in this respect more nearly resembles the phalanges seen in the living genus *Camelus*." Thus, Gidley provided no generic or specific designation for the specimen, while noting similarities to phalanges of the Camelopini and Camelini.

Since Gidley's description, approximately 30 camel fossils, many of which are fragmentary, have been collected from Pleistocene deposits in the Old Crow Basin. Among these, a few teeth (particularly upper molars), several astragali, a calcaneum, and a few phalanges are sufficiently well preserved to be described (Figures 64A-D, 65A-B, D-E, Tables 70-73). These fossils are closest in shape and size to a very large member of the Camelini and are referred to a genus and species within that tribe. Of the two possible genera (*Camelus* and *Paracamelus* - unless a new genus is represented) to which the fossils may belong, a large species of *Paracamelus* seems the better choice according to comparative material and published data that I have examined. Pending

Figure 64. A. Anterior view of a right calcaneum (NMC 13589, Old Crow Locality 11A) of a large Pleistocene camel (Camelini).

B. Medial view of NMC 13589.

C. Posterior view of a right astragalus (NMC 13590, Old Crow Locality 11A) of a large Pleistocene camel (Camelini).

D. Anterior view of NMC 13590.

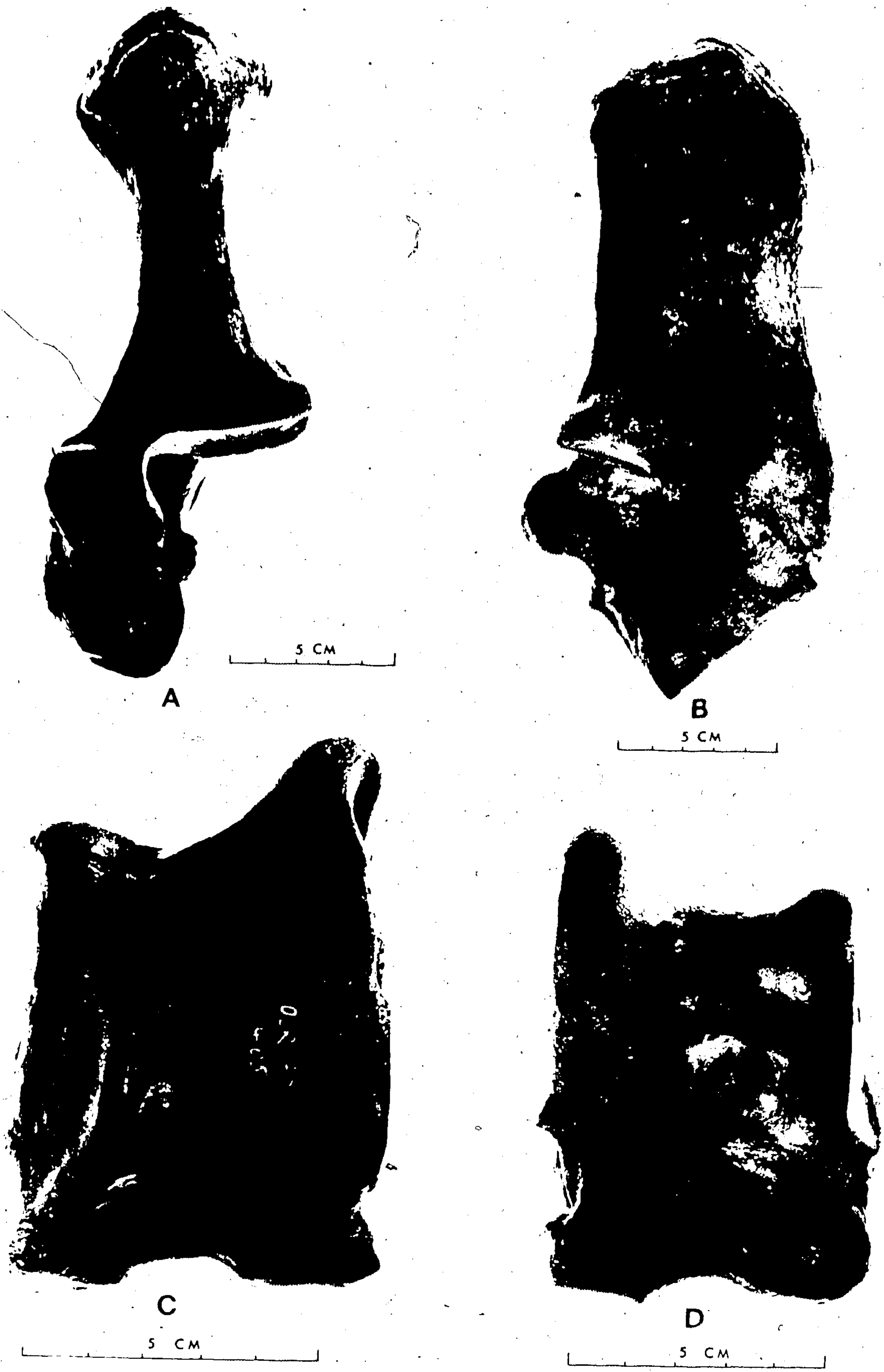

5 CM
A
B
5 CM
C
5 CM
D
5 CM

Figure 65. A. Occlusal view of right upper molar (RM^2) (NMC 27486, Old Crow Locality 127) of a Pleistocene camel (Camelini).

B. Occlusal view of left upper molar (LM^2) (NMC 20407, Old Crow Locality 22) of a Pleistocene camel (Camelini).

C. Occlusal view of RM_3 (NMC 23285, Old Crow Locality 85) of a Pleistocene camel (tentatively referred to *Camelops* sp.).

D. Anterior view of a second phalanx (NMC 14400, Old Crow Locality 21) of a Pleistocene camel (Camelini).

E. Anterior view of a first phalanx (NMC 14775, Old Crow Locality 29) of a Pleistocene camel (Camelini).


A
B
C
5 CM
D
E

TABLE 70. Measurements of Pleistocene camel (Camelini) teeth from the Yukon Territory compared to those of *Paracamelus* from the Pliocene of China, Recent *Camelus*, and the Pleistocene western camel (*Camelops hesternus*) from California.

Specimens	Measurements (mm)* 1	2	3	4	5	6
Camelini.Pleistocene, Y.T.						
NMC 24213 Old Crow Loc. 66	35.8	27.8+	–	–	–	–
NMC 20407 Old Crow Loc. 22	–	–	50.4	37.7	–	–
NMC 27486 Old Crow Loc. 127	–	–	46.1	37.8	–	–
NMC 23268 Old Crow Loc. 11A	–	–	–	–	40.3	24.9
Paracamelus gigas.Upper Pliocene, China (Zdansky 1926, p. 11)						
Catalog number unknown	30.0	29.6	?46.0	42.4	34.7	?28.5
Catalog number unknown	–	–	50.0	41.0	–	–
Camelus bactrianus.Recent						
NMC 32202 Zoo specimen	24.5	27.0	48.9	32.2	38.5	23.1
Camelops hesternus.Pleistocene, Calif. (Webb 1965, Tables 5-6)						
UCMP 20028	19.7	23.8	39.2	30.8	28.2	19.9
UCMP 20040	28.0	22.5	51.9	32.8	38.7	21.5
LACM Z252	27.0	22.6	44.1	26.4	–	–
LACM Z256	30.4	20.3	54.5	28.2	–	–
LACM Z257	–	–	–	–	43.7	22.3
LACM Z263	–	–	–	–	34.9	21.0
LACM Z265	–	–	–	–	29.3	19.2

* 1 - P^4 length. 2 - P^4 width. 3 - M^2 length. 4 - M^2 width. 5 - M_1 length. 6 - M_1 width.

Table 71. Measurements of Pleistocene camel (Camelini and *Camelops hesternus*) astragali from the Yukon Territory compared to those of other Pliocene to Recent camels.

Specimens	Measurements (mm)*			
	1	2	3	4
Camelini.Pleistocene, Y.T.				
NMC 13590 Old Crow Loc. 11A	99.5	88.1	77.3	67.5
NMC 14100 Old Crow Loc. 11	103.6	95.1	79.9	67.0
NMC 19082 Old Crow Loc. 66	103.8	95.2	82.2	66.5
NMC 22951 Old Crow Loc. 66	99.2+	94.4	78.7	–
NMC 23568 Old Crow Loc. 11A	90.8+	93.0+	82.4	63.8+
NMC 20208 Old Crow Loc. 44	92.0+	–	–	–
Paracamelus gigas.Upper Pliocene, (Zdansky 1926, p. 33) China				
Catalog number unknown	98.0	88.5	75.5	62.0
Titanotylopus spatulus.Early Pleistocene (late Blancan) (Breyer 1974, Table 3) Nebraska Lisco C				
M	90.0	72.0	–	–
N	36	36	–	–
SE	0.88	0.70	–	–
Camelops hesternus.Pleistocene, Y.T.				
NMC 29194 Sixtymile Loc. 3	77.1	71.5	58.2	55.3
Camelops hesternus.Pleistocene (Webb 1965, Table 12) Calif.				
M	86.2 ± 0.50	80.2 ± 0.74	67.3 ± 0.73	57.9 ± 0.59
OR	80.5 – 91.9	75.2 – 85.3	62.4 – 72.5	55.3 – 64.6
N	18	18	18	18
SD	2.11	3.15	3.07	2.48
CV	2.35 ± 0.39	3.93 ± 0.66	4.56 ± 0.76	4.30 ± 0.72
Camelus bactrianus.Recent				
NMC 32202 Zoo specimen	74.9	68.8	56.0	50.2

* 1 - Length (lateral side). 2 - Length (medial side). 3 - Minimum length. 4 - Distal width.

Table 72. Measurements of a Pleistocene camel (Camelini) calcaneum from the Yukon Territory compared to calcanea of other Pliocene to to Recent camels.

Specimens	Measurements (mm)*			
	1	2	3	4
Camelini.Pleistocene, Y.T.				
NMC 13589 Old Crow Loc. 11A	207.1	102.6	60.8	70.0
Paracamelus gigas.Upper Pliocene, China (Zdansky 1926, p. 33)				
Catalog number unknown	181.0	90.0	52.5	57.0
Titanotylopus spatulus.Early Pleistocene, (late Blancan) Nebraska (Breyer 1974, Table 2) Lisco C				
M	188.0	79.0	-	-
N.	28	28	-	-
SE	1.77	0.76	-	-
Camelus bactrianus.Recent				
NMC 32202 Zoo specimen	139.9	71.4	41.2	44.2
Camelops hesternus.Pleistocene, Calif. (Webb 1965, Table 12)				
M	161.9 ± 1.14	70.7 ± 1.39	48.1 ± 0.92	59.8 ± 0.79
OR	157.0 - 170.0	65.0 - 76.7	40.5 - 53.2	56.4 - 65.3
N	13	13	13	13
SD	4.13	5.03	3.30	2.87
CV	2.56 ± 0.50	7.10 ± 1.39	6.85 ± 1.34	4.80 ± 0.94

* 1 - Maximum length.

2 - Maximum anteroposterior diameter.

3 - Transverse diameter of tuber calcis.

4 - Anteroposterior diameter of tuber calcis.

Table 73. Measurements of Pleistocene camel (Camelini) first and second phalanges from the Yukon Territory compared to those of other Pliocene to Recent camels.

Specimens		Measurements (mm)* 1	2	3	4	5	6	7
irst Phalanges								
amelini, Pleistocene, Y.T.								
MC 27266 Old Crow Loc. 29		134.3	56.1	46.9	34.9	29.1	50.9	40.0
MC 26957 Old Crow Loc. 23S		124.5	56.7	45.4	33.7	27.1	49.1	36.3
MC 14775 Old Crow Loc. 29		121.0a	62.0a	–	33.0a	–	50.0a	–
MC 8623 Old Crow - exact locality unknown (plaster cast of USNM specimen)		115.2	52.5	40.7	34.1	25.[illegible]	44.8a	34.4a
racamelus gigas. Upper Pliocene, China Zdansky 1926, pp. 20, 33-34)								
orelimb - Catalog number unknown		130.0	46.0	45.0	–	–	–	39.0
indlimb - Catalog number unknown		121.0	48.0	38.5	–	–	39.3	32.0
tanotylopus spatulus. Early Pleistocene ate Blancan) reyer 1974, Table 1) Nebraska sco C								
		119.0	57.0	–	–	–	–	–
		80	80	–	–	–	–	–
		1.43	0.72	–	–	–	–	–
melus bactrianus. Recent C 32202 Zoo specimen								
relimb		100.3	41.6	34.0	20.8	20.6	38.9	29.8
ndlimb		91.3	37.8	29.7	18.6	17.7	34.3	26.5
melops hesternus. istocene, Calif. bb 1965, Tables 10, 12)**								
elimb	M	122.3 ± 1.62	47.3 ± 0.97	38.9 ± 1.20	–	–	39.[illegible] ± 0.[illegible]	33.9 ± 0.71
	OR	117.0 – 127.0	44.0 – 52.0	36.0 – 45.0	–	–	[illegible] – 42.0	32.0 – 37.0
	N	7	7	7	–	–	7	7
	SD	4.30	2.56	3.18	–	–	1.87	1.87
	CV	3.51 ± 0.94	6.88 ± 1.62	6.45 ± 1.52	–	–	6.95 ± 1.[illegible]	4.66 ± 1.10
dlimb	M	108.4 ± 1.19	45.2 ± 1.04	38.7 ± 0.83	–	–	[illegible].6 ± 0.85	31.1 ± 0.48
	OR	[illegible] – [illegible].0	42.0 – 51.0	36.0 – 43.0	–	–	34.0 – 42.0	29.0 – 34.0
	N	9	9	9	–	–	9	9
	SD	[illegible]56	3.11	2.50	–	–	2.54	1.45
	CV	3.28 ± 0.78	6.88 ± 1.62	6.45 ± 1.52	–	–	6.95 ± 1.64	4.66 ± 1.10
nd Phalanges***								
lini, Pleistocene, Y.T.								
14400 Old Crow, Loc. 21		82.7	50.2	38.9	38.3	27.8	46.4+	30.6e
camelus gigas. Upper Pliocene, a (Zdansky 1926, pp. 20, 33)								
limb - Catalog number unknown		?74.0	?37.0	27.0	–	–	?41.0	–
limb - Catalog number unknown		69.0	31.0	21.0	–	–	38.5	–
lus bactrianus. Recent 32202 Zoo specimen								
imb		65.6	31.6	27.4	25.8	17.0	37.2	18.5
imb		61.8	31.1	26.3	24.9	18.0	36.2	19.5

Total length.

Proximal width.

Proximal depth.

Midshaft width.

5 - Midshaft depth.

6 - Distal width.

7 - Distal depth.

esumably the forelimb measurements were accidentally switched with those of the hindlimb in *Camelops hesternus*, Webb (1965, p. 32) states, "The phalanges of the hind foot are slightly smaller than in the fore foot." tabular data are corrected here.

asurements of second phalanges are not given for *Titanotylopus spatulus* by Breyer (1974) or for *Camelops hesternus* Webb (1965).

comparison of the Yukon fossils with actual specimens of *Paracamelus*, I prefer to leave their generic and specific designation in abeyance. *Paracamelus* has not been reported previously from North America.

Referred specimens

Three incisors have been collected. NMC 19068 from Old Crow Locality 66 is a slightly worn RI_1 lacking most of the root. A 15 mm-long facet with vertical striae occurs on its anteromedial surface, suggesting that I_1s rubbed up and down against each other - probably when food was being nipped or torn up by the camel. NMC 19068 is approximately 22 mm wide and 56 mm long. The enamel is stained black. NMC 15428 from Old Crow Locality 14N is a complete, slightly worn LI_3. It is approximately 18 mm wide and is 75 mm long. The enamel is black and the root is reddish brown. NMC 28386 from Old Crow Locality 134 is a complete, heavily worn RI_3. It is about 19 mm wide and 77 mm long. The enamel is of dark ivory color; the root is stained dark brown.

Among the cheek teeth, only the following relatively complete specimens are described. NMC 24213 from Old Crow Locality 66 is an RP^4 lacking portions of the anterolingual and posterolabial surface enamel. It is doubtfully referred to the Camelidae. It appears to be slightly larger than a P^4 of *Paracamelus gigas* and is much larger, especially in length, than P^4s of a Recent Bactrian camel (*Camelus bactrianus*, NMC 32202) and Pleistocene western camels (*Camelops hesternus*). An interesting feature of this tooth is the broad plication that enters the lingual part of the fossette - a feature that [illegible] (1965, p. 43) has noted in all specimens of *Megatylopus matthewi* which were available to him. I do not know if this character has been reported in *Paracamelus*. It requires further comparison with large cervid P^4s, as it also bears resemblance to this tooth in *Alces latifrons* (Kahlke 1956, Vol. II, Figure 22). The tooth is stained black.

NMC 20407 from Old Crow Locality 22 is an LM^2. Its size and the heavy wear on the occlusal surface indicate that it represents an adult. NMC 27486 from Old Crow Locality 127 is an RM^2. Like NMC 20407 it is well worn, lacks most of the roots, has grayish enamel and brown-stained dentine, and is similar in size to M^2s of *Paracamelus gigas*. These molars are markedly broader than M^2s of the Bactrian camel and *Camelops hesternus*.

NMC 23268 from Old Crow Locality 11A is an RM_1. It is well worn, has grayish black enamel and is larger than most other camel M_1s to which it was compared (Table 70).

Six astragali, obviously derived from very large camels, are in the collection. The best preserved is NMC 13590 from Old Crow Locality 11A. It is a right astragalus that articulates well with a right calcaneum NMC 13589 found at the same locality in the same year. NMC 13590 is very close in size to an astragalus of *Paracamelus gigas*, and to the type astragalus of *Megatylopus major* from Alachua Clays of Tertiary age from Florida that measures 99.5 mm long x 66.0 mm in distal width. Further, the lateral articular facets of NMC 13590 match almost exactly those illustrated by Zdansky (1926, Figure 15), except that no groove is seen between the parasustentacular and sustentacular facets. Evidently a narrow one is present in *Paracamelus gigas* which extends farther back than in NMC 13590, but which does not completely separate the two facets. This groove is also present in *Camelus* and is very broad and deep in *Titanotylopus spatulus* from the Lisco localities in Nebraska (J. Breyer, personal communication 1975). In medial view the Yukon specimen closely resembles astragali of *Titanotylopus spatulus* (Breyer 1974, Figure 4A). From a dorsal view, the sustentacular surface of NMC 13590 is like that of *Paracamelus*: both are much broader than that of *Camelus*.

Other right astragali include: NMC 14100 from Old Crow Locality 11, which is pitted on the sustentacular surface and has tough, sandy matrix adhering to depressions on the lateral surface; and NMC 23568 from Old Crow Locality 11A, which has been severely damaged by a carnivore gnawing on the anterior and posterior ends.

Left astragali include: NMC 19082 from Old Crow Locality 66 - the largest of the fossil astragali preserved, and larger than any of *Paracamelus gigas* or *Titanotylopus. spatulus* mentioned by Zdansky (1926, p. 33) or Breyer (1974, Table 3), respectively; NMC 22951 from Old Crow Locality 66, which is badly eroded; and NMC 20208, excavated from the top of the organic subunit of Unit 1 at Old Crow Locality 44, which may be of late Illinoian or early Sangamon age. Generally, these astragali have dimensions larger than the means of any *Paracamelus*, *Titanotylopus*, *Camelus* or *Camelops* astragali to which they were compared (Table 71).

The single right calcaneum, NMC 13589 from Old Crow Locality 11A, is in good condition except for slight damage to the posterior part of the sustentaculum. The specimen is close in size and shape to calcanea of *Titanotylopus*, except that the convexity beneath the sustentaculum is slightly less than in the fossils from Lisco, Nebraska (J. Breyer, personal communication 1975). I can see no difference between NMC 13589 and clear photographs of five views of a left calcaneum of *Paracamelus gigas* (M 1548) from Zdansky's collection from the Pliocene of China. I am grateful to N.J. Mateer of the Paleontological Institute of Uppsala University for supplying the prints. A calcaneum (possibly M 1548) of *P. gigas* measured by Zdansky averages approximately 15% smaller than NMC 13589, and the mean of a series of *Titanotylopus* calcanea from the early Pleistocene of Nebraska averages nearly 16% smaller.

Casts of the astragalus NMC 13590 and the calcaneum NMC 13589 were sent to S.D. Webb and J. Breyer for identification. I am most grateful for their comments. Webb (personal communication 1975) agreed with me that the fossils did not belong to *Camelops*, but a larger camelid, stating, "They may well belong to *Paracamelus* or *Camelus* extensively recorded across Northern Asia (especially Siberia) and into Eastern Europe." Breyer (personal communication 1975) concludes: "I would not hesitate to say that the specimens are from a member of the Camelini. As to the generic assignment I am not certain. The calcaneum and the general size suggest *Titanotylopus*. The astragalus is another matter. Both the calcaneum and the astragalus have the form of the same elements in *Camelus*, but the size difference is considerable. I have never examined postcranial elements of *Paracamelus*, certainly it cannot be ruled out." Therefore, on the basis of these two fossils Webb and Breyer agree that a member of the Camelini is represented.

Three distal metapodial fragments are preserved. NMC 20856 from Old Crow Locality 74 includes the "fork" between ?metatarsals III and IV, and the medial half of the distal end of one of these ?metatarsals, including part of the articular surface. The anteroposterior diameter of the articulation is 49.1 mm, while the length from the top of the "fork" to the extremity of the distal articular surface is 79 mm - over twice the "fork" length of the metapodials in Recent *Camelus bactrianus* (approximately 36 mm). NMC 27501 from Old Crow Locality 66 and NMC 20278 from Old Crow Locality 75 are distal articular ends of metapodials. The latter is too heavily damaged to obtain reliable measurements. The former has a distal width of 52.1 mm and a distal depth of 70.0 mm. This compares to distal widths and depths of 46.0 mm and 48.5 mm (metatarsal IV) and 54.0 mm and 55.0 mm (metacarpal III) in *Paracamelus gigas* (Zdansky 1926, pp. 20, 33).

A few first phalanges are referred to a large member of the Camelini. It should be noted that there seems to be no way of distinguishing phalanges of the hindfoot from those of the forefoot except that the latter tend to be slightly larger. The relatively large size of NMC 27266 from Old Crow Locality 29 suggests that it is from a forefoot. Its surface is pitted in places, as if it had been attacked by acid in the groundwater. NMC 26934 from Old Crow Locality 23S, a distal fragment of a first phalanx, is slightly larger than the same part of NMC 27266, and is probably from the forefoot, too. NMC 26957 from Old Crow Locality 23S and NMC 14775 from Old Crow Locality 29 are of similar size. Both are stained dark brown. NMC 8623 from a locality some 50 miles (80 km) up the Old Crow River is smaller than the other specimens, and the measurements provided for *Paracamelus gigas*. Nevertheless, I consider it, NMC 26957 and 14775 as probably representing first phalanges of the hindfoot, for they average 10% smaller than NMC 27260 - approximately the relationship of forelimb to hindlimb first phalanges in *Paracamelus gigas*, *Camelops hesternus* and *Camelus bactrianus* (Table 73).

The first phalanges of the large Yukon camel are similar in length and depth to one of *Paracamelus gigas*, but they are broader. As in *Titanotylopus spatulus* (Breyer 1974, p. 76, Figure 2) the posterior surfaces of all Yukon first phalanges can be divided into three nearly equal segments: (a) the proximal, covered by rugosities of the suspensory ligaments and indented centrally from below by a smooth wedge, the edges of which are termed "arms"; (b) a smooth central portion; and (c) the distal trochlear portion. It is worth noting that the emarginations below the proximal portion display "arms" of subequal length like *Titanotylopus* - except for NMC 26957, which has "arms" of unequal length like those of *Hemiauchenia (= Tanupoloma)* (Breyer 1974, p. 75, Figure 2c). I suspect, therefore, that this feature is to some extent variable in the large Yukon camel. *Camelops* can be readily separated from the large Yukon camel, *Titanotylopus* and *Hemiauchenia* on characters of the posterior surface of the first phalanx, for in *Camelops* the rugose area for the attachment of the suspensory ligaments extends half way down the shaft; nor is the distal border of the roughened proximal portion indented by a smooth wedge.

NMC 14400 from Old Crow Locality 21 articulates well with the large first phalanx (NMC 27266), and probably represents a second phalanx of the forefoot.

According to measurements given by Zdansky (1926, p. 20), a second phalanx of the forefoot of *Paracamelus gigas* is between 10% and 30% smaller than the Yukon specimen.

Discussion

All of the large Yukon camel bones are stained brown to blackish brown, and are probably of pre- late Wisconsin age. The astragalus (NMC 20208) excavated from the top of Unit 1 at Old Crow Locality 44 indicates that this species may have lived in the Yukon until late Illinoian or early Sangamon time, if the specimen had not been reworked from older sediments. Remains of large camels other than those attributed to *Camelops* have not been recorded previously from Eastern Beringia.

Fossils of various camels, mainly referred to *Camelops* or *Hemiauchenia*, have been reported from deposits of Kansan to Wisconsin age at Medicine Hat, Alberta (Stalker and Churcher 1970; Harington 1976, pp. 31-41), but no large members of the Camelini resembling *Paracamelus* have been recorded there. However, Reimchen (1968, pp. 14-15, Table 2) has described a distal articular fragment of a metapodial (UA* 1622) having a distal width of 61.0 mm and a distal depth of 51.0 mm (slightly larger than NMC 20278), which he refers to *Titanotylopus* sp. The specimen was derived from Saskatchewan gravels in northwest Edmonton, Alberta, which Reimchen (1968, p. 41) suggests are of Yarmouth or earlier age.

The camels (Subfamily Camelinae) originated from a *Protolabis*-like ancestor during the Miocene. That stock gave rise to three tribes which have probably evolved separately since Barstovian time: the Lamini (*Pliauchenia, Hemiauchenia, Paleolama, Lama*); the Camelopini (*Megatylopus, Camelops*); and the Camelini (*Procamelus, Titanotylopus, Paracamelus, Camelus*).

The Camelini had its origins in North America with *Procamelus* of the late Miocene to middle Pliocene. Evidently *Titanotylopus* stemmed from *Procamelus* in the middle Pliocene and survived until the mid-Pleistocene. It was confined to North America - particularly the western parts. *Procamelus* was also ancestral to the Eurasian camels (*Camelus* and *Paracamelus*).

Camelus occupied western Siberia, the Black Sea area, and the lower Volga (*Camelus bactrianus knoblochi*) during the middle Pleistocene, and Armenia (*Camelus dromedarius dahli*) during the late Pleistocene. It is also known from the Pleistocene of Europe, and North Africa. Bactrian camels occur naturally in small numbers in the Gobi Desert, while dromedaries are used domestically from North Africa to India (Burton 1965, p. 194). Apparently *Camelus* arose from *Paracamelus* in the upper Pliocene (*contra* Webb 1965, Figure 22) (Gromova 1968, p. 496).

Paracamelus to which genus the large Yukon camel may belong, or to which it may be closely allied, is known from the upper part of the middle Pliocene to the early Pleistocene of Asia. Specifically, *P. gigas* and *P. praebactrianus* are recorded from the middle or upper Pliocene of the northern Caucasus, northern Kazakhstan, western Siberia and the Irtysh region; *P. alexejevi* is recorded from the middle Pliocene of Odessa and southern Moldavia; *Paracamelus* is also recorded from the Middle Pliocene to lower Pleistocene of northern China, Mongolia, the Soviet Union, Rumania and Hungary. A dwarf subgeneric group *(Neoparacamelus)* occurs in Pliocene to lower Pleistocene deposits near the Black Sea (Khaveson 1954; Gromova 1968, p. 499). Presumably the ancestors of *Paracamelus* crossed the Bering Isthmus from North America to Asia in the early to middle Pliocene. Perhaps the large Yukon camel fossils are the remains of this Beringian "missing link", or more likely a later Pleistocene form derived from it that was able to survive until late

Illinoian or early Sangamon time in this rather isolated northern pocket.

Paracamelus was approximately 16% larger than the living Bactrian camel and it had a long, narrow skull. Zdansky (1926, p. 35) states that, apart from its significantly larger size and massiveness, it is difficult to distinguish *Paracamelus gigas* from the living camels. A complete skeletal mount of the smaller *P. alexejevi* in the Museum of the Geological Institute of the Ukranian Academy of Science, Kiev provides a good idea of the conformation of this animal (Khaveson 1954, Plate X).

Presumably *Paracamelus* occupied arid steppe grasslands in interior continental regions. Modern camels are able to grow extremely thick pelts under cold environmental conditions. I have seen Bactrian camels at ease, wandering over snow-covered terrain in mid-winter at the Alberta Game Farm near Edmonton, and Sanderson (1955, p. 248) states that Bactrian camels may be encountered "plodding stolidly through north-Asiatic winter blizzards...". Undoubtedly *Paracamelus* and the large Yukon camel were well adapted to surviving under cold conditions. Perhaps *Paracamelus*, like living camels, commonly fed on dry scrub, and providing it had sufficient water at intervals, could travel great distances.

Little is known about the natural predators of camels. Marks on the astragalus NMC 23568 indicate that it was gnawed by a medium to large-sized carnivore. The gnaw marks appear to have been made when the bone was fresh. The animal responsible for the marks could have killed the camel, or may have been a scavenger that attacked the carcass after the camel died.

Camelops hesternus (western camel)

Remains of the western camel (Figures 65C, 66A-B, Table 71) are very rare in Pleistocene deposits of the Yukon Territory.

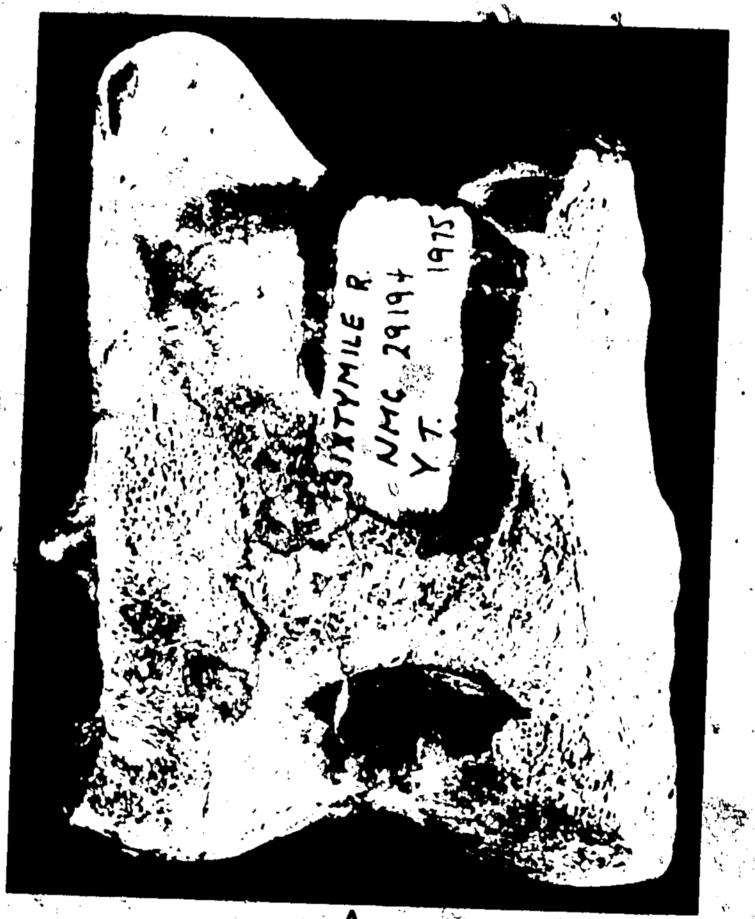
Referred specimen

Only one specimen can be definitely referred to this species. It is a left astragalus (NMC 29194) from Sixtymile Locality 3 showing signs of erosion on the medial and lateral margins of the sustentacular facet. On the average, it is 21% smaller than an astragalus (NMC 13590) of a large Yukon camel referred to the Camelini. In most measurements NMC 29194 is between 3 and 5 mm smaller than the smallest specimens in a sample of 18 astragali of *Camelops hesternus* from late Pleistocene deposits at Rancho La Brea, California, but this is 4 mm greater in lateral length than the mean

Figure 66. Left astragalus (NMC 29194, Sixtymile Locality 3) of a Pleistocene western camel (*Camelops hesternus*).

A. Posterior view.

B. Anterior view.



A

B

of a sample of 62 *Camelops* astragali from three faunas of Irvingtonian land mammal age (Gordon, Hay Springs and Rushville) (Breyer 1974, Table 3). It is slightly larger than an astragalus of Recent *Camelus bactrianus* (NMC 32202), but appears to match closely good line drawings and photographs of *Camelops hesternus* astragali (Webb 1965, Figure 15; Breyer 1974, Figure 6C-D).

The valley of the proximal trochlea of NMC 29194 forms a more acute angle than in astragali of the large Yukon camels, and the medial trochlear crest seems to be more pronounced than in a figured specimen of *Camelops hesternus* (Webb 1965, Figure 15). A posterior projection between the fibular salient and the distal astragalar facet is better developed than in the large Yukon camel astragali. This projection shows clearly in a photograph of *Camelops* provided by Breyer (1974, Figure 6D).

The angle of obliquity of the tibial ligament surface relative to the plane of the medial articular facets appears to be important in differentiating astragali belonging to different camelid taxa. The angle is more acute in the Yukon western camel NMC 29194 (27°) than in either the large Yukon camel (average 42.5°)

or Recent *Camelus bactrianus* (50°). It is interesting to note that in *Hemiauchenia*, the tibial ligament surface is parallel to that of the medial articular facets (Breyer 1974, p. 80). It may be worth pursuing a study of all camelids in this respect, in an attempt to discern whether or not large samples of astragali representing different groups could be separated. Functional reasons for differences observed could also be examined.

NMC 29194 is light brown, and is fresher in appearance than any of the camel fossils from the Old Crow Basin. This specimen from the Sixtymile fauna is probably of late Wisconsin age, according to the affinities of that fauna with faunas from Gold Run Creek near Dawson and Lost Chicken Creek, Alaska (Harington 1976 MS. p. 63).

NMC 23285 from Old Crow Locality 84 is an RM_3 lacking roots and the posteriormost cusp. It is of similar size and shape to *Camelops hesternus* M_3s described by Webb (1965). The degree of wear on its occlusal surface suggests that it represents an animal in early maturity. Because the tooth is fragmentary, slightly worn, and because I have not been able to compare it directly with M_3s of *Camelops hesternus*, it is doubtfully referred to the western camel and the Camelidae.

Discussion

Evidently very few western camels occupied the unglaciated part of the Yukon Territory during the late Wisconsin: perhaps they were there for a relatively short time. The species reached the Yukon from southern North America.

In Alaska, fossils referred to *Camelops* have been reported by Frick (1930, p. 79), Geist (1953, p. 172; 1956, p. 201) and Guthrie (1968b, p. 353; 1972, p. 296, chart) from the Fairbanks area. Repenning identified *Camelops* remains with an assemblage including small horse, bison, mammoth, mountain sheep, wolf, hare and ?caribou from Canyon Creek near Big Delta (Webber 1975, p. 67). These specimens have not yet been formally described. The only radiocarbon date on *Camelops* sp. from Eastern Beringia is from the ?Fairbanks area. Analysis of collagen from a metapodial yielded a date of 24,900 $^{+1,100}_{-1,000}$ years B.P. (I-2117) (J.V. Matthews, Jr., personal communication 1975), indicating that the species was living in central Alaska near the peak of the Wisconsin glaciation.

In Canada, apart from the Yukon Territory, finds of *Camelops* are, so far, restricted to Alberta and Saskatchewan. The earliest report is of *Camelops* sp.

from early Pleistocene (Aftonian) deposits at Wellsch Valley, Saskatchewan. *Camelops minidokae* is recorded from the lowest Pleistocene (Kansan) mammal-bearing stratum represented near Medicine Hat, Alberta. In addition, this genus is recorded from a series of progressively younger deposits there (e.g. *Camelops* sp. of Yarmouth interglacial age; *Camelops hesternus* - Sangamon interglacial; *Camelops* cf. *hesternus* - early Wisconsin, early mid-Wisconsin, late mid-Wisconsin; *Camelops* sp. - late Wisconsin). A proximal phalanx probably referable to *Camelops* was collected in eastern Edmonton, Alberta, and *Camelops* cf. *hesternus* of late Wisconsin age has been reported from Empress, Alberta. In Saskatchewan, *Camelops* cf. *hesternus* and *Camelops* sp. are known from deposits of Sangamon interglacial or Wisconsin interstadial age at Fort Qu'Appelle and Saskatoon, respectively (Harington 1976 MS. pp. 24-40).

Camelops remains are common in the United States. Although Webb (1965, p. 44) lists the earliest occurrence of the genus as late Pliocene, I can uncover no records earlier than those from Cita Canyon, Texas and Sand Draw (Keim Formation), Nebraska, which are considered to be of early Pleistocene (late Blancan) age (Hibbard 1970, Table 3; Ski *et al.* 1972, p. 114, Figure 60). The genus is represented in the Borchers fauna (Aftonian interglacial) of Kansas (Hibbard 1970, Table 5; Skinner *et al.* 1972, Figure 60). *Camelops* is relatively common in Kansan age faunas of the Great Plains and Central Lowland provinces, such as: Gilliland and Rock Creek, Texas; Holloman, Oklahoma; and the Cudahy fauna of Kansas and Texas. During early and late Illinoian time, this camel occurred in Kansas, and in the following Sangamon interglacial phase it was present at Slaton, Texas and Cragin Quarry, Kansas (Hibbard 1970, Tables 6-7). Among many other Wisconsin age faunas, *Camelops* is recorded from vari[illegible]ties in New Mexico, Texas and Kansas.

In summary, *Camelops* first appeared in southern North America during the early Pleistocene (late Blancan). It evidently stemmed from *Megatylopus*, which occupied approximately the same region throughout the Pliocene (Webb 1965, p. 44). Apparently *Camelops* first penetrated the southwestern plains of Canada (Wellsch Valley) during the Aftonian interglacial and was relatively common there and in the western United States until late Wisconsin time. Perhaps during the Sangamon interglacial it was able to spread northward to Eastern Beringia, where it lived at least until the peak of the Wisconsin glaciation. Establishing the age of the fossils in stream channel fill at Canyon Creek, Alaska may be of critical importance to discovering when *Camelops* first entered Eastern Beringia. In southern North America, *Camelops hesternus* became extinct toward the close of the last glaciation. Webb (1974b, p. 207), in commenting on the absence of *Camelops* in Florida during the Pleistocene, remarks: "It now seems unlikely that *Camelops* even ranged into eastern North America." I speculate that the reason for the inability of this genus to flourish there was because the area was wetter than the plains and largely dominated by forest. Presumably for the same reason, fossils of the American lion *(Panthera leo atrox)* have never been recorded from northeastern North America. It seems to have been a carnivore adapted to open grassland or parkland.

Camelops hesternus was confined to North America. In life, it probably looked very much like a large (7 feet (2.1 m) to the top of the back) dromedary *(Camelus dromedarius)*. A good restoration is provided by Webb (1965, Frontispiece) and a photograph of a mounted skeleton in the Los Angeles County Museum is given by Stock (1965, Figure 21). Its limbs were 20% longer, its leg joints knobbier, and its head was longer and narrower than those of the dromedary. Although the base of the neck was very low, the head was normally carried high. The tall neural spines and lack of lumbar spines suggest that the western camel had a single mid-dorsal hump situated somewhat farther forward than in the dromedary. In *Camelops hesternus* the toes were not as fully encased in a pad or as broadly flattened as in the Bactrian camel or the dromedary. Mummified remains of this species have been found in a cave near Fillmore, Utah, with dried muscle still attached to the skull (Romer 1928, p. 19).

During the Pleistocene, large herds of *Camelops* roamed the western parts of North America. Such finds as dozens of well preserved specimens of Wisconsin age excavated from the tar pits at Rancho La Brea, California, tend to support this statement. Although primarily adapted as a grazer, the long neck and limbs of *Camelops hesternus* were probably advantageous for occasional browsing (Webb 1965, p. 33). It appears to be a good paleoenvironmental indicator of arid scrublands and grasslands, and the Yukon and Alaskan occurrences suggest that it could tolerate cool, at times snow-covered, steppe grasslands.

Association of western camels with Paleo-Indians is claimed at the following archeological sites: Sandia Cave, Burnet Cave, and Clovis, New Mexico; Paisley Cave, Oregon; the Lindenmeier site, Colorado; Tule Springs, Nevada; and Double Adobe, Arizona (Martin and Guilday 1967, p. 46). Bones of this species have also turned up in the main occupation level at Jaguar Cave, Idaho, which has been radiocarbon dated at 10,370 ± 350 years B.P. (Kurtén and Anderson 1972, Table 16). However, no archeological kill sites are known. Perhaps American lions were able to prey on these fleet-footed camels.

Family Cervidae

Cervus elaphus (wapiti)

Several wapiti specimens (Figures 67A-B, 68A[illegible], Tables 74-76) have been collected from Yukon Pleistocene deposits. Most fossils are from the Dawson Area, and all seem to be of late Wisconsin age.

<u>Referred specimens</u>

One of the best specimens is a shed left antler (DCMP-3) from Sulphur Creek near Dawson. It lacks the tips of the third (supernumerary), fifth and seventh tines. Its surface detail is well preserved. The fossil is large compared to antlers of living wapiti, for if it were measured by Boone and Crockett Club standards - providing it had a uniform mate - it would be a new world's record. The specimen has been illustrated, but not described in detail, by Guthrie (1966, p. 50, Figure 2). A feature of this specimen that characterizes some Alaskan Pleistocene wapiti

Figure 67. Posterior cranial fragment with antler pedicels (NMC 6750, Dawson Locality 5) of a wapiti *(Cervus elaphus)*.

A. Dorsal view.

B. Left lateral view. Anterior is to the left.

A

B

Figure 68. A. Anterior views of a right humerus (NMC 17048, Old Crow Locality 1) of a postglacial wapiti *(Cervus elaphus)* (left) and a right humerus (NMC 36163, Alberta) of a Recent wapiti *(Cervus elaphus)* (right).

B. Lateral view of NMC 17048. Note large facets on the lateral epicondyle (bottom centre) and the posterior lateral tuberosity (top centre).

C. Posterior views of NMC 17048 (right) and [illegible]3. Note facet on bottom right of [illegible], which yielded a radiocarbon date of 4,570 ± 100 years B.P. (I-7796).

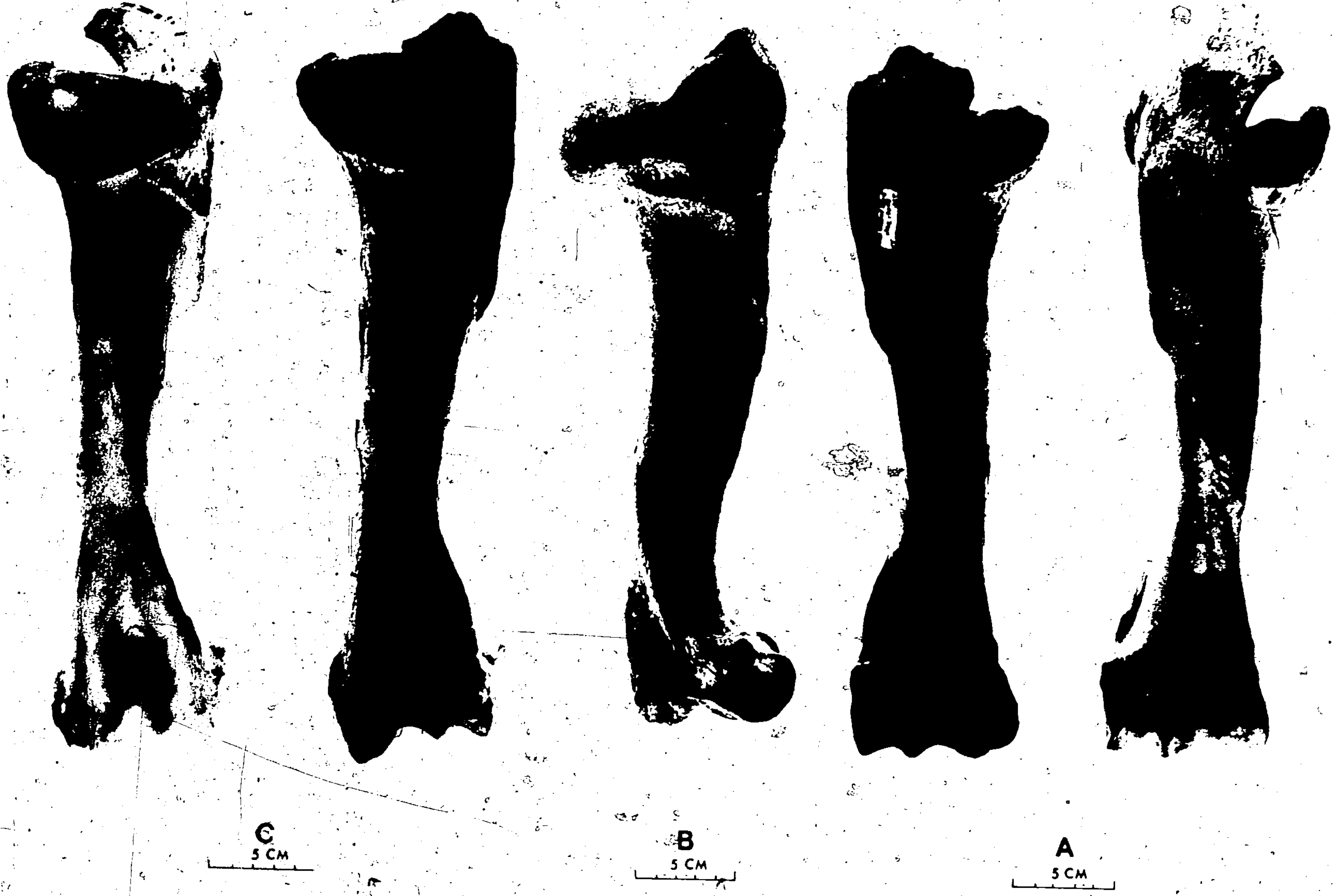

C
5 CM
B
5 CM
A
5 CM

Table 74. Measurements of Pleistocene wapiti (*Cervus elaphus*) antlers from the Yukon Territory and Alaska compared to a Recent wapiti antler from Alberta.

Specimens	Measurements (mm)*				
	1	2	3	4	5
Cervus elaphus, Pleistocene, Y.T.					
DCMP-3 Sulphur Creek (Dawson Area)	110.0	90.0	1180.0	910.0	195.0
NMC 11672 Dawson Loc. 15	73.0^{+}	65.5^{+}	-	-	170.0
Cervus elaphus, Pleistocene, Alaska					
NMC 25873 Lost Chicken Creek	99.0	88.0	-	-	179.0
Cervus elaphus, Recent, Alberta					
NMC 11691 Waterton	91.3	81.5	1120.0	710.0	160.0

*1 - Maximum diameter of antler base.

2 - Minimum diameter of antler base.

3 - Straight line measurement from base to tip of most distal tine.

4 - Length along beam from antler base to main distal fork (fork between fifth and sixth tines in DCMP-3).

5 - Circumference of beam midway between base and main distal fork.

Table 75. Measurements of a Pleistocene wapiti (*Cervus elaphus*) cranial fragment from the Yukon Territory compared to crania of Recent wapiti from Alberta.

Specimens	Measurements (mm			
	1	2	3	4
Cervus elaphus.Pleistocene, Y.T.				
NMC 6750 Dawson Loc. 5	66.8	117.4	61.8	56.0
Cervus elaphus.Recent, Alberta				
NMC 36163 Banff	59.3	111.3	55.8	53.9
NMC 11691 Waterton	44.0a	112.1	62.3**	61.3**

*1 - Distance between the fronto-parietal and occipital sutures on the mid-line.

2 - Minimum cranial breadth immediately posterior to the antler pedicels.

3 - Maximum diameter of antler pedicel.

4 - Minimum diameter of antler pedicel.

** Antlers attached.

Table 76. Measurements of a postglacial wapiti *(Cervus elaphus)* humerus from the Yukon Territory compared to humeri of Recent wapiti from Alberta.

Specimens	Measurements (mm)*						
	1	2	3	4	5	6	7
Cervus elaphus.Postglacial, Y.T.							
NMC 17048 Old Crow Loc. 1	334.0+	96.0	302.0	37.0	47.0	73.0	72.0
Cervus elaphus.Recent, Alberta							
NMC 36163 Banff	332.0	101.0	299.0	34.0	45.0	73.0	72.0
NMC 33481 -	336.0	102.0	301.0	36.0	46.0	74.0	72.0

*1 - Total length.
2 - Maximum proximal depth.
3 - Proximal end of head to distal end of lateral condyle.
4 - Minimum width of shaft.
5 - Minimum depth of shaft.
6 - Maximum distal width.
7 - Maximum distal depth.

antlers is the presence of a well developed supernumerary tine above the first (brow) and second (bez) tines. Although Murie (1957) has not recorded supernumerary tines of this type in Recent North American wapiti, they are known from Europe (Winans 1913). Some measurements of DCMP-3 are recorded in Table 74.

NMC 11672 from Dawson Locality 15 is the proximal third of a shed right antler. It retains traces of the deep, longitudinal vascular grooving that helps to distinguish *Cervus* from *Rangifer* antlers. The first and second tines are broken near their roots. Only minimum measurements (Table 74) can be recorded on the antler base because it is heavily eroded.

The tips of two antlers (NMC 17259, 11710) from Dawson Locality 28 are referred to *Cervus elaphus* because of their ridged and knobby surface and roundness, which characterize the appearance of Recent wapiti tines examined. The tip of NMC 11710 has been gnawed by a rodent.

A heavily eroded dorsal fragment of a cranium with antler pedicels (NMC 6750) from claim 19 on Eldorado Creek (near Dawson Locality 5) is of historic as well as paleontological interest, for it was collected by the surveyor William Ogilvie in 1898. It was recovered at a depth of 19 feet (5.8 m) below the surface. Although a note with the fossil indicates that it was derived from Klondike gravels, matrix still adhering to it consists of fine micaceous silt or muck. The presence of antler pedicels and the degree of suture fusion indicate that a male in early maturity is represented. All morphological features preserved on NMC 6750 are readily matched in a Recent male wapiti cranium (NMC 36163). The antlers had been shed before death, because only the pedicels are present. Stags usually begin to drop their antlers in February and start growing them again in April (Banfield 1974, p. 399), so the individual represented by the fossil probably died between February and April. Some measurements are provided in Table 75. Fine rootlet impressions are seen on the upper surface of the fossil, suggesting burial in a grassland environment.

NMC 17048 from Old Crow Locality 1 is a nearly complete right humerus. It is well preserved (even to detailed surface sculpture), relatively pale (more like the 12,000-year-old bones from Old Crow Locality 11(1) than the older, darker bones from the Old Crow Basin), and matches very closely two Recent adult wapiti humeri (NMC 33481, 36163).

Facets are evident on NMC 17048, being most easily seen on the lateral epicondyle and on the posterior prominence of the lateral tuberosity near the head of the humerus. The alignment of small parallel grooves on these facets suggests that the bone was ground down at an angle not quite perpendicular to its long axis. The camber and high polish on the facets, most noticeable near their margins, suggest that the humerus was later rubbed across a soft surface. Facets on this bone are reminiscent of those discovered on other more deeply stained, and almost certainly, much older bones from the Old Crow Basin. While most of the specimen has been sacrificed to obtain a radiocarbon date, the parts showing the clearest facets have been preserved in case archeologists are interested in trying to establish whether they have been made by man or other natural causes. Radiocarbon analysis of the shaft of this specimen yielded a date of 4,570 ± 100 years B.P. (I-4225), indicating that wapiti lived in the Old Crow Basin during postglacial time.

Discussion

Except for NMC 11672, which is heavily eroded, Yukon Pleistocene wapiti seem to have been slightly larger than modern Alberta wapiti, according to comparisons of various skeletal elements. Probably most wapiti specimens from the Dawson Area are of late Wisconsin age, for they are not deeply stained. The single specimen from the Old Crow Basin evidently represents an animal that lived there about 4,600 years ago. Wapiti no longer occur in Alaska or the Yukon, so they may have become extinct in Eastern Beringia, or they may have withdrawn southward, during the hypsithermal.

In other parts of Canada, wapiti remains varying in age from Pleistocene to Recent have been reported from Ontario (e.g. Hamilton (Burlington Heights) - late Wisconsin to postglacial; Strathroy - postglacial to Recent?; Kingston - postglacial to Recent?; Waterford - postglacial to Recent (antler in Eva Brook Donly Museum, Simcoe), Sydenham - postglacial to Recent?; Lanark - postglacial to Recent?), Saskatchewan (e.g. Saskatoon - Sangamon interglacial or mid-Wisconsin; Veregin - Pleistocene to Recent; Oxbow - postglacial (approximately 5,000 years old)), Alberta (e.g. Edmonton - late Pleistocene; Medicine Hat - Sangamon interglacial), British Columbia (e.g. Hanging Valley Creek - postglacial to Recent?; Australian - postglacial?; Kamloops area - postglacial to Recent?), and the Northwest Territories (Julian archeological site at Fisherman Lake) (Hay 1923, Cowan 1941, Stalker and Churcher 1970, Harington 1976 MS., Fedichichuk 1970, and records and specimens in the Quaternary Zoology Section, National Museums of Canada). According to this evidence, the earliest recorded wapiti from Canada are of Sangamon interglacial age, and wapiti became most widespread and abundant in southern Canada during the postglacial.

In the conterminous United States, wapiti remains are widespread, but mainly northern. The earliest reports from Cumberland Cave, Maryland (Kansan) and Conard Fissure, Arkansas (early Illinoian), require further substantiation. *Cervus elaphus* bones have been recorded from Wisconsin and postglacial sites in Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, New Jersey, New York, North Carolina, Oklahoma, Pennsylvania, Tennessee, Vermont, Virginia, Washington, Wisconsin and Wyoming (B. Kurtén, personal communication 1976).

Many specimens referred to *Cervus elaphus* have been collected from Alaska. Most are from Wisconsin sediments (but a few appear to be of Illinoian age (Guthrie and Matthews 1971, p. 496)) at the following localities near Fairbanks: Cripple Creek, Fairbanks Creek, Gold Hill, Engineer Creek, Lower Goldstream Creek, and Dome Creek. Other specimens have been collected at Chicken, Ingle and Lost Chicken creeks in eastern Alaska; Gertrude Creek in central Alaska; and Rainbow Mine and Koyuk River in western Alaska. The localities span the Eastern Beringian refugium (Guthrie 1966, Figure 1, Table 1).

Measurements of a shed left antler (NMC 25873) from Lost Chicken Creek are given in Table 74. There is no proximal supernumerary tine. The distal halves of first, second and third tines are lacking, and the main beam is broken just beyond the root of the third tine. NMC 25873 is light in color, and is probably of late Wisconsin age.

The earliest record of *Cervus* cf. *elaphus* in North America and Beringia is based on a P^4 and a naviculocuboid from ?Nebraskan deposits at Cape Deceit (Guthrie and Matthews 1971, Figure 10).

The only record of *Cervus elaphus* in the major Pleistocene mammal faunas of Siberia is from the early Wisconsin Iedoma Suite in the Kolyma Lowland (Sher 1971).

In Europe, *Cervus elaphus*—of the acoronate type (often having five tines including a simple terminal fork; Kahlke 1959, Figure 5; Kurtén 1968, Figure 69) has been recorded from Günz (?Nebraskan) deposits at Süssenborn and Mindel (?Kansan) deposits at Mosbach in Germany. Coronate forms occured as early as the Günz at Hundsheim, and by Cromerian (?Aftonian) interglacial time, red deer of the modern type had spread through central Europe. Kurtén (1968, p. 162) remarks that the European fossil record shows that the simpler acoronate form became dominant during cold phases, and the coronate forms held sway during the warmer phases of the Pleistocene. Perhaps largest and most complex antlers are developed by wapiti and red deer during periods when nutritive conditions in the environment are most favorable for this species. *Cervus elaphus* was common in Europe during the late Pleistocene.

Dietrich (1938) suggests that the simpler acoronate form of *Cervus elaphus* evolved from an early Villafranchian species with three or four tines on each antler, *Metacervocerus pardinensis*, which is known from Perrier. So *Cervus elaphus* seems to have originated in Europe about the beginning of the Pleistocene. During the early Pleistocene (Günz - Nebraskan), favorable environmental conditions seem to have resulted in a radiation of *Cervus elaphus* from Europe to Alaska. Wapiti may have penetrated southern North America by Kansan (Cumberland Cave) or early Illinoian (Conard Fissure) time, but those records must be better substantiated. Firmer evidence (Medicine Hat) indicates that wapiti were present on the southwestern prairies during the Sangamon interglacial, and that they occupied the Eastern Beringian and southern refugia during the Wisconsin glaciation. During the postglacial they became extinct in or withdrew from Alaska and the Yukon, and became abundant and widespread throughout central North America. Since the European occupation of North America, wapiti herds have been greatly decimated, becoming extinct in most parts of their range except the western mountain regions and relatively isolated hilly areas.

Wapiti or red deer *(Cervus elaphus)* are Holarctic in distribution, having occupied Scotland, continental Europe, central Asia, and northern North America in early historic time. Wapiti are large, sturdy deer. Males average 7.5 feet (231 cm) in length and 700 pounds (315 kg) in weight. They have prominent white rump patches, and males carry long curving antlers with many tines. During the summer they travel in bands. Females and calves, often numbering about 25, forage together, while males form bachelor bands. Large herds of 100 or more animals form after the rut. They are a migratory species, at least in the mountainous areas, where winters are spent in protected valleys and summers are spent in high alpine valleys.

Wapiti prefer open areas, such as alpine pastures, marshy meadows, prairies and aspen parkland. In Eastern Beringia during the Pleistocene they seem to have thrived in cool, dry grassland or open parkland conditions. The species feeds mainly on willow, aspen and poplar twigs and leaves, bark, herbs and grasses. Apart from man, the main predators of the wapiti are the mountain lion, wolf and brown bear.

All of those predators lived in the Yukon during the Pleistocene.

Alces latifrons (giant moose)

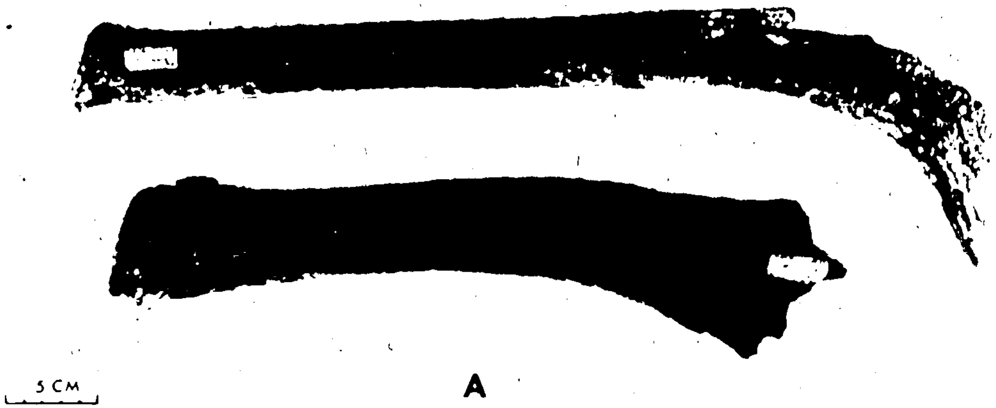
Antler beams of giant moose (Figures 69A-C, 70, Table 77) are not uncommon in Yukon Pleistocene deposits. All but two of those reported are from the Old Crow Basin. Antler beams of this species have been described previously from Alaska under the name "*Cervalces alaskensis*" (Frick 1937, p. 203), but there is no doubt that they are very different in size and proportion to beams of the best preserved specimen (PU 10648) of *Cervalces scotti* (Scott 1885, p. 191, Figure 5), while they conform closely to antler beams of Eurasian *Alces latifrons*.

I was first convinced that *Alces latifrons* was represented in Eastern Beringian ice age deposits in 1966 when attempting to identify a massive antler beam (NMC 10477) collected by V. Rampton in 1962 on the Old Crow River. Fossils collected since then have reinforced the preliminary evidence, and I suggest that many specimens previously described as *Cervalces* (e.g. *C. roosevelti*, *C. borealis*) actually represent *Alces latifrons*, and indicate that this giant moose had reached southern North America from Eastern Beringia by at least Sangamon time and perhaps as early as Kansan time.

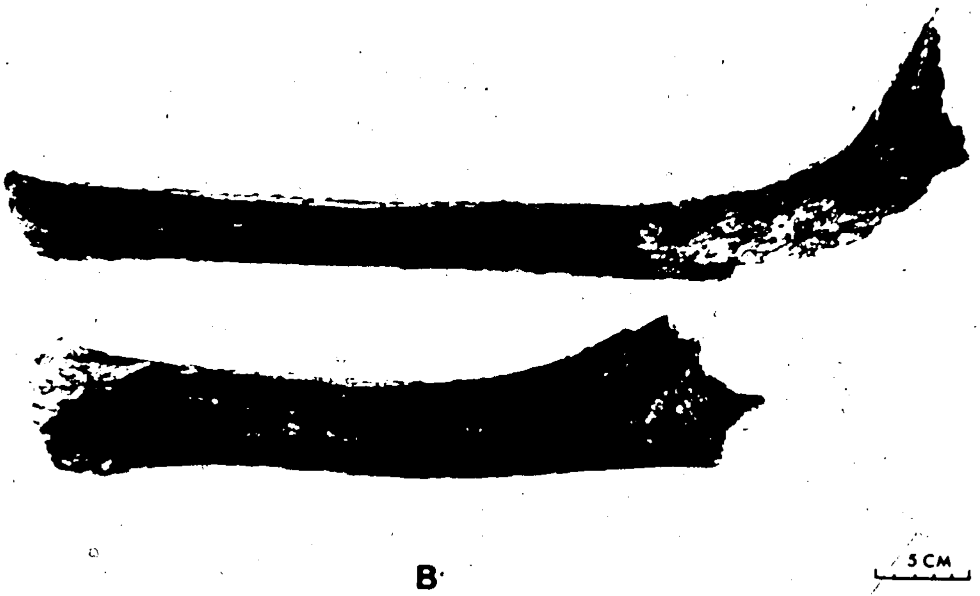
Figure 69. A. Dorsal views of a left antler beam (NMC 16505, Old Crow Locality 8) of a Pleistocene giant moose *(Alces latifrons)* (top) and a left antler beam (NMC 15258, Old Crow Locality 22) of a Pleistocene giant moose *(Alces latifrons)* (bottom).

B. Anterior views of NMC 16505 (top) and NMC 15258 (bottom).

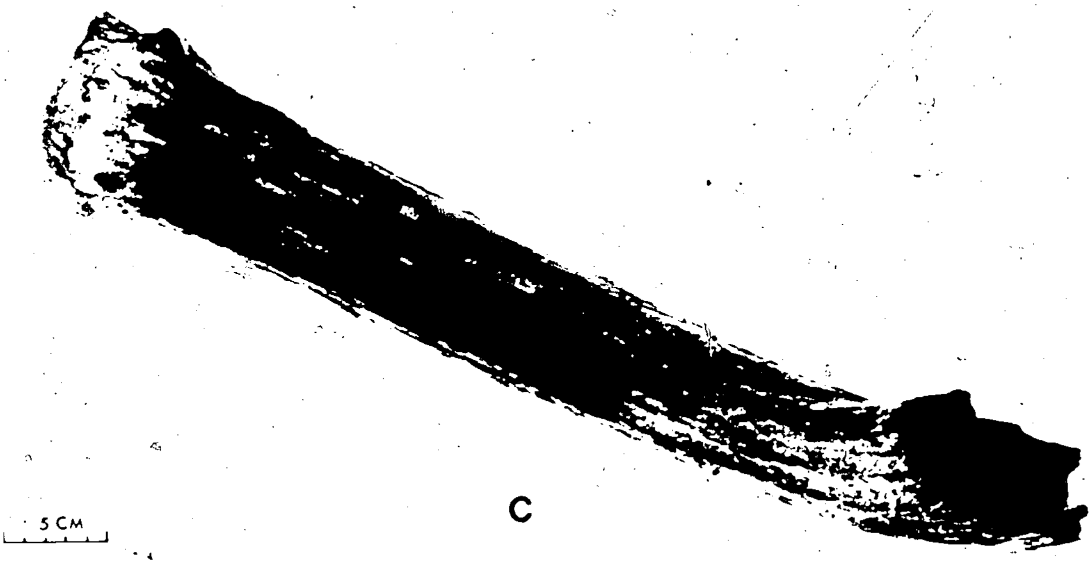
C. Anterior view of a left antler beam (NMC 10477, Old Crow Locality 8) of a Pleistocene giant moose *(Alces latifrons)*.



A



B



C

Figure 70. Restoration of a giant moose *(Alces latifrons)* charging wolves *(Canis lupus)*. Ink sketch by Bonnie Dalzell.

Table 77. Measurements of 11 Interior giant moose (*Alces latifrons*) antlers from the Yukon Territory and Alaska compared to those of *Alces latifrons* from Eurasia and *Cervalces scotti* from the United States.

Specimens	Measurements (mm)*								
	1	2	3	4	5	6	7	8	9
Alces latifrons, Pleistocene, Y.T.									
NMC 16505 Old Crow Loc. 8	460	61	55	155	46	42	44	39	296.8
NMC 10477 Old Crow Loc. 8	430	110	79	290e	74	73	71	69	148.3
NMC uncatalogued Old Crow Loc. 22	397†	82	76	230	61	61	61	60	-
NMC 25963 Dawson Loc. 29	380	75	68	195	60	54	57	53	194.9
NMC 24150 Old Crow Loc. 11S	365†	75	70	200	59	55	55	50	-
NMC 15256 Old Crow Loc. 22	350a	77	67	204	58	54	53	50	171.6
NMC 11336 Dawson Loc. 25	320	71	65e	180	47	46	45	40e	177.8
NMC 13618 Old Crow Loc. 11A	300e	88	67	200	55	48	-	-	150.0
NMC 13615 Old Crow Loc. 11A	-	85	73	230	67	56	68	57	-
NMC 27113 Old Crow Loc. 29 (immature?)	196†	34	30	98	26	24	29	28	-
								Average	189.9
Alces latifrons, Pleistocene, Alaska Fairbanks area (Shar 1970, p. 55)									
F:AM 30497	450	-	-	-	70a	-	70a	-	-
F:AM 30496	430	-	-	-	60a	-	60a	-	-
F:AM field no. 3552	290	-	-	-	75a	-	75a	-	-
Alces latifrons, Pleistocene, Siberia**									
GIN $\frac{835-525}{32}$ Bolshaya Chukochya	500a	86	63	233	93	69	59a	60a	214.6
Catalog no. unknown Khara-Aldan	496	114	110	287	86	85	-	-	172.8
GIN 361 Aldan	400	115	97	260	89	80	-	-	153.8
GIN "873" Kolyma Lowland	307	69	59	186	-	-	-	-	165.1
GIN 426 Yenesei	300	120	97	245	83	66	-	-	122.5
								Average	165.8
Alces latifrons, Pleistocene, Europe Mosbach, Germany (Sher 1971, Table 27)									
M	382	89	89	223	68	67	-	-	171.3
OR	240- 500	73- 114	71- 113	180- 270	51- 87	57- 83	-	-	133.3- 185.2
N	25	16	16	23	19	19	-	-	23
Cervalces scotti, Pleistocene, U.S.A.***									
Catalog no. unknown, Topeka, Kansas	270	72	-	-	-	-	58	50	-
Uncataloged, Columbia, New Jersey	215	98	90a	210	62	55	59	52	102.4
Catalog no. unknown, Mount Herman, New Jersey	185	91	81	-	53	53	55	52	-

* 1 - Length of beam from burr to beginning of palmation.
2 - Maximum diameter of burr.
3 - Minimum diameter of burr.
4 - Circumference of beam directly distal to burr.
5 - Maximum diameter of beam (50 mm from burr).
6 - Minimum diameter of beam (50 mm from burr).
7 - Maximum diameter of beam (100 mm from burr).
8 - Minimum diameter of beam (100 mm from burr).
9 - Slenderness index (%) ($\frac{\text{Measurement 1}}{\text{Measurement 4}}$ x 100). Slenderness is directly proportional to the %-reading.

** I am grateful to A.V. Sher for allowing me to measure specimen GIN $\frac{835-525}{32}$ and GIN "873" during a visit to the Paleontological Institute, USSR Academy of Sciences, Moscow. Measurements of the remaining specimens are derived from Table 27 (Sher 1971).

*** I am grateful to G.J. Sawyer for allowing me to measure the Columbia specimen and to C.S. Churcher for data on the Mount Herman and Topeka specimens.

[Light copy]

I follow Kahlke (1956, Vol. II, p. 12) in considering *Alces* the most appropriate generic designation for the giant moose rather than *Libralces* (Azzaroli 1953, pp. 16, 19). In this respect, I agree fundamentally with the opinions expressed by Sher (1971, p. 196).

Referred specimens

The largest antler beam recovered so far from deposits in the Yukon Territory is NMC 10477 from Old Crow Locality 8. It is darkly stained and closely matches antler beams from near Fairbanks, Alaska (particularly F:AM 30496) and the Aldan River in Siberia (GIN 361). It is larger than the holotype of *Alces latifrons* from Norfolk, England described by Johnson (1874, p. 1), which has a beam measuring approximately 300 mm from burr to beginning of palmation, and a beam diameter of approximately 63 mm. NMC 10477 is displayed in the National Museum of Natural Sciences, Ottawa.

NMC 24150 from Old Crow Locality 11S is part of a right antler beam. There is no indication of the beginning of the palmation at the distal end, so probably it was relatively long. The surface of this specimen has been heavily eroded, as have the others. A few show evidence of very deep, longitudinal vascular grooves, however. NMC 15258 from Old Crow Locality 22 is a right antler beam. Only a few patches of the original surface are preserved near the burr. Its ventral surface extends farther into the palmation than does the dorsal surface. NMC 16505 from Old Crow Locality 8 is a right antler, which, although longer (460 mm) from burr to beginning of the palmation than any other giant moose antlers collected from the Yukon, is unusually gracile. This is indicated by its very high slenderness index (Table 77). Perhaps its slenderness can be explained by the lack of full maturity of the individual that bore it. NMC 25969 from Dawson Locality 29 is a right antler beam, the dorsal surface of which extends well into the palmation. Its surface has been heavily eroded. The specimen is paler than any of the Old Crow specimens, which are stained dark brown. NMC 27113 from Old Crow Locality 29 is a small, right antler beam. Because of the similarity of its proportions to beams from mature males of *Alces latifrons*, it is tentatively considered to represent an immature giant moose.

NMC 11336, a left antler fragment from Dawson Locality 29, is unique among the Yukon specimens in that the first posterior tine is largely preserved (perhaps the distal quarter is missing). In that feature it matches a well preserved left antler of *Alces latifrons* from middle Pleistocene gravels from Süssenborn, Germany (Kahlke 1956, Vol. I, Plate 2), and is radically different from the condition at the beginning of the palmation in a recently discovered specimen of *Cervalces scotti* from Columbia, New Jersey (in the personal collection of G.J. Sawyer, Paulina, New Jersey), with which it was directly compared. Relative to the Yukon giant moose specimens, *Cervalces scotti* has much shorter antler beams (averaging approximately 207 mm — less than 55% of the Yukon *A. latifrons* average), and the anterior and posterior parts of the palmation rise sharply upward, almost simultaneously, whereas in *Alces latifrons* the part of the antler at the beginning of the palmation lies nearly flat, and the posterior segment of the palmation begins its backward curve much closer to the burr than the anterior segment.

NMC 13618 from Old Crow Locality 11A is a left antler beam lacking the distal half of the dorsal surface. The outer surface is blackish brown, while the exposed inner antler [illegible] is paler and shows evidence of replacement by iron [illegible]. NMC 13615 from Old Crow Locality 11A is the medial [illegible] of a left antler beam. It is heavily eroded and stained. The robustness of the beam suggests [illegible] its original condition, it may have approached NMC 10477 in size. An uncataloged antler beam from Old Crow Locality 22 was equally large. Most of it was sacrificed to obtain a radiocarbon date.

The following basal fragments, probably representing originally long antler beams, are referred to *Alces latifrons*: NMC 14908 from Old Crow Locality 31; NMC 14056 from Old Crow Locality 8; and NMC 16378 from Old Crow Locality 67.

Discussion

The Yukon giant moose specimens are considered to be mainly of pre- late Wisconsin age. Probably none of the specimens is older than those from the Olyor Suite (?Kansan) in the Kolyma Lowland of Siberia. If the radiocarbon date on an uncataloged antler beam from Old Crow Locality 22 is correct (33,800 ± 2,000 years B.P. (I-4229)), then giant moose may have survived until mid - Wisconsin time in Eastern Beringia. Generally, the Yukon antler beams are more slender than those of Eurasian *Alces latifrons* (Table 77).

In other parts of Canada, long, massive moose-like antler beams are known from deposits of probable Sangamon interglacial age at Fort Qu'Appelle, Saskatchewan, and from Sangamon or early Wisconsin sediments at Toronto, Ontario. I tentatively refer the former (NMC 11961 - 310 mm long from burr to palmation, with a beam diameter of 50 mm), designated as *Cervalces roosevelti* by Khan (1970, p. 55, Figure 2), and more doubtfully the latter (ROM 20176 - 330 mm long from burr to palmation, with a beam diameter of 60 mm), designated as *Cervalces borealis* by Bensley (1913, p. 2), to *Alces latifrons*. An unusual feature of ROM 20176 is the pronounced upward convexity of the beam. It is worth noting that a moose-like deer ("*?Alces* sp.") has been reported from Sangamon interglacial deposits at Medicine Hat, Alberta (Stalker and Churcher 1970).

Perhaps some of the larger antler beams referred to *Cervalces roosevelti* from the conterminous United States (e.g. Denison, Iowa (Hay 1914, pp. 261-269); Giltner, Nebraska (Cook 1931, p. 279)) represent the giant moose *Alces latifrons*. The Giltner specimen is considered to be of Kansan age.

At least two antler beams (F:AM 30496, 30497), and possibly a third (F:AM field no. 3858), from ice age sediments in the Fairbanks area of Alaska are referred to *Alces latifrons*. Although designated

"Cervalces alaskensis" by Frick (1937, p. 203), there is no doubt that they are closer to the type of *Alces latifrons* than the most complete specimen (PU 10648) of *Cervalces scotti*, a fact suspected by Sher (1971, p. 199).

In Siberia, *Alces latifrons* is recorded from the Olyor Suite (?Kansan) on the Bolshaya Chukochya River (Sher 1971, Plate XIV-4), and from other sites containing fossils of possible middle Pleistocene age (e.g. Aldan, Yenesei, Lena (Vangengeim 1961), and Khara - Aldan (Rusanov 1968)). It is also known from western Siberia (Vangengeim and Zazhigin 1965). *Alces latifrons postremus*, with antlers approaching those of the modern moose, *Alces alces*, has been described by Vangengeim and Flerov (1965). It has been reported from Mindel - Riss (?Kansan - Illinoian) deposits in Yakutia and Kamchatka (Sher 1971, Table 27). Possibly this form lies closer to *Alces alces* than to *Alces latifrons* (Sher 1971, p. 197).

In other parts of the Soviet Union, the giant moose is known from the Urals (Yakhimovich 1965) and Kazakhstan (Bazhanov and Kostenko 1962). It is also an important member of the Tiraspol faunistic complex (Gromov 1948), which is typical of the Mindel (?Kansan) of the southern area of the European part of the Soviet

Union. Tiraspol in Moldavia is the most important locality for middle Pleistocene biostratigraphic correlation between Europe and Asia (Kahlke 1973, p. 24).

In Europe, *Alces latifrons* had become well established during the Cromer (?Aftonian) interglacial and Mindel (?Kansan) glacial phases (e.g. Cromer Forest Bed, Norfolk, England; Mauer, Mosbach, Süssenborn, Germany).

The earliest stages of moose evolution are poorly known. In Vereshchagin's (1967b, Figure 6) phylogeny of the Tribe Alcini, *Alces latifrons* is derived from a *Eucladoceros* stock in the latter half of the late Pliocene. He considers *Cervalces scotti* and *Alces alces* to be early Pleistocene offshoots from *Alces latifrons*. Kurtén (1968, p. 167) believes the earliest recognizable ancestor of the moose to be the Gallic moose *(Alces gallicus)* of the Villafranchian of Europe (e.g. the Crags in Norfolk; Senèze and possibly Perrier in France; and Erpfingen in Germany). A large antler beam from deposits near Kumertau in the southern Urals, considered by Vereshchagin (1967, p. 9) to be of late Pliocene age, may be referrable to this taxon. The Gallic moose was about the same size as

Alces alces, but its antlers were shaped like long-handled spoons. The small palmation was fringed with short tines. Its antlers had a span of 3 m or more, suggesting that it could not have lived in heavily forested regions.

The transition from the Gallic moose to the giant moose evidently occurred near the earliest part of the middle Pleistocene in Europe (e.g. Mosbach I, Germany, and the Waalian (?Nebraskan) interstadial of the Forest Bed in Norfolk, England). The antler palmations of the moose at this stage were smaller, and the beams were longer than those typical of later *Alces latifrons* (Kurtén 1968, p. 168). During the Mindel (?Kansan), there was a remarkably broad dispersal of giant moose from England, through Germany, Moldavia and Siberia to Alaska and the Yukon, and possibly to southern North America (Giltner, Nebraska). Presumably this dispersal was concomitant with the spread of cool, grasslands and parklands in the northern Holarctic region. Evidently *Alces latifrons* gave way to *Alces alces* in Siberia during the Mindel - Riss (?Kansan - Illinoian) period. The giant moose seems to have been present as late as Sangamon (Fort Qu'Appelle) or possibly Wisconsin time in southern North America, while it evidently survived until mid-Wisconsin time in Eastern Beringia.

I think that the fossil evidence indicates a general reduction in beam length and an increase in palmation area from late Pliocene to Recent. All stages seem to be present, e.g. *Alces gallicus - Alces latifrons - Alces latifrons postremus - Alces alces.* This reduction of beam length and increase in palmation area suggests an increasing use of boreal forest habitat throughout the Pleistocene. Such a trend may have been induced by growing competition with more specialized cool grassland or parkland herbivores like mammoths, muskoxen, wapiti or red deer, and bison. Therefore, I cannot agree with Vereshchagin's (1967, p. 10) statement that "It is difficult to concede the possibility that the highly specialized, long-beamed antlers of *Alces latifrons* were transformed during the first half of the Pleistocene into the short-beamed antlers of the present-day elk (moose)".

Alces latifrons seems to have had as broad a range in the middle to late Pleistocene of the Holarctic as the woolly mammoth had in the late Pleistocene. The giant moose stood 1.9 to 2 m at the shoulders (Kurtén 1968, p. 168) and was characterized by antler beams 300 to 500 mm in length, with an equal length being given to the palmation. Its skull was heavily built and its limbs were much stouter and longer than those of the modern moose (Sher 1971, Plate XIV-1, 2). Like its ancestor the Gallic moose, the giant moose was not adapted to dense forest. In addition to the great span of the antlers that would hamper movement of the giant moose in heavily forested areas, paleobotanical data from Tiraspol indicate that *Alces latifrons* occupied cool forest-steppe or parkland regions away from dense forest. Probably cool, tundra-like grasslands with steppe elements were predominant in the Kolyma and Aldan regions when *Alces latifrons* lived there (Sher 1971, p. 198, Giterman 1973, p. 67). Therefore, I suggest that the giant moose is a paleoenvironmental indicator of cool steppe-like grasslands or parklands. Nothing is known of the feeding habits of this species; presumably marsh plants, willows and other shrubs were important dietary items. Probably wolves were among its major predators.

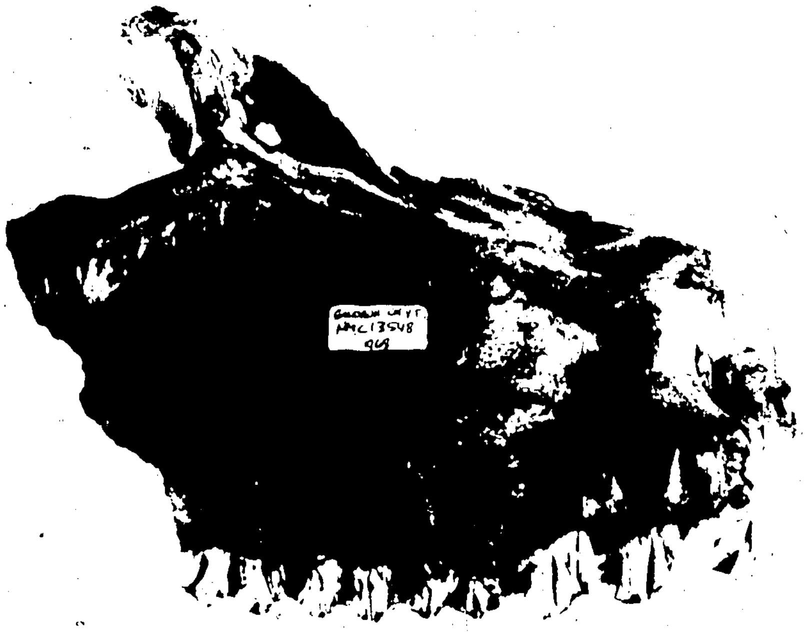
Alces alces (moose)

Moose remains (Figures 71A-B, 72A, Tables 78-80) are fairly common in Pleistocene deposits. Except for a few cranial and postcranial specimens from Gold Run Creek that are relatively complete and are clearly assignable to *Alces alces*, only readily identifiable antler fragments are described. A description of other skeletal material will be deferred until casts of *Alces latifrons* are available to

Figure 71. Right facial fragment with RP^2-RM^3 (NMC 13548, Dawson Locality 32) of a Pleistocene moose *(Alces alces)*.

A. Lateral view.

B. Occlusal view.



A

B

Table 76. Measurements of Pleistocene moose (Alces alces) antlers from the Yukon Territory compared to those of Recent moose from Ontario.

Specimen	1	2	3	4	5	6	7	8	9
	Measurements (mm)*								
Alces alces, Pleistocene, Y.T.									
NMC 29003 Dawson Loc. 17	210	72	53	184	60	47		46	114.1
NMC 10474 Dawson Loc. 19	200	106	74	195	59	[illegible]		51	102.6
NMC 19473 Dawson Loc. 19	190	91	76	190	59	51		51	100.0
NMC 25197 Old Crow Loc. 19	190	73	65	170	46	45	50	41	111.8
NMC 29004 Dawson Loc. 17	180	84	77	217	64	56	62	53	83.0
NMC 29092 Dawson Loc. 17	180	77	72	184	52	46	53	46	97.8
NMC 14006 Old Crow Loc. 1	180	83	67	174	51	44	46	47	103.5
NMC 25527 Old Crow Loc. 143	175	89	73	215	66	57	58	56	81.4
NMC 11667 Dawson Loc. 13	175	71	62	185	53	48	56	43	94.6
NMC 26255 Old Crow Loc. 18	170	86	72	200	53	51	60	43	85.0
NMC 17212 Dawson Loc. 32	165	78	68	185	53	49	56	43	89.2
NMC 13547 Dawson Loc. 32	160	82	75	200	62	53	71	47	80.0
NMC 29232 Dawson Loc. 13	160	61	52	174	48	45	50	39	92.0
NMC 27082 Old Crow Loc. 32 (Immature?)	160	58	41	150	39	35	47	29	106.7
NMC 17753 Dawson Loc. 32	150	69	63	177	46	44	56	40	84.8
NMC 16929 Porcupine R. (Johnson Village)	145	58	52	161	47	43	57	39	90.1
NMC 26923 Old Crow Loc. 21	142	71	57	180	54	49	64	42	78.9
NMC 26485 Old Crow Loc. 143 (Immature?)	110?	62	51	132	44	25	68	24	83.3?
								Average	93.3
Alces alces, Recent, Ontario**									
OR	108- 189	75- 105	65- 100	-	44- 67	43- 58	67- 80	46- 49	-
N	8	8	8	-	8	8	8	8	-

* 1 - Length of beam from burr to beginning of palmation.

2 - Maximum diameter of burr.

3 - Minimum diameter of burr.

4 - Circumference of beam directly distal to burr.

5 - Maximum diameter of beam (50 mm from burr).

6 - Minimum diameter of beam (50 mm from burr).

7 - Maximum diameter of beam (100 mm from burr).

8 - Minimum diameter of beam (100 mm from burr).

9 - Index of slenderness (%) ($\frac{\text{Measurement 1}}{\text{Measurement 4}}$ x 100). Slenderness is directly proportional to the % reading.

** I am grateful to C. S. Churcher for providing me with these measurements.

Light copy

Table 79. Measurements of Pleistocene moose (*Alces alces*) maxilla and mandibles from the Yukon Territory compared to those of Recent moose from Canada.

Specimens	Estimated age of individual (years)	Sex	Measurements (mm)*														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Maxilla																	
Alces alces.Pleistocene, Y.T.																	
NMC 13548 Dawson Loc. 32	Adult	-	27.5	26.5	26.2	30.0	27.0	32.4	28.4	29.8	29.9	32.1	30.1	31.2	152.6	70.9	83.7
Alces alces.Recent, Canada																	
NMC 4840 Quebec	Adult	♂	25.2	25.2	24.0	28.3	25.7	30.6	33.1	27.5	29.6	30.0	31.1	30.4	152.0	71.2	81.6
NMC 4412 N.B.	Adult	♀	23.5	21.3	23.9	25.0	22.5	27.1	28.3	26.9	30.4	29.8	30.4	29.5	143.6	66.7	79.1
Mandibles																	
Alces alces.Pleistocene, Y.T.																	
NMC 11639 Dawson Loc. 32	5	-	21.1	14.5	24.7	17.7	28.2	21.8	28.8	22.8	30.4	23.5	39.2	23.2	166.6	73.1	94.0
LUM 1.3 Dawson Loc. 32	14+	-	19.3+	13.9	24.4	17.3	28.9	21.3	26.0	20.5	29.0	22.2	40.6	21.4	165.4	72.3	93.4
Alces alces.Recent, Canada																	
NMC 4840 Quebec	-	♂	19.8	14.9	23.8	16.5	25.9	19.0	30.5	19.1	30.4	21.8	38.6	22.3	166.[illegible]	71.9	93.8
NMC 4412 N.B.	-	♀	19.3	13.9	23.6	16.6	25.8	18.7	27.7	20.5	30.0	21.6	35.3	22.8	164.7	70.1	94.0

* 1 - Length P2.
2 - Width P2.
3 - Length P3.
4 - Width P3.
5 - Length P4.
6 - Width P4.
7 - Length M1.
8 - Width M1.
9 - Length M2.
10 - Width M2.
11 - Length M3.
12 - Width M3.
13 - Alveolar length P2-M3.
14 - Alveolar length P2-P4.
15 - Alvealar length M1-M3.

Table 80. Measurements of Pleistocene moose (*Alces alces*) radii and metatarsals from the Yukon Territory compared to those of Recent moose from Canada.

Specimens	Estimated age of individual	Sex	Measurements (mm)*						
			1	2	3	4	5	6	7
Radii									
Alces alces. Pleistocene, Y.T.									
NMC 11640 Dawson Loc. 32	-	-	420.0	80.7	50.7	45.0	29.9	75.2	59.5
NMC 11641 Dawson Loc. 32	-	-	-	-	-	40.0	30.0	72.1	54.8
Alces alces. Recent, Canada									
NMC 4850 Quebec	Adult	♂	425.0	82.1	51.1	47.9	-	79.3	60.4
NMC 4412 N.B.	Adult	♀	407.0	70.3	41.5	33.5	25.3	66.2	50.1
Metatarsals									
Alces alces. Pleistocene, Y.T.									
NMC 13546 Dawson Loc. 32	-	-	407.0	52.7	55.1	35.8	39.6	64.4	43.6
Alces alces. Recent, Canada									
NMC 4850 Quebec	Adult	♂	408.0	53.4	54.7	35.5	40.1	67.3	45.0
NMC 4412 N.B.	Adult	♀	385.2	46.4	47.7	27.1	31.2	58.6	38.8

* 1 - Total length.
2 - Proximal width.
3 - Proximal depth.
4 - Midshaft width.
5 - Midshaft depth.
6 - Distal width.
7 - Distal depth.

aid in separating moose from giant moose remains. Occasionally, winter fecal pellets of moose have been collected from Pleistocene sediments in the Old Crow Basin.

Referred specimens

Referred left antlers - NMC 10474 from Dawson Locality 19 consists of an antler beam with the anterior half of the palmation bearing four tines. The tips of the tines and the posterior part of the antler base have been gnawed by rodents. Part of the pedicel is attached to the beam. The specimen is dark brown. NMC 10473 from the same locality consists of a shed antler. The anterior half of the palmation bearing five tines is attached to the beam. One tine projects ventrally from the base of the first cluster of four. As in NMC 10474, the proximal portion of the posterior half of the palmation is present. NMC 13547 from Dawson Locality 32 consists of a shed beam with the central part of the palmation. It is iron-stained. NMC 16255 from Old Crow Locality 18 is a shed antler with the central part of the palmation and the bases of anterior and posterior segments. NMC 27082 from Old Crow Locality 32E is relatively small, probably representing an immature male. I estimate that the proximal half of the palmation, including both anterior and posterior portions, is present.

Most of the dark brown outer surface of the antler has been eroded. NMC 11667 from Dawson Locality 13 consists of a shed beam with the proximal part of the palmation. Its light brown surface has darker patches. NMC 29003 from Dawson Locality 17 is an eroded antler beam with a small part of the palmation. The ventral surface extends farther into the palmation than does the dorsal surface. The specimen is stained brown. NMC 14006 from Old Crow Locality 1 is a deeply-stained beam with the proximal quarter of the palmation. It is attached to part of the left frontal bone. Probably the individual represented by the fossil died during autumn or early winter. NMC 17512 from Dawson Locality 32 is heavily weathered. A fragment of the anterior part of the palmation is attached to the beam. NMC 28527 from Old Crow Locality 143 consists of an unshed antler beam attached to a fragment of left frontal bone. The frontal shows the knob between the antlers that is typical of *Alces*. The surface of this heavily iron-stained fossil seems to have been pitted by acidic groundwater. Probably the animal represented by NMC 28527 died in autumn when the antlers had reached full maturity, but prior to winter when they are shed (Peterson 1966, p. 329). NMC 29002 from Dawson Locality 17 lacks the distal, upper portion of the antler beam. The lower segment extends into the proximal part of the palmation. The specimen is stained brown.

Referred right antlers - NMC 25197 from Old Crow Locality 19 consists of a beam with the proximal half of the palmation. Although no tines are preserved, part of the inflection dividing the anterior from the posterior part of the palmation is present. The ventral surface is well preserved, showing details of the vascular pattern. NMC 29232 from Dawson Locality 13 consists of a heavily eroded beam with the proximal third of the palmation. It is attached to the frontal region of the cranium. Like NMC 28527, NMC 29232 represents an individual that probably died in autumn or early winter. The specimen is tan and may be of late Wisconsin age. NMC 17559 from Dawson Locality 32 is a shed beam lacking most of the palmation. NMC 16929 from near Johnson Village on the Porcupine River is a deeply iron-stained beam with the proximal part of the palmation. NMC 28485 from Old Crow Locality 143 is a small, well preserved beam. The beam gradually flattens and spreads laterally toward its distal extemity, so any measurement from the burr to the beginning of the palmation is arbitrary. This reddish brown antler fragment probably represents an immature male. NMC 17594 from Dawson Locality 28 is a beam with a small part of the anterior portion of the palmation. It is dark brown.

It is worth noting that the slenderness index of Yukon Pleistocene *Alces alces* antlers averages approximately half that of *Alces latifrons* from the same region (Tables 77, 78). Ice age moose antlers from the Yukon differ little in size from those of modern Ontario moose.

NMC 13548 from Dawson Locality 32 is a right maxillary fragment with RP^2-RM^3, part of the palatine process and most of the right malar and lacrimal bones. Among specimens of Recent moose to which it was compared, the fossil is closest to an adult male (NMC 4840).

Two mandibular fragments with teeth from Dawson Locality 32 also compare well with those of Recent moose. NMC 11639, part of a left mandible with LP_2-LM_3, represents an individual of approximately 5 years of age according to Zaripov's aging system for Recent moose based on degree of wear of the mandibular tooth row (Heptner and Nasimowitsch 1967, p. 212). LUM 1.3 is a right mandibular fragment with RP_2-RM_3. It seems to have been derived from an individual over 14 years of age.

Limb bones recovered at Dawson Locality 32 include a left radius with part of the ulna fused to the shaft (NMC 11640), and the distal half of a right radius (NMC 11641). These specimens are well matched by a Recent adult radius (NMC 4850). NMC 13546, a right metatarsal, also compares closely with the same bone from NMC 4850 - a mounted skeleton of a Recent moose. A left astragalus (LUM 1.169) compares well in maximum length, width and depth (72.9 mm x 49.8 mm x 39.4 mm) to that of a Recent adult moose from New Brunswick (NMC 4412) (73.5 mm x 48.5 mm x 40.4 mm).

Discussion

The deep staining and high degree of permineralization of some of the moose specimens (e.g. NMC 28527 and 28485) suggest a pre- late Wisconsin age. No fossils of *Alces alces* have been recovered from Unit 2 at Old Crow Locality 44, and no radiocarbon analyses have been carried out on moose remains from Eastern Beringia. However, *Alces alces* is a member of the Gold Run Creek fauna, which is of late Wisconsin age (approximately 22,000 to 32,000 years B.P.) (Harington and Clulow 1973, p. 697), so the species probably occupied Eastern Beringia during the Wisconsin glaciation - a point that seems to be supported by the present distribution of moose subspecies in North America. Remains of moose have been reported from postglacial deposits at Engigstciak near the northern Yukon coast (Mackay *et al.* 1961, p. 34).

The moose is not known from any of the major faunas in the rest of Canada (Harington 1976 MS.), but remains of Pleistocene to Recent age are recorded from: Saskatchewan (Pike Lake - ROM 5544; Pasqua - NMC 11317), Alberta (Rimbey - NMC 12231, an unusual digitate antler), British Columbia (McBride Creek - (Cowan 1941, p. 47); near Fort Nelson - NMC 13744). The deep iron-staining of the Fort Nelson specimen and the heavy permineralization of the partial antler from Rimbey suggest that they are of pre- postglacial age.

In the conterminous United States, *Alces alces* remains have been recorded from sites in Illinois, Kentucky, Michigan, Minnesota, Ohio, South Carolina, Washington and possibly a few other states. These specimens are either of uncertain age, or are definitely late Wisconsin to postglacial in age (B. Kurtén, personal communication 1976).

In Alaska, the earliest moose ("*Alces* sp. (moose)") record appears to be from loess of Illinoian age at Cripple Creek near Fairbanks (Péwé and Hopkins 1967, p. 268).

Fossils of *Alces alces* are fairly common in Wisconsin deposits of the Fairbanks region (Guthrie 1968b, Table 1). *Alces* sp., of possible late Wisconsin age or postglacial age, has been reported from the Tofty area (Repenning *et al.* 1964, p. 183). *Alces alces* has also been recorded from Eschscholtz Bay in western Alaska (Richardson 1854, p. 20). A complete frozen and untransported moose carcass was found in postglacial silt near Fairbanks according to J.L. Giddings (Péwé 1975a, p. 101).

Sher (1971, p. 197) mentioned the discovery of a metatarsal of "*Alces* sp." from the Utka Beds of Riss II (late Illinoian) age in the Kolyma Lowland of northeastern Siberia. In size, it lay between modern *Alces alces* and *Alces latifrons*. In Siberia, moose remains are also known from late Pleistocene (Illinoian to Wisconsin?) sediments on Bolshoi Lyakhov Island. Regarding that record and other fossils of *Alces alces* in Siberia, Vangengeim (1961, p. 145) states: "It is known from numerous localities beginning from the end of the lower Pleistocene; remains of elk {moose} are encountered most frequently in the deposits of the upper Pleistocene. Of interest is the finding of a cast-off antler on Bolshoi Lyakhov Island, which perhaps should be dated at the time of the climatic optimum (hypsithermal) of the Holocene, when the northern boundary of the forest occupied a maximal northern position." It is difficult to understand how the shed antler could date from the hypsithermal, however, for then sea water probably separated Bolshoi Lyakhov Island from the mainland. I think a time near the beginning of the late Wisconsin glaciation would be more likely for moose to be on that island. Moose are capable of moving far into tundra regions (Banfield 1974, Map 169).

According to Kurtén (1968, p. 169), *Alces alces* first appeared in Europe during the Riss (Illinoian) and was common there during the Eem (Sangamon) interglacial and the Würm (mid-Wisconsin) interstadial.

In summary, it seems that *Alces alces* evolved during the early Illinoian from a relatively small form of the giant moose (e.g. *Alces latifrons postremus*) that was adapting to life in the boreal forest, or in the more heavily wooded, marshy parts of parkland regions. Its dispersal centre may have been western Beringia. By the late Illinoian it had spread throughout the Holarctic from Siberia to Europe and to northwestern

North America. Presumably moose reached Eastern Beringia by moving through patches of boreal forest that may have existed in some of the more poorly drained areas on the Bering Isthmus. Evidently this species did not reach southern North America until mid-Wisconsin time (a Sangamon penetration is conceivable). During the last glaciation, probably moose were isolated in at least two main areas of boreal forest south of the ice, as well as in Eastern Beringia. Probably *Alces alces americana* subspeciated in the northeastern United States, *Alces alces shirasi* in the northwestern United States, and *Alces alces gigas* in Eastern Beringia (Peterson 1955, p. 14). Youngman (1975, p. 161) considers that *Alces alces andersoni* is an intergrade between *Alces alces gigas* and adjacent southern subspecies. At present, moose occur throughout the Yukon Territory: they are common in both the Dawson and Old Crow areas.

Moose now occupy boreal forest belts across northern Eurasia from Scandinavia to the Pacific coast, and across North America from Alaska to Maine and Newfoundland. They are the largest living deer. Males weigh 725-1,400 pounds (329-635 kg) and females 500-900 pounds (227-408 kg The moose is characterized by its long face with overhanging muzzle, unusually long legs, and in males, large palmate antlers. Moose prefer boreal forest - especially areas of second growth or intermediate stages of forest succession interspersed with lakes and streams - and its fossils are probably good paleoenvironmental indicators of such conditions. This suggests to me that some areas of boreal forest have existed in Eastern Beringia throughout the late Pleistocene, no matter how bleak some of the pollen records from central and western Alaska may appear. According to available data, it appears that moose and their probable ancestors the giant moose lived together in Eastern Beringia - although probably the giant moose arrived earlier. I suggest that *Alces latifrons* occupied the open steppe-like or parkland regions, while *Alces alces* was mainly concentrated in more densely wooded, marshy regions within the refugium.

Moose are relatively solitary, however, they sometimes congregate in marshy areas that produce good forage. Their long legs allow them to move well in deep snow that often gathers in the boreal forest. They are excellent swimmers and spend more time in the water than most deer. Moose seek out aquatic vegetation during the summer, in addition to their basic diet of broad-leafed trees and shrubs (e.g. willow). In winter, balsam fir is an important food. These large animals require about 5 pounds (2.3 kg) of browse per hundred pounds of moose per day (i.e. approximately 50 pounds (22.7 kg) per day for a medium-sized bull). Wolves are the main predators of the moose. They are adept at weeding out old, weak and younger animals. Brown bears are sometimes able to prey on cows and calves in spring, and black bears can run fast enough to catch moose calves (Peterson 1966, pp. 326-329; Banfield 1974, p. 396).

Rangifer tarandus (caribou)

Caribou remains (Figures 72b, 73A-B, 74A-B, Tables 81-84) are among the most common from Yukon Pleistocene deposits. Of hundreds of specimens collected, only the more complete antlers, cranial fragments and metapodials are described. Most antlers are of the cylindrical type that presently characterize the barren-ground subspecies. The fossil evidence from Old Crow suggests that caribou occupied that area throughout the late Pleistocene, perhaps from Illinoian time to the present.

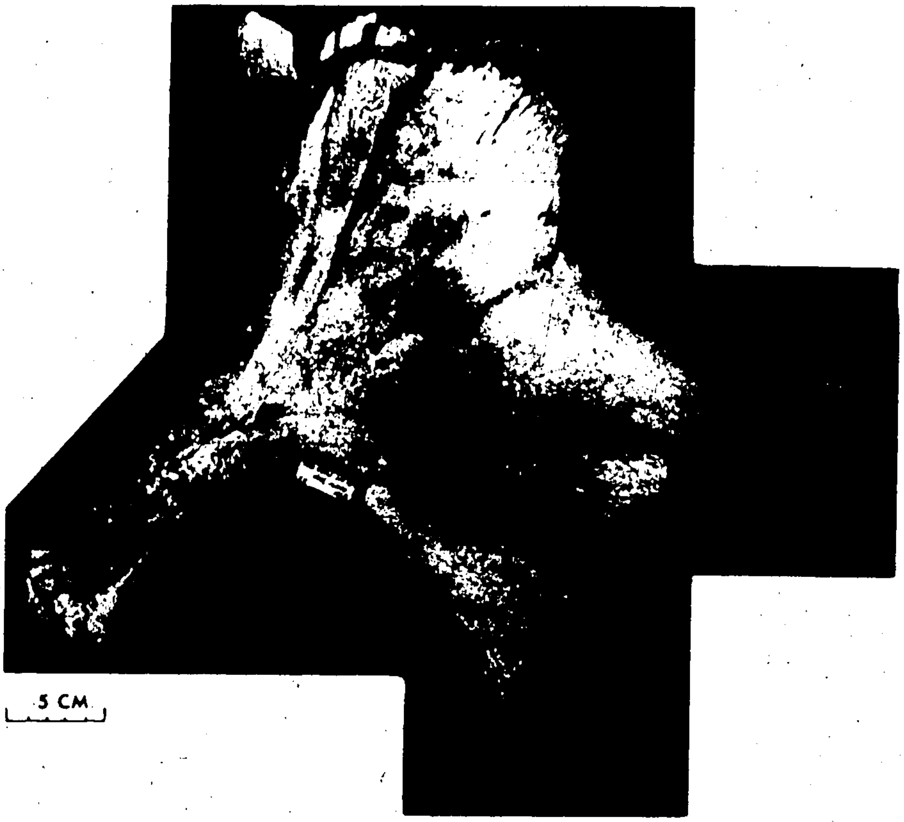
Antlers are common in the collection. Most consist of the proximal half of the beam with broken tines and were shed.

Referred specimens

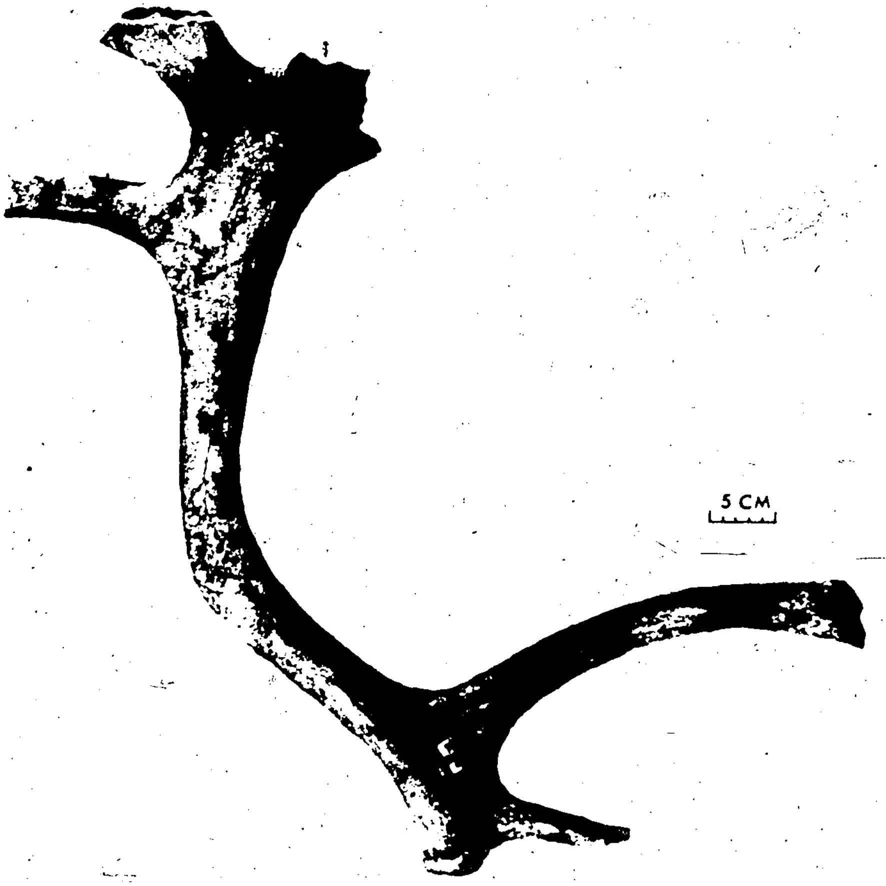
Referred left antlers - NMC 13538 from Dawson Locality 32 is a buff-colored, shed antler that is complete except for the tips of the tines. A keel if formed in place of the first posterior tine. Proximal portions of the second and third posterior tines are present. A 650 mm segment of beam is

Figure 72. A. Dorsal view of a left antler fragment (NMC 16255, Old Crow Locality 18) of a Pleistocene moose *(Alces alces)*.

B. Medial view of a left antler (NMC 13538, Dawson Locality 32) of a Pleistocene caribou *(Rangifer tarandus)*.



A

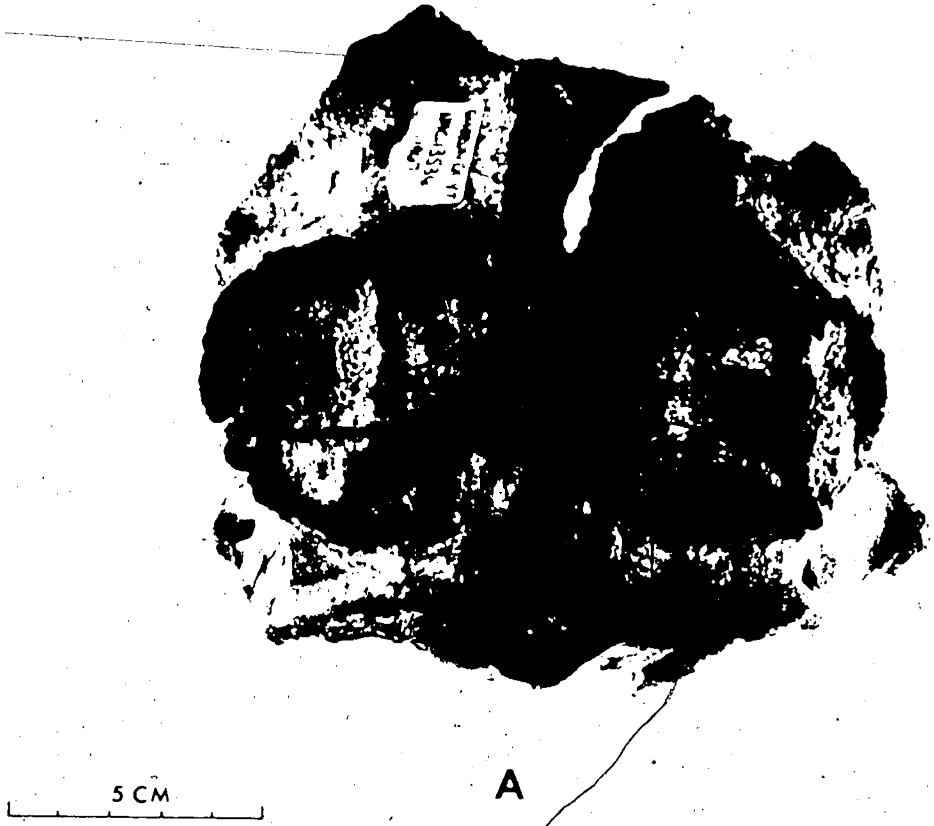


B

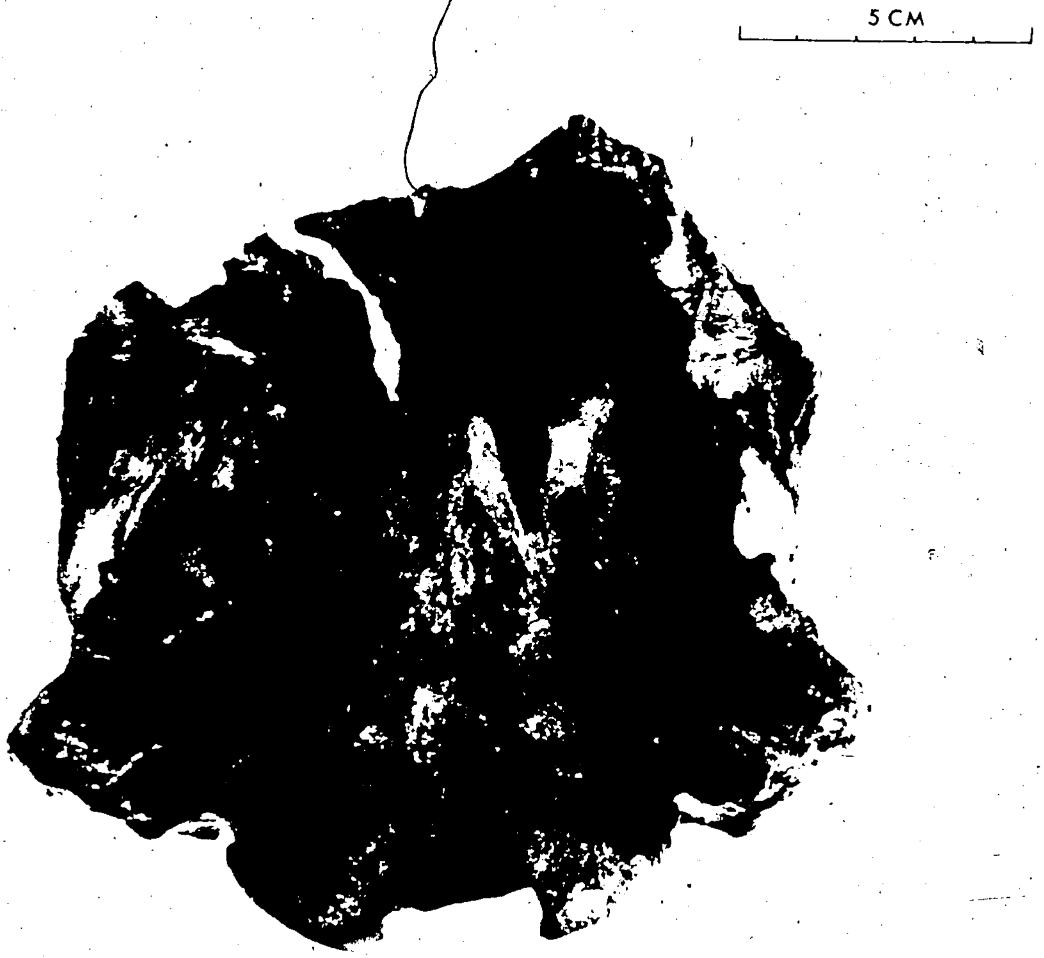
Figure 73. Posterior cranial fragment (NMC 13536, Dawson Locality 32) of a Pleistocene caribou *(Rangifer tarandus)*.

A. Dorsal view. Note circular antler pedicel areas on either side of the frontal suture.

B. Ventral view.



A



B

Figure 74. Right mandible with RP_2-RM_3 (NMC 24211, Old Crow Locality 12) of a Pleistocene caribou *(Rangifer tarandus)*.

A. Lateral view.

B. Occlusal view.


5 CM
5 CM
A
B

Table 81. Measurements of Pleistocene caribou *(Rangifer tarandus)* antlers from the Yukon Territory.

Specimens	Measurements (mm)*						
	1	2	3	4	5	6	7
Rangifer tarandus. Pleistocene, Y.T.							
NMC 13538 Dawson Loc. 32	47.7	45.4	71.3	40.5	46.3	39.8	270e
NMC 13539 Dawson Loc. 32	39.0	32.6	45.0	33.8	40.3	32.4	260
NMC 13543 Dawson Loc. 32	45.9	40.0	47.8	33.3	37.8	34.4	-
NMC 13544 Dawson Loc. 32	36.0	27.8	37.0	24.2	29.5	27.7	225
NMC 11643 Dawson Loc. 32	45.3	39.1	40.7	32.7	37.7	35.2	-
NMC 13540 Dawson Loc. 32	49.0	41.7	40.6	33.5	-	-	-
NMC 20838 Old Crow Loc. 11A	50.0	38.5	42.5	32.0	35.8	31.9	340
NMC 17320 Dawson Loc. 7	50.6	44.7	44.2	38.4	36.4	36.4	-
NMC 14009 Old Crow Loc. 3	40.6	34.6	36.2	28.8	33.2	26.7	340
NMC 17195 Old Crow Loc. 11	60.9	50.4	45.2	36.8	45.0	34.8	360
NMC 25926 Dawson Loc. 16	47.8	39.3	45.4	33.1	43.7	32.9	360
NMC 25925 Dawson Loc. 16	47.4	41.4	39.8	32.8	33.3	33.8	-
NMC 11724 Dawson Loc. 28	43.0	41.4	50.2	39.2	41.3	37.5	380
NMC 11334 Dawson Loc. 25	49.2	43.1	43.3	37.0	47.9	36.0	275
NMC 28583 Old Crow Loc. 71	39.3	35.3	44.8	30.1	32.9	29.0	-
NMC 17595 Dawson Loc. 28	40.0	33.3	33.3	29.9	30.5	27.5	270
NMC 20839 Old Crow Loc. 11A	43.4	36.0	40.7	32.0	35.0	29.6	
NMC 20454 Old Crow Loc. 20	55.2	39.5	-	-	39.8	35.9	
NMC 17907 Dawson Loc. 32	46.8	37.6	48.4	35.0	46.3	30.6	
NMC 18198 Old Crow Loc. 44	41.3	35.4	39.0	31.1	34.3	31.1	
NMC 11335 Dawson Loc. 25	48.3	42.1	44.7	36.4	44.8	36.2	
NMC 28955 Old Crow Loc. 22	47.8	43.6	44.9	35.8	45.2	33.5	440e
NMC 25260 Peel Plateau Loc. 1	35.6	30.6	38.0	29.5	34.7	29.3	-
NMC 7752 Dawson Loc. 9	51.6	41.3	53.2	39.1	50.0	37.2	265
NMC 14848 Old Crow Loc. 27	33.3	28.0	-	-	31.7	25.9	350
NMC 20128 Old Crow Loc. 74	51.0	40.9	45.5	32.6	42.6	31.0	-
NMC 23207 Old Crow Loc. 27	43.1	37.3	38.2	30.8	33.8	29.5	-
NMC 14933 Porcupine Loc. 35	34.0	28.9	38.5	27.0	35.8	26.2	290
NMC 25213 Dawson Loc. 29	35.5	26.6	41.6	23.5	28.3	24.0	275
NMC 17357 Dawson Loc. 2	45.9	45.7	42.0	33.7	39.5	-	-
NMC 29019 Dawson Loc. 16	47.0	44.0	52.5	42.5	42.0	36.3	-
NMC 11347 Dawson Loc. 2	39.6	39.1	37.9	32.8	35.1	31.3	-
NMC 29138 Sixtymile Loc. 3	38.9	35.3	39.4	27.8	29.7	27.3	-
NMC 24197 Old Crow Loc. 82	33.4	31.1	38.1	25.9	-	-	-
NMC 23208 Old Crow Loc. 133	41.9	28.4	41.2	33.3	[illegible].0	29.7	-
NMC 26880 Old Crow Loc. 22	48.7	37.6	-	-	37.2	37.3	-
NMC 14347 Old Crow Loc. 14N	38.9	40.0	-	-	35.5	32.0	-
NMC 16465 Old Crow Loc. 53	47.1	45.2	47.3	40.2	45.7	34.8	-
NMC 27403 Old Crow Loc. 81	43.2	42.2	43.7	46.5	40.0a	35.4	-
NMC 27450 Old Crow Loc. 65S	34.2	27.6	32.2	21.3	-	-	-
NMC 25965 Old Crow Loc. 25	31.7	25.4	31.2	20.9	23.6	20.3	-
NMC 26796 Old Crow Loc. 20	40.4	34.3	43.6	33.9	-	-	-
NMC 28343 Old Crow Loc. 136	36.5	34.0	35.2	31.2	-	-	-
NMC 27081 Old Crow Loc. 32E	44.4	41.9	46.8	36.1	41.9	36.3	-
NMC [illegible] Old Crow Loc. 114	37.3	35.2	34.6	36.1	34.9	29.9	-
NMC 29137 Sixtymile Loc. 3	21.6	19.7	20.5	15.8	-	-	-

---

* 1 - Anteroposterior diameter of antler base (or pedicel below burr, if antler is attached to cranium).

2 - Mediolateral diameter of antler base (or pedicel below burr, if antler is attached to cranium).

3 - Minimum anteroposterior diameter of beam between first (brow) and second (bez) anterior tines.

4 - Minimum mediolateral diameter of beam between first and second anterior tines.

5 - Anteroposterior diameter of beam 100 mm distal to the centre of the second anterior tine.

6 - Mediolateral diameter of beam 100 mm distal to the centre of the second anterior tine.

7 - Straight line distance from posterior of burr to cen of base of first posterior tine (where present).

Table 82. Measurements of Pleistocene caribou (*Rangifer tarandus*) crania from the Yukon Territory compared to those of Recent caribou from North America.

Specimens	Sex	Measurements (mm)*							
		1	2	3	4	5	6	7	8
Rangifer tarandus. Pleistocene, Y.T.									
NMC 13536 Dawson Loc. 32	♂	90.0	100.8	61.0	84.2	70.8	42.6	102.0	114.0e
LUM 1.16 Dawson Loc. 32	-	88.6	87.2	53.9	74.5	65.3	41.5	102.0	101.1
NMC 14905 Old Crow Loc. 31	♂	72.0	97.0	55.4	86.0	76.7	46.0	104.6	-
NMC 25924 Dawson Loc. 16	-	74.0	98.0	55.9	81.3	68.1	42.3	94.9	-
NMC 25179 Dawson Loc. 16	♂	79.0	-	61.5	-	69.4a	-	105.3	119.9
NMC 16368 Old Crow Loc. 66	-	67.2a	84.6a	51.3a	73.6a	70.7	44.5	-	-
NMC 13621 Old Crow Loc. 2	-	70.8a	92.3a	59.0	85.2	69.2	42.0a	-	-
NMC 25183 Dawson Loc. 16	♂	-	-	-	-	-	-	95.0e	106.5
NMC 17400 Sixtymile Loc. 1	♂	-	-	-	-	-	-	109.3	120.3
NMC 14016 Old Crow Loc. 2	-	-	-	-	-	68.3	44.5	-	-
NMC 27807 Old Crow Loc. 83	-	-	-	-	-	68.5	47.6	-	-
NMC 25968 Dawson Loc. 29	-	-	-	-	-	-	-	99.1	-
Rangifer tarandus granti. Recent, N. America									
NMC 22808 Alaska	♂	91.2	101.1	60.0	80.6	69.6	43.4	100.0	102.4
NMC 2270 Y.T.	♂	89.5	107.0	68.1	88.6	82.8	52.4	102.0	96.9
NMC 2263 Y.T.	♀	78.0	96.2	58.1	80.2	73.9	43.2	94.6	94.6
Rangifer tarandus groenlandicus. Recent, N. America									
NMC 24326 N.W.T.	♂	93.5	105.6	63.4	88.7	67.8	52.7	107.6	113.1
NMC 22111 Man.	♀	79.9	82.1	71.6	70.8	67.8	42.1	87.6	87.9
NMC 22104 N.W.T.	♀	72.0	80.3	49.1	72.8	62.6	39.1	86.6	91.1
Rangifer tarandus pearyi. Recent, N. America									
NMC 22827 N.W.T.	♂	74.9	97.0	55.8	89.9	63.7	40.4	89.3	95.4

* 1 - Cranial height, dorsal lip of foramen magnum to highest point on frontal suture between antler pedicels.

2 - Cranial height, ventral margin of occipital condyle to highest point on frontal suture between antler pedicels.

3 - Occipital height, dorsal lip of foramen magnum to top of nuchal crest.

4 - Occipital height, ventral margin of occipital condyle to top of nuchal crest.

5 - Maximum width across occipital condyles.

6 - Maximum width across posterolateral margins of basioccipital.

7 - Minimum width of cranium below and just posterior to antler pedicels.

8 - Minimum width across frontals immediately anterior to antler pedicels.

\ light copy

Table 83. Measurements of Pleistocene caribou *(Rangifer tarandus)* mandibles compared to those of Recent caribou from North America.

Specimens	Sex	Estimated Age ([illegible]	Measurements (mm)* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Rangifer tarandus, Pleistocene, Y.T.																		
NMC 14339 Old Crow Loc. 14N	-	6	28.8	14.7	54.6	10.1	7.5	15.0	10.6	17.3	11.5	10.9	9.6	19.3	11.0	21.9	10.1	97.5
NMC 29050 Dawson Loc. 30	-	14	28.8	14.3	-	7.6^{+}	6.2^{+}	14.1	-	14.6	11.0	16.9	10.1	18.7	11.2	26.2e	10.7	98.6e
NMC 28737 Old Crow Loc. 11	-	5	31.8	15.8	39.9	12.3	8.9	16.2	11.3	18.3	13.1	18.8	11.0	-	-	-	-	-
NMC 14991 Old Crow Loc. 69	-	4	-	17.0	-	-	-	-	-	-	-	20.8	11.8	21.9	12.4	23.4	11.2	-
NMC 22889 Old Crow Loc. 11A	-	15	-	15.2e	-	-	-	14.1	10.7	16.7	11.4	16.0	9.7	12.9	10.9	-	-	-
NMC 17083 Old Crow Loc. 8	-	4	29.1	15.4	47.2	-	-	-	-	-	-	-	-	-	-	-	-	108.2e
NMC 26591 Old Crow Loc. 11A	-	2	-	13.8	50.4**	-	-	11.1**	6.7**	19.5**	8.6**	17.6	9.6	18.8	10.5	22.0	-	100.6e**
NMC 13607 Old Crow Loc. 11A	-	1.5a	24.5	12.6	42.5**	8.4**	4.8**	12.3**	6.5**	19.4**	7.9**	18.2	9.2	-	-	-	-	-
NMC 26976 Old Crow Loc. 22	-	.25	23.6	12.6	-	8.9**	4.7**	13.9**	6.8**	23.0**	9.1**	-	-	-	-	-	-	-
NMC 28739 Old Crow Loc. 4	-	.17	20.3	11.9	-	9.0**	4.4**	13.5**	7.1**	22.2**	9.0**	-	-	-	-	-	-	-
Rangifer tarandus, Recent, Alaska																		
NMC 32207	♀	3.5	29.3	13.5	52.0	10.0	7.1	14.1	9.2	16.0	10.4	17.2	9.0	18.3	9.8	23.5	10.2	98.0
Rangifer tarandus groenlandicus, Recent, N.W.T. (Miller 1974, Tables 7, 8)																		
Males																		
M	♂♂	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	97.0
N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	236
SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.8
Females																		
M	♀♀	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	95.7
N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	334
SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.4

* 1 - Mandibular depth at centre of M_1.
2 - Mandibular width at centre of M_1.
3 - Length from anterior of P_2 alveolus to posterior of mental foramen.
4 - P_2 length.
5 - P_2 width.
6 - P_3 length.
7 - P_3 width.
8 - P_4 length.
9 - P_4 width.
10 - M_1 length.
11 - M_1 width.
12 - M_2 length.
13 - M_2 width.
14 - M_3 length.
15 - M_3 width.
16 - P_2-M_3 alveolar length.

** Measurements taken on deciduous teeth or from alveoli of deciduous teeth.

Light copy

Table 84. Measurements of Pleistocene caribou (*Rangifer tarandus*) metapodials from the Yukon Territory compared to those of Recent caribou from Alaska and the Northwest Territories.

Specimens	Sex	Measurements (mm)*						
		1	2	3	4	5	6	7
Metacarpals								
Rangifer tarandus.								
Pleistocene, Y.T.								
NMC 26690 Old Crow Loc. 27W	-	218.4	38.4	28.6	25.6	26.4	46.0	24.6
NMC 14698 Old Crow Loc. 28	-	214.7	37.2	26.9	22.9	21.5	44.2	24.3
NMC 15268 Old Crow Loc. 22	-	208.7	37.0	28.0e	20.1	21.8	45.3	23.2+
NMC 29126 Sixtymile Loc. 3	-	200.3	34.9	26.3	19.4	21.4	43.6	22.2
NMC 29125 Sixtymile Loc. 3	-	197.5	35.0	[illegible]	21.9	21.3	43.1	23.2
NMC 26774 Old Crow Loc. 20	-	197.3	33.8	[illegible]	20.3	20.0	42.2	22.1
NMC 15356 Old Crow Loc. 14N	-	196.7	38.4	27.9	23.9	23.7	45.3	23.8
NMC 25242 Dawson Loc. 2	-	194.1	36.2	26.8	18.6	21.3	43.6	23.3
Rangifer tarandus.								
Recent, Alaska								
NMC 32207	♀	215.8	35.9	26.7	21.3	19.9	45.9	25.2
Metatarsals								
Rangifer tarandus.								
Pleistocene, Y.T.								
NMC 14950 Eagle Loc. 37	-	292.7	31.2	36.2	27.9	30.2	43.9	25.0
NMC 13537 Dawson Loc. 32	-	279.0	32.2	35.0	24.4	32.9	43.5	21.6+
NMC 29251 Old Crow Loc. unknown	-	257.1	-	-	17.0	21.6	34.5+	20.0+
NMC 17248 Dawson Loc. 28	-	255.3	27.1	32.3	19.8	29.0	39.2	21.2
Rangifer tarandus.								
Recent, N. America								
NMC 32213 Alaska	♀	291.6	35.7	38.9	25.0	37.1	47.5	26.5
NMC 22972 N.W.T.	♂	267.4	31.1	35.7	26.3	34.7	42.4	24.8
NMC 22980 N.W.T.	♂	261.4	29.3	31.9	20.0	28.7	40.7	23.0
NMC 22978 N.W.T.	♂	255.3	29.5	33.5	23.2	30.3	41.2	23.1

*1 - Total length.
2 - Proximal width.
3 - Proximal depth.
4 - Midshaft width.
5 - Midshaft depth.
6 - Distal width.
7 - Distal depth.

preserved. The specimen is on display in the National Museum of Natural Sciences, Ottawa. NMC 27953 from Old Crow Locality 114 is a shed antler with stubs of the brow (first anterior) and bez (second anterior) tines. A 190 mm segment of beam is preserved. The specimen is stained orange-brown. NMC 27081 from Old Crow Locality 32E is a shed antler with stubs of the brow and bez tines. A 240 mm segment of beam is preserved. It is stained black. NMC 28343 from Old Crow Locality 136 is a shed antler with the stub of the brow tine and approximately a quarter of the bez tine. A 190 mm segment of beam is preserved. The surface of the fossil is pitted. It is stained dark brown. NMC 26796 from Old Crow Locality 20 is a shed antler with proximal halves of the brow and bez tines. The beam, of which 190 mm is preserved, is compressed laterally and spreads anteroposteriorly between the tines, approaching the woodland caribou form. The surface of the specimen is deeply pitted and is stained brownish black. NMC 17357 from Dawson Locality 2 is a shed antler with a stub of the brow tine and about half of the bez tine (which seems to have been gnawed at the distal extremity). The brow and bez tines are relatively far apart (160 mm). Pyrolusite "stars" are seen on the medial surface. A 290 mm segment of beam is preserved. NMC 25213 from Dawson Locality 29 is a shed antler with stubs of the brow, bez and first posterior tines. A 330 mm segment of beam is preserved. Material in cracks suggests that the fossil was deposited in a peat layer.

NMC 13540 from Dawson Locality 32 is a shed antler with proximal halves of brow and bez tines. A 290 mm segment of beam is preserved. It is rust colored. NMC 25260 from Peel Plateau Locality 1 is a shed antler with a stub of the brow tine, and the proximal third of the bez tine. An incipient tine is evident on the lateral surface at the level where a first posterior tine is usually found. A 580 mm segment of the beam is preserved. It was not found in place, but S.C. Zoltai, who collected it, remarked that it was probably from a peat layer of Pleistocene age. NMC 13539 from Dawson Locality 32 is a shed antler with proximal thirds of the brow and bez tines and the base of the first posterior tine. A 480 mm segment of the beam is preserved. It varies from orange-brown to black. NMC 20839 from Old Crow Locality 11A is attached to a small part of the cranium. The distal half of the brow tine and most of the bez tine is lacking. A 300 mm segment of beam is present. The fossil is brownish black and has been deeply pitted by acids in the groundwater. The pits are mainly concentrated on the dorsal surface. NMC 28583 from Old Crow Locality 71 is a shed antler with complete (300 mm long) brow tine. The tip of the bez tine is missing and no first posterior tine or keel is developed. A 740 mm segment of beam is preserved. The specimen is stained dark brown. NMC 11724 from Dawson Locality 28 is a shed antler with the stub of the brow tine, a large bez tine lacking the tip, and the stub of a small, laterally compressed first posterior tine. A 580 mm segment of beam is preserved. It is light buff to tan. NMC 25925 from Dawson Locality 16 is a shed antler with a stub of the brow tine, and about half of the bez tine. A 430 mm segment of beam is preserved. A first posterior tine is not present. The fossil is dark tan. NMC 14009 from Old Crow Locality 3 is a heavily weathered, iron-stained antler beam with attached cranial fragment. The stub of the brow tine and the proximal third of the bez tine are present. The first posterior tine is very small. NMC 20838 from Old Crow Locality 11A consists of most of a beam fused to a small cranial fragment. The distal half of the brow tine and the end of the bez tine are missing. A keel is developed in place of the first posterior tine. A 600 mm segment of beam is preserved. The fossil is stained rusty brown.

Referred right antlers - NMC 11643 from Dawson Locality 32 consists of most of a tan colored antler beam fused to a cranial fragment. The stub of the brow tine and half of the bez tine are present. A 600 mm segment of beam is preserved. NMC 17320 from

Dawson Locality 7 consists of most of a tan colored shed antler, lacking the ends of brow and bez tines. The bez tine has deep gnaw marks. A broad ridge, but not a keel, is developed in place of a first posterior tine. A 720 mm segment of beam is preserved. Fine rootlet impressions cross the surface of the fossil. NMC 17195 from Old Crow Locality 11 consists of an antler beam attached to a cranial fragment. The tips of brow and bez tines are missing. A small, incipient tine is located 20 mm distal to the bez tine. The tip of the first posterior tine is lacking. A 420 mm segment of beam is preserved. The specimen is stained deep brown. NMC 25926 from Dawson Locality 16 is a shed antler with only the stubs of brow, bez and first posterior tines. It is stained light, reddish brown, and has been radiocarbon dated at 23,900 ± 470 years B.P. (I-8580), which tends to support the idea that caribou were present near Dawson near the peak of the last glaciation. NMC 11334 from Dawson Locality 25 is a shed antler with most of a well developed brow tine. Approximately two-thirds of the bez tine, and the stub of the first posterior tine are present. A 440 mm segment of beam is preserved. The fossil is stained deep brown. NMC 17595 from Dawson Locality [illegible] shed antler with stubs of brow and bez tines. A [illegible] is developed in place of the first posterior tine. A 600 mm segment of beam is preserved. It is stained dark rust. NMC 20454 from Old Crow Locality 20 is a shed antler with short portions of the brow and bez tines - which, in this specimen, originate at the same point near the burr. A 420 mm segment of beam is preserved. The surface of the specimen is stained light rusty brown. NMC 17907 from Dawson Locality 32 is a shed antler with a stub of the brow tine and the proximal half of the bez tine. The base of the laterally compressed first posterior tine is present. Gnaw marks are seen on the surface of the beam opposite the first posterior tine, and on the bez tine. NMC 18198 from Old Crow Locality 44 is a shed antler with a stub of the brow tine and the proximal half of the bez tine. The beam is relatively straight, and there is no evidence of a first posterior tine. A 450 mm segment of beam is preserved. Although this fossil was not in place in Unit 2, other caribou remains were collected from that unit, which may be of Sangamon interglacial age. NMC 18198 was evidently derived from a peat deposit, for peat adhered tightly to most of its surface. Samples of this peat were taken for identification. NMC 11335 from Dawson Locality 25 is a shed antler with a stub of brow tine, half of a well developed bez tine, and the stub of a small first posterior tine. A 470 mm segment of beam is preserved.

The surface of the specimen is rust colored. NMC 28955 from Old Crow Locality 22 is a shed antler with a third of the brow tine, two-thirds of a well developed bez tine and part of a small first posterior tine. A 680 mm segment of beam is preserved. NMC 7752 from Dawson Locality 9 is a short, robust, laterally compressed, shed antler. It appears to be more like woodland caribou than tundra caribou antlers (Banfield 1961, p. 34). The brow tine is broken near the base and approximately a quarter of the large, flattened bez tine is preserved. The first posterior tine is poorly developed. A 360 mm segment of beam is present. Gnaw marks are evident on the [illegible] near the first posterior tine. NMC 13543 from Dawson Locality 32 is a shed antler with the stubs of brow and bez tines. A 350 mm segment of beam is preserved. The specimen is rusty brown in color. NMC 14848 from Old Crow Locality 27 is a shed antler with the stub of a laterally compressed brow tine. No bez tine is developed. the first posterior tine is heavily eroded. A 590 mm segment of beam is preserved. It is stained dark brown. NMC 20129 from Old Crow Locality 74 is a brownish black, shed antler with a trace of the brow tine and approximately half of the bez tine. A 420 mm segment of beam is preserved. NMC 23027 from Old Crow Locality 27 is a shed antler with a stub of the brow tine, and a quarter of the bez tine. It should be examined by archeologists, for the brow tine may have been cut off. Part of a slanting, polished facet is preserved on the medial surface of the stub. A 400 mm segment of beam is preserved. NMC 13544 from Dawson Locality 32 is a heavily iron-stained, shed antler with approximately half of the brow tine and the stub of the bez tine. Damage to the beam may have resulted in its abnormal lateral convexity between the bez and first posterior tines. A 300 mm segment of beam is preserved. NMC 14933 from Porcupine Locality 35 is a dark brown shed antler. Both brow and bez tines are broken near their points of origin. A stub of the first posterior tine is present. A 380 mm segment of beam is preserved. NMC 29019 from Dawson Locality 16 is a shed antler with approximately a third of the brow tine and half of the bez tine. A 230 mm segment of beam is preserved. It is stained orange-brown. NMC 11347 from Dawson Locality 2 is a shed antler with halves of the brow and bez tines. A 240 mm segment of beam is preserved. It is grayish buff. NMC 29138 from Sixtymile Locality 3 has a stub of the brow tine and approximately half of the bez tine. The antler beam, of which 250 mm is preserved, is attached to a small cranial fragment. NMC 24197 from Old Crow Locality 82 is an antler with two-thirds of the brow and bez tines. It is attached to a fragment of the

braincase. A 140 mm segment of beam is preserved.
NMC 23208 from Old Crow Locality 133 is a shed antler with only a nubbin in the position of the brow tine, and a stub of a large bez tine. The posterior edge of the antler base may be faceted. A 250 mm segment of beam is preserved. The fossil is dark brown to black. NMC 26880 from Old Crow Locality 22 is a heavily iron-stained antler with brow and bez tines having the same point of origination above the burr. Possibly half of the brow tine is present. The bez tine is broken near its source on the beam. The antler is attached to a small cranial fragment. The distal 85 mm of the beam was heavily gnawed by a medium-sized to large carnivore. NMC 14347 from Old Crow Locality 14N is an antler with the stub of a brow tine. No bez tine is seen. The antler is attached to a fragment of the braincase. A 200 mm segment of beam is preserved. It is stained orange-brown. NMC 16465 from Old Crow Locality 53 is a shed antler with stubs of brow and bez tines. It is stained a light rust color. NMC 27043 from Old Crow Locality 81 is a shed antler with part of the brow tine and a stub of the bez tine. The distal part of the bez tine was gnawed. A 190 mm segment of beam is preserved. It is stained dark brown. NMC 27540 from Old Crow Locality 65S is a small, heavily eroded, shed antler with stubs of brow and bez tines. A 150 mm segment of beam is preserved.

It is dark brown. NMC 25965 from Old Crow Locality 25 is a shed antler. The brow tine has been broken off at the base, and approximately a quarter of the bez tine is present. A 260 mm segment of beam is preserved. It is stained reddish brown. NMC 29137 from Sixtymile Locality 3 is a shed antler of a female. It lacks a brow tine, but most of the bez tine is present. A 150 mm segment of beam is preserved. It is light buff. Because female antlers are dropped during the calving period, this specimen indicates that some caribou calving occurred in the Sixtymile area during the late Wisconsin.

The fact that 33% of 24 male caribou antlers sampled from the Old Crow - Porcupine region were unshed and that 10% of 20 male antlers sampled from the Dawson - Sixtymile region were unshed suggests that many male caribou were present in both regions during the winter (when they drop their antlers) and that more bucks died in the late summer or autumn (when their antlers are well developed) in the Old Crow - Porcupine region than in the Dawson - Sixtymile region. Possibly a number of these deaths occurred during the rutting period.

Several cranial fragments are in the collections from the Yukon. NMC 13536 from Dawson Locality 32 lacks antlers and bone anterior to the orbits. It is cracked near the frontal suture. Apparently the antlers were shed not long before the death of the individual represented. Maximum diameter of the antler scars is approximately 50 mm. NMC 13536 is comparable in size to crania of Recent adult male barren-ground caribou (NMC 22808, 24326). It is tan in color. LUM 1.16 from Dawson Locality 32 also lacks antlers and bone anterior to the orbits.

NMC 14905 from Old Crow Locality 31 is a posterior cranial fragment. It represents a male according to the large diameter (55 mm) of the antler scars. The relatively high degree of fusion of the frontal suture suggests that the fossil represents an animal in advanced adulthood. Occipital and basioccipital surfaces are minutely pitted, probably due to acids in the groundwater. NMC 14905 is dark brown. NMC 25924 from Dawson Locality 16 is a posterior cranial fragment lacking the entire bottom of the braincase and the left occipital condyle. The frontal extends approximately 40 mm forward from the supraorbital foramina. Maximum diameter of the antler scars is about 42 mm. The bone is tan.

NMC 25179 from Dawson Locality 16 is a posterior cranial fragment with eroded occipital margins. Maximum diameter of the antler scars is 34 mm. The fossil is stained orange-buff. NMC 16368 from Old Crow Locality 66 is a cranial fragment lacking bone anterior to the antler pedicels. The dorsal surface of the fragment is heavily eroded, and parts of the left side of the occiput are lacking, including much of the left occipital condyle. It is stained reddish brown.

NMC 13621 from Old Crow Locality 2 consists of most of the occipital region and part of the basicranium. The bone is stained light brown on the surface, but has a rather chalky appearance inside. It may be of Pleistocene to Recent age. NMC 25183 from Dawson Locality 16 is the dorsal part of a braincase consisting of most of the frontal and parietal bones to which proximal parts of both antlers are attached. Presumably the caribou represented by the fossil died in late summer or autumn near Dawson. The largest of the two pedicels measures approximately 39 mm x 34 mm below the burr. Probably a male in early adulthood is represented. The fossil is tan.

NMC 17400 from Sixtymile Locality 1 was collected by H.S. Bostock in 1933. It consists of the posterior part of the frontals with the stubs of large antlers attached, the parietals, and the upper half of the occipital region. The largest pedicel below the burr measures approximately 60 mm x 52 mm. The surface of the specimen is highly oxidized. It and NMC 25179 are the largest cranial fragments in the collection. NMC 11645 from Dawson Locality 32 consists of the right temporal region and a portion of the right frontal of a braincase with the proximal half of an antler attached. The small size of the antler, which lacks a brow tine, but possesses the stub of the bez tine, indicates that the fossil was derived from a female, and further that it had probably died near Dawson between October and May. The pedicel below the burr measures 25 mm x 23 mm. A 170 mm segment of beam is preserved.

NMC 14016 from Old Crow Locality 2 consists of central and left parts of the basicranial region. It is stained deep, reddish brown. NMC 27807 from Old Crow Locality 83 consists of the occipital condyle, the posterior half of the basioccipital, and some surrounding bone. It is gray with rusty brown patches.

NMC 25968 from Dawson Locality 29 is the upper part of a braincase with antler pedicels. The maximum diameter of the antler scars is 36 mm. An interesting feature of the specimen is that much of its surface, which is tan in color, is covered by a thick layer of gray siltstone that may be [illegible] nic origin. A cursory examination revealed [illegible] appear to be small shards of volcanic glass in [illegible] ground mass. It may offer the possibility of a check between a radiocarbon date on bone collagen and an age estimate derived from analysis of the glass shards. NMC 13620 from Old Crow Locality 11A is another frontlet bearing pedicels with antler scars reaching a maximum diameter of 42 mm. It represents a male. This small fragment of bone is relatively heavy and is stained black. It is probably of pre- late Wisconsin age.

Eleven mandibular fragments are described. In most cases the mandibular bone is brown, as is the dentine exposed on the occlusal surfaces of the teeth. The fossils range in age from juvenile to very old. Estimates of the chronological ages of the caribou represented by these fossil mandibles with teeth are based on Miller's (1974, Plates A, B) carefully calibrated chronological series, including mandibles with teeth from one quarter month to 17 years of age. His data are derived from a study of mandibles from more than 900 individuals of both sexes of barren-ground caribou *(Rangifer tarandus groenlandicus)* belonging to the Kaminuriak population, which ranges from northern Manitoba and Saskatchewan to southeastern Keewatin in the Northwest Territories.

Referred left mandibles - NMC 28739 from Old Crow Locality 4 is a complete mandible except for bone anterior to the mental foramen. dLP$_2$-dLP$_4$ are present, and LM$_1$ has started to erupt. I estimate that the specimen represents a 2-month-old calf. The mandibular bone is stained reddish brown. NMC 26976 from Old Crow Locality 22 is the posterior part of a mandible with slightly worn dLP$_2$-dLP$_4$. LM$_1$ has erupted and part of LM$_2$ can be seen through a break in the bone posterior to LM$_1$. I estimate that this fossil represents a 3-month-old calf. The diastema and bone on the inferior margin of the mandible (below dLP$_2$-dLP$_4$) are lacking. NMC 28737 from Old Crow Locality 11 has LP$_2$-LM$_1$ and partial alveoli for LM$_2$-LM$_3$. The mandible lacks bone anterior to the mental foramen and posterior to the alveolus for LM$_3$. The teeth present are well worn, and I estimate that a 5-year-old caribou is represented.

Referred right mandibles - NMC 13607 from Old

Crow Locality 11A is a mandible lacking the anterior tip and bone posterior to RM_2. dRP_2-dRP_4 are well worn. RM_1 and the alveolus for RM_2 are present. I estimate that the mandible was derived from a 17-month-old caribou. NMC 26591 from Old Crow Locality 11A is a mandible lacking the anterior tip and bone posterior to RM_3. dRP_2 is lost and both dRP_3 and dRP_4 are heavily worn. RM_1 and RM_2 are moderately and slightly worn, respectively. RM_3 has erupted and its unworn crests are approximately 5 mm above the alveolar margin. I estimate that the specimen represents an animal that is nearly 2 years old (more precisely 22 months). NMC 14991 from Old Crow Locality 69 is a mandibular fragment with the anterior root and posterior cusp of RP_4, and RM_1-RM_3. The anterolingual portion of RM_3 is broken and occlusal wear on its posterior cusps is slight. I estimate that the specimen represents a 4-year-old animal. NMC 17083 from Old Crow Locality 8 consists of most of a mandible except for the anterior tip and bone posterior to RM_3. The roots of RM_1, part of the posterior cusp of RM_2, and the alveoli for the remaining cheek teeth are present. I estimate that it is from an approximately 4-year-old animal. The bone is tan - more like late Wisconsin bone from Old Crow and Dawson areas than the evidently older more deeply stained bone from those regions.

NMC 14339 from Old Crow Locality 14N consists of a mandible lacking the anterior tip and the ascending ramus above the level of the cheek teeth. The teeth comprise moderately worn RP_2-RM_3. I estimate that the caribou that this specimen represents was 6 years old. NMC 29050 from Dawson Locality 30 is the central part of a mandible with heavily worn RP_2-RM_3. The teeth are slightly chipped. The small size of the loops on RM_1 indicates that the animal from which the fossil was derived had reached an age of approximately 14 years. NMC 22889 from Old Crow Locality 11A is a mandible with heavily worn RP_3-RM_2, and partial alveoli for RP_2 and RM_3. The lateral surface is pitted, perhaps by acids in the groundwater. I estimate that the caribou represented by this specimen was about 15 years old at death. The loops on RM_1 have been almost completely worn away.

As mentioned previously with respect to horses, metapodials provide an insight into the size of mammals. Only complete metacarpals and metatarsals of Yukon Pleistocene caribou are described.

Referred left metacarpals - NMC 15356 from Old Crow Locality 14N seems to have been gouged and pitted by carnivore teeth on the proximal quarter of the shaft. It is stained dark brown.

Referred right metacarpals - NMC 26690 from Old Crow Locality 27W is stained blackish brown. NMC 14698 from Old Crow Locality 28 is dark reddish brown. It closely matches a metacarpal of a Recent female from Alaska (NMC 32207). NMC 15268 from Old Crow Locality 22 is split in the upper part of the shaft and eroded on the posterior surface of the distal articulation. It is stained brown. NMC 29126 from Sixtymile Locality 3 is light tan and relatively fresh in appearance. NMC 26774 from Old Crow Locality 20 apparently has tooth marks of a medium-sized carnivore that cross the length of the shaft. It is stained dark brown. NMC 29125 from Sixtymile Locality 3 is light tan and has fine rootlet impressions on its anterior surface. Pyrolusite "stars" are seen on the surface. A chip of bone is missing from the anteromedial part of the shaft. NMC 25242 from Dawson Locality 2 is light tan, and like NMC 29125 and 29126, is probably of late Wisconsin age.

Referred left metatarsals - NMC 13537 from Dawson Locality 32 lacks bone on both sides near the centre of the shaft. A fine pattern of rootlet impressions covers the surface, possibly indicating that the caribou represented died in a grassland environment. The bone is dark tan. NMC 29251 from an unknown locality in the Old Crow Basin is small and slender compared to NMC 13537. The upper half of the shaft is badly split. It is stained dark brown.

Referred right metatarsals.- NMC 14950 from Eagle Locality 37, although larger than any other Yukon Pleistocene metatarsals collected, is slightly smaller than the metatarsal of a Recent female from Alaska (NMC 32213). It is stained dark brown. NMC 17248 from Dawson Locality 28 is damaged on the lateral side near the proximal end of the shaft, and is cracked. It is light tan. The fossil metatarsals lie within the range of Recent caribou metatarsals from Alaska and the Northwest Territories.

Discussion

Caribou remains have been recorded from many localities throughout the unglaciated Yukon Territory, such as Dawson, Sixtymile, Old Crow, Porcupine River, Eagle River and Peel Plateau. They range in age from pre- late Wisconsin to postglacial. I have excavated specimens *in situ* from the organic subunit of the basal clay at Old Crow Localities 11 and 12, which may be of late

Illinoian age, and from Unit 2 at Old Crow Locality 44, which may be of Sangamon interglacial age (>54,000 years B.P.). Radiocarbon dates on caribou bone vary in age from mid-Wisconsin to postglacial. Radiocarbon analysis of bone from a fleshing tool made of a caribou tibia from Old Crow Locality 14N yielded a date of $27,000 \pm {}^{3,000}_{2,000}$ years B.P. (GX-1640). This specimen has been discussed previously under the genus *Homo*. An antler from Dawson Locality 16 yielded a date of 23,900 ± 470 years B.P. (I-8580), indicating that caribou were isolated in Eastern Beringia during the peak of the Wisconsin glaciation. Radiocarbon dates of 6,450 ± 135 years B.P. (I-4221) and 5,010 ± 100 years B.P. (I-8642) on an antler from Old Crow Locality 69 and a radio-ulna from Dawson Locality 8, respectively, indicate that caribou were in the Old Crow and Dawson areas during the warmest part (hypsithermal) of the postglacial. Mackay, *et al.* (1961, p. 34) mention a radiocarbon date of 3,250 years B.P. (P-228) on a caribou antler from the lower fossiliferous layer at Engigstciak near the arctic coast of the Yukon.

In other parts of Canada, caribou fossils have been reported from: gravels 3 feet (0.9 m) above bedrock and 165 feet (50.3 m) below the surface at Wingdam, British Columbia (Cowan 1941, p. 43), in what I consider may be interglacial deposits of Sangamon age or earlier - the specimen may represent a taxon other than *Rangifer tarandus*; Sangamon interglacial deposits at Medicine Hat, Alberta (Stalker and Churcher 1970); late Wisconsin gravels at Cochrane, Alberta. Fossils from these gravels have yielded radiocarbon dates of approximately 11,000 years B.P. (Churcher 1968, p. 1470); late Wisconsin to postglacial deposits near Toronto (e.g. Carleton Bar, Taylor's Brickyard), Ontario (Coleman 1899, p. 195; Hay 1923, p. 244); late Pleistocene to postglacial deposits in the Northwest Territories: e.g. Baillie Islands; Masik River, Banks Island; raised beaches of probable postglacial age near Alert, Ellesmere Island; postglacial (approximately 5,000 years old) deposits at Great Bear River; and Acasta Lake and Grant Lake (approximately 7,000 years old) (Banfield 1961, p. 34; Harington 1971a, pp. 82-83; Harington 1976 MS., pp. 49, 53).

In the conterminous United States, caribou remains are known from: Idaho, Iowa, Minnesota, Wisconsin, Illinois, Kentucky, Michigan, Tennessee, Virginia, Pennsylvania, New Jersey, New York, Vermont, Connecticut, Massachusetts, and Ohio (Anderson and White 1975, p. 63). Evidently a *Rangifer*-like form - possibly related to the rst group" (Cervidae - genera and species undetermined) of deer from the Yukon Pleistocene - occupied South Dakota during Nebraskan or Kansan time (Green and Lillegraven 1965, p. 48). Three records from Sullivan County, Tennessee (Guy Wilson, Beartown, and Baker Bluff caves), mark the southernmost known limits of caribou in North America. They lie some 200 miles (322 km) southeast of the Wisconsin terminal moraine in Ohio, and 800 miles (1,287 km) south of the known historic range of *Rangifer tarandus* in North America. Radiocarbon dates associated with caribou in the conterminous United States are: 19,700 ± 600 years B.P. (I-4163) from Guy Wilson Cave, Tennessee; 13,460 ± 420 years B.P. (SI-461) from Saltville, Virginia; 12,530 ± 370 years B.P. (I-4137) from Dutchess Quarry, New York; 10,370 ± 350 years B.P. from Jaguar Cave, Idaho (Guilday and Hamilton 1975, p. 111; Kurtén and Anderson 1972, Table 16). These dates support the occurrence of caribou herds well south of the North American continental ice mass during the peak of the Wisconsin glaciation.

In Alaska, the earliest record of caribou ("*Rangifer* sp.") is rather insecure. The identification is based solely on a heavily worn dP^3 from Cape Deceit (?Nebraskan) (Guthrie and Matthews 1971, Figure 10). The pelvis of a deer, "probably *Rangifer*", found in a gully in the coastal bluffs of Baldwin Peninsula, Kotzebue Sound, may have been derived from beds dating to the time of the Kotzebuan marine transgression (?Yarmouth interglacial) (Péwé and Hopkins 1967, pp. 268-269, footnote C). Caribou fossils have been collected from Illinoian deposits at Cripple Creek Sump and Gold Hill near Fairbanks (Péwé 1975a, Table 11). *Rangifer tarandus* has also been reported from Wisconsin sediments at Fairbanks and Engineer creeks in the same area (Guthrie 1968b, Table 1). Remains of what may be caribou ("Cervidae cf. *Rangifer*") are known from late Pleistocene sediments at Tofty (Repenning *et al.* 1964, Table 1). Repenning (Weber 1975, p. 67) has identified "caribou(?)" bones from late Pleistocene stream channel fill at Canyon Creek near Big Delta. I (Harington 1976 MS., pp. 75, 78) have identified late Pleistocene *Rangifer tarandus* fossils from the Kuk and Ikpikpuk rivers near the arctic coast of Alaska, and from late Wisconsin deposits at Lost Chicken Creek in eastern Alaska.

In Siberia, the earliest evidence is "*Rangifer* sp." from the Olyor Suite of ?Kansan age (Sher 1971, p. 89). *Rangifer tarandus* is reported from: the Riss II (late Illinoian) Utka Beds on the Maly Anyui River; late Pleistocene (Illinoian to Wisconsin) deposits of Bolshoi

Lyakhov Island (Vangengeim 1961); the early Wisconsin Iedoma Suite on the Kolyma River; the late Wisconsin Alioshka Suite on the Kolyma River, and many other sites of late Wisconsin or early postglacial age (e.g. Proliv Dmitriya Lapteva, and the Berelekh River (radiocarbon dated at 12,240 ± 160 years B.P.)) (Vereshchagin 1974).

The earliest known record of *Rangifer tarandus* in Europe is from Günz II (?late Nebraskan) sands at Süssenborn, Germany. Caribou occur next in Mindel (?Kansan) deposits at Mosbach, Bad Frankenhausen, and Steinheim. The species is also known from sediments of Riss (Illinoian) age. During the Würm (Wisconsin) glaciation it ranged widely throughout Europe from Spain and Italy to the southern USSR (Kurtén 1968, p. 170). Remains are particularly abundant in Magdalenian deposits, which span the period from approximately 15,000 to 10,000 years B.P. (Ucko and Rosenfeld 1967, p. 31), when it was the main prey of many groups of early human hunters.

Banfield (1974, p. 383) gives several anatomical reasons for considering *Rangifer* to be an extremely primitive deer. Despite this evidence, the ancestry of the genus is not known. I would, however, point out the remarkable similarity in the appearance of the antlers of *"Cervus savini"* (e.g. BM(NH) M 6093, M 17179) from the Forest Bed of Trimingham near Norfolk, England, and those of *Rangifer tarandus*. Although *"Cervus savini"* is probably somewhat later in age than caribou fossils from Süssenborn, I speculate that this deer had Villafranchian ancestors in southern Europe, which were related to the *Euctenoceros* stock. The possibility of parallel evolution of similar antler forms complicates the problem of tracing the evolution of taxa such as *Rangifer* where early fossil evidence is scarce.

I suggest that the boreal forest-adapted woodland caribou with its relatively heavy, laterally compressed antler beams would most closely approach the ancestral form. When the expansion of cool steppe grasslands and tundra occurred near the beginning of the Pleistocene, presumably this ancestral form, which may have adapted to feeding on arboreal lichens, would have the basic adaptation necessary for exploiting new arctic and alpine tundra habitats that offered an abundance of ground and rock lichens. Considering the openess of this fresh terrain, it is reasonable to expect that larger antlers like those of the barren-ground caribou would be developed; they would probably be advantageous from a viewpoint of social behavior.

In summary, *Rangifer* may have evolved in Beringia, or in boreal areas to the south of it, and spread widely across cool, tundra-like terrain of the Holarctic from Alaska (Cape Deceit) to Europe (Süssenborn) in Nebraskan time. It is known from northeastern Siberia (Kolyma River) and Europe during the Kansan glaciation, but, surprisingly, does not appear to be certainly represented from North American then. *Rangifer tarandus* is known from Illinoian deposits of Alaska (Fairbanks) and possibly Illinoian sediments in the Yukon (Old Crow), and was well established from western Europe to northeastern Siberia during that glaciation. The species first seems to have reached central North America (Medicine Hat) during the Sangamon interglacial. By the time the Wisconsin ice sheet had reached its maximum extent caribou occupied a thin, possibly discontinuous, belt of tundra-like terrain and boreal forest from Idaho to Tennessee (the southern limit). Caribou were abundant in Eastern Beringia during the late Wisconsin. At that time, in Eurasia, caribou were common in Siberia and had reached the southern European limits of their range in Italy and Spain. They began shifting northward to Scandinavia during the Mesolithic period. Herds existed in the northwestern United States

(Jaguar Cave) and on the edge of the southwestern Canadian prairies about 10,000 to 11,000 years ago, while in eastern North America, evidently caribou had retreated northward to New York by about 12,500 years ago (Dutchess Quarry).

At least some caribou occupying the western part of the southern refugium were of the graceful-antlered barren-ground form (e.g. ISUM 23114), while some in the east were of the woodland form (e.g. CM 12603) (Guilday 1966, p. 325). Therefore, in an attempt to explain the distribution of Recent subspecies, I suggest the following scheme: (a) during the retreat of the late Wisconsin ice herds of barren-ground caribou *(Rangifer tarandus groenlandicus)* from Minnesota to Idaho moved northward into the northern Cordillera, Keewatin, and across sea ice to Baffin Island and southwest Greenland (probably reinvading the area from which their ancestors had been displaced) by about 7,000 years ago (Acasta Lake) or later; (b) that woodland caribou *(Rangifer tarandus caribou)* concentrated in the northeastern United States retreated to their present range [illegible] Quebec and Newfoundland, and also spread northwestward into the broadening boreal forest as it shifted to the north, the barren-ground caribou having moved north ahead of the woodland animals; (c) that small tundra caribou or Peary caribou *(Rangifer tarandus pearyi)*, having been isolated in unglaciated western Banks Island, spread eastward across the sea ice to occupy most of the Canadian Arctic Islands; (d) that small Greenland caribou *(Rangifer tarandus eogroenlandicus)*, derived from a similar stock to the Peary caribou, survived the Wisconsin glaciation in the Pearyland refugium, spreading south along the east coast during the postglacial, where they recently became extinct; (e) that Grant's caribou *(Rangifer tarandus granti)*, which subspeciated in Eastern Beringia, remained for the most part in that region, possibly with some intergradation with *Rangifer tarandus groenlandicus* to the east and *Rangifer tarandus caribou* to the south (Youngman 1975, pp. 163, 166); and (f) that Dawson's caribou *(Rangifer tarandus dawsoni)* became isolated from other herds of the woodland type on the British Columbia mainland and survived the Wisconsin glaciation in impoverished range on the Queen Charlotte Islands, where they became extinct about 1936.

Caribou or reindeer *(Rangifer tarandus)* occur in a broad belt of tundra and bordering boreal forest from Scandinavia to Siberia and across North America from Alaska to Greenland and Newfoundland. In the Yukon Territory, woodland caribou *(Rangifer tarandus caribou)* are found in the southern half, while Grant's caribou *(Rangifer tarandus granti)*, which are most closely related to the tundra form *(Rangifer tarandus groenlandicys)*, dominate the northern half. Occasionally, Peary caribou *(Rangifer tarandus pearyi)* may reach the northern Yukon (Youngman 1975, p. 163).

Caribou are small to medium-sized deer characterized by chunky, well-furred bodies, large blunt muzzles, short ears and tails, large hooves and semipalmate antlers that generally sweep back, out and then forward, having two main proximal tines (brow and bez) which branch off close to the burr, and other distal tines. Unlike most deer, female caribou usually bear antlers, albeit short and spindly ones compared to those of males. Since antlers of females and subadults are smaller and weaker, they are less likely to be preserved; therefore, most Pleistocene caribou antlers found are those of adult males. In adult males, antler growth begins in March, and by October when rutting begins, they are several feet long and polished clean of velvet. Antlers are dropped in winter, beginning in November. Antlers of adult females develop from June to September, are polished clean of velvet in late October, and are dropped during calving in April or May. Caribou antlers are notoriously variable within populations (Kelsall 1968 p. 38), making identification of fossil antler fragments of caribou or related taxa by paleontologists a hazardous task.

Caribou are gregarious, generally occurring in bands of 10 to 50, or in loose herds of up to a thousand animals. They become concentrated at three periods: (a) in late winter before the spring migration; (b) after calving; and (c) during the rutting period before the autumn migration. They can travel rapidly and swim well, buoyed up by their thick coats. Barren-ground caribou move up to 800 miles (1,287 km) between summer tundra range and winter range on the margin of the boreal forest. Mountain and woodland caribou, like wapiti, tend to migrate from higher summer range to lower winter range.

Caribou occupy arctic and alpine tundra, subarctic taiga, and boreal and subalpine forest. As almost all of the caribou antlers from Yukon Pleistocene deposits are of the barren-ground type, presumably they are indicative of broad areas of tundra-like terrain, and perhaps some zones of boreal or subalpine forest in Eastern Beringia during the late Pleistocene. Fossil antler fragments (keeping in mind their variability) suggest that woodland caribou rarely lived in the Dawson and Old Crow areas during the late Pleistocene. Caribou are well adapted to cold conditions, by their thick, well-insulated coats, blunt, heavily-furred muzzles, short furry ears and tails and large hooves (which aid their movement over snow, and which develop so that the pads are insulated in winter).

Lichens are the main food of caribou - particularly in winter. They eat about 10 pounds (4.5 kg) of lichens per day. Other winter foods are horsetails, sedges, and willow and birch twigs. Summer diet includes mushrooms, lichens, grasses, sedges, forbs, and willow and birch twigs and leaves.

Man is one of the main predators of caribou. Archeological evidence from Old Crow and Dawson areas indicates that people likely hunted caribou there during the mid- to late Wisconsin. Archeologists have shown, or have given good reasons for inferring, that caribou were important prey of Paleo-Indians in eastern North America during the late Wisconsin. In the west, caribou remains have been found in middens approximately 10,300 years old at Jaguar Cave, Idaho. Likely, caribou were hunted at Acasta and Grant lakes, Northwest Territories about 7,000 years ago by hunters that had moved northward with the retreating

Wisconsin ice (Harington 1976 MS., pp. 95-96). Apart from man, wolves are the most serious predator of caribou. They generally kill young, old or disabled animals. Brown bears, wolverines and lynx occasionally kill caribou. According to Banfield (1974, p. 386), eagles are important predators of new-born calves.

Cervidae (genera and species undetermined)

In the collection of antler remains from Yukon Pleistocene deposits are two groups of cervid specimens that neither correspond to typical barren-ground caribou nor wapiti. They have in common laterally compressed beams, and bot some characteristics of woodland caribou antlers, but I am not sure that they are referable to *Rangifer tarandus* or even *Rangifer*. Until the evidence is clearer, these groups will be considered as belonging to undetermined genera and species of deer (Figure 75A-D, Table 85).

Referred specimens

The first group consists of seven antler fragments that have the following characteristics: (a) beams that are oval (anteroposteriorly longer) to round in cross section at the burr; (b) beams that gradually become laterally compressed, and which tend to spread

Figure 75. Proximal portion of an unshed right antler (NMC 14338, Old Crow Locality 14N) of a Pleistocene cervid (genus and species undetermined - "First Group").

A. Medial view.

B. Anterior view.

Fragment of a shed right antler (NMC 29139, Sixtymile Locality 3) of a Pleistocene cervid (genus and species undetermined - "Second Group").

C. Medial view

D. Anterior view.

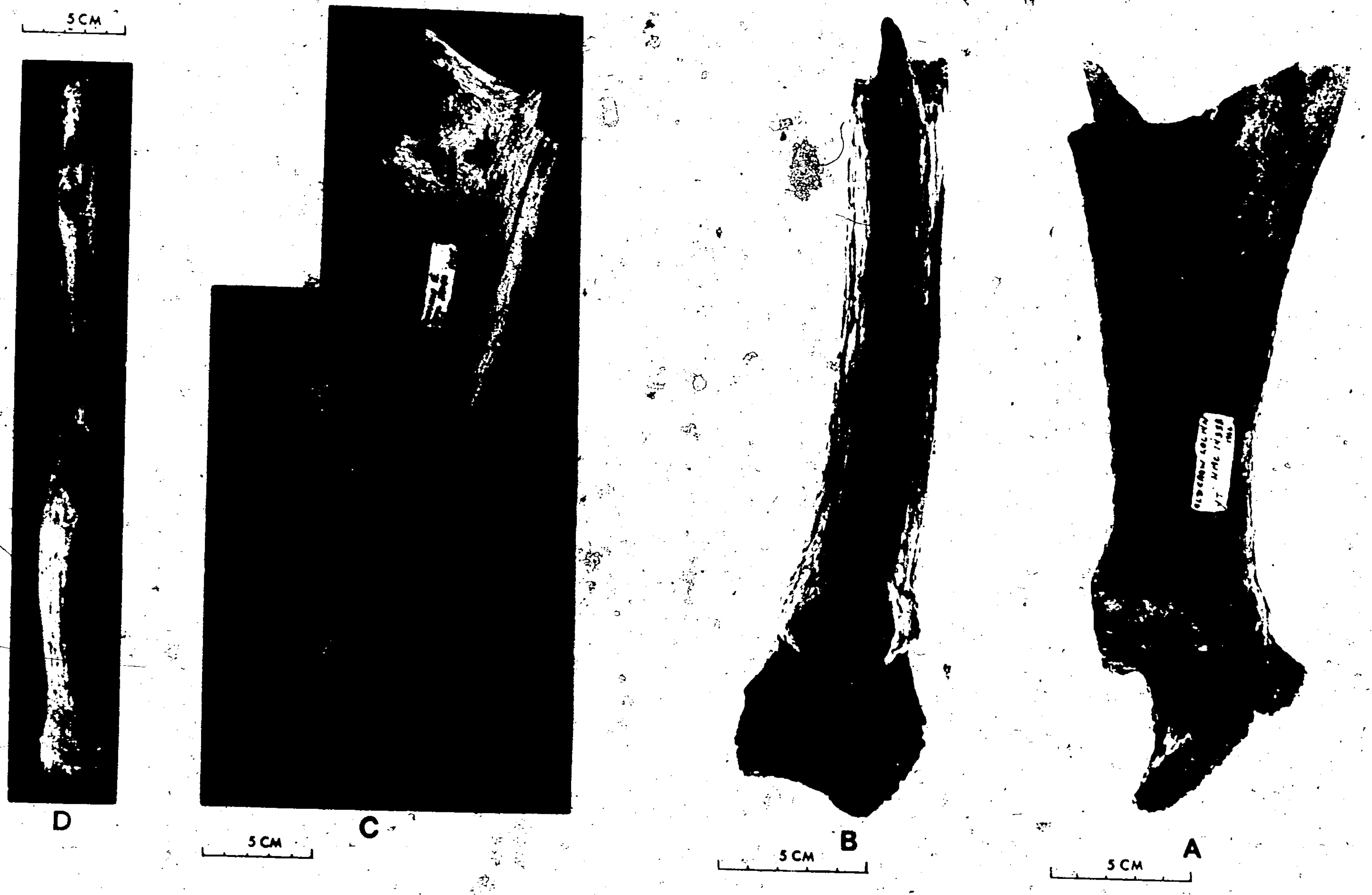

5 CM
D
5 CM
C
B
5 CM
A
5 CM

Table 85. Measurements of Pleistocene cervid (genus and species undetermined) antlers from the Yukon Territory.

Specimens	Measurements (mm)*							
	1	2	3	4	5	6	7	8
Cervidae (genus and species undetermined)								
First Group.								
NMC 27841 Old Crow Loc. 67		45.3	53.9	41.9	53.0	37.5	72.0	
NMC 20917 Old Crow Loc. 29	49.7	40.8	48.7	37.8	48.3	37.1	50.2	[illegible]
NMC 13619 Old Crow Loc. 11A	52.2	48.8	45.4	36.8	46.6	35.5	53.9	32.9
NMC 23371 Old Crow Loc. 42	44.9	44.1	46.8	41.9	51.2	40.2	60.5e	40.3e
NMC 14338 Old Crow Loc. 14N	43.8	44.0	48.3	35.0	58.5	32.5	81.5	33.5
NMC 24181 Old Crow Loc. 3 (immature?)	29.6	26.6	38.0	22.2	46.6e	19.0	-	-
NMC 14760 Old Crow Loc. 29 (immature?)	29.8	25.3	33.2	17.2	-	-	-	-
Second Group.								
NMC 29139 Sixtymile Loc. 3	32.4	29.8	36.1	26.3	52.6	22.6	-	-
NMC 27999 Old Crow Loc. 95	27.7	22.6	35.8	18.3	38.3	17.3	44.2	15.7
NMC 28202 Old Crow Loc. 116	35.7	31.0	51.7a	25.4a	53.4	24.4	-	-

* 1 - Anteroposterior diameter of antler base (or pedicel below burr, if antler is attached to cranium).

2 - Mediolateral diameter of antler base (or pedicel below burr, if antler is attached to cranium).

3 - Minimum anteroposterior diameter of beam 50 mm above burr.

4 - Minimum mediolateral diameter of beam 50 mm above burr.

5 - Minimum anteroposterior diameter of beam 100 mm above burr.

6 - Minimum mediolateral diameter of beam 100 mm above burr.

7 - Minimum anteroposterior diameter of beam 175 mm above burr.

8 - Minimum mediolateral diameter of beam 175 mm above burr.

anteroposteriorly as the distance from the burr increases; (c) beams that are generally teardrop-shaped (widest part posterior), or rarely elliptical (anteroposteriorly longer) in cross section half way between the burr and the second anterior tine (where it is preserved); (d) brow projections apparently varying from single, well developed tines, to twin, stubby projections - the medial one being directed slightly inward toward the mid-line of the cranium, the lateral one projecting forward; to a single nubbin directed slightly inward in the smaller antlers assigned to this group; (e) brow projections located close to or arising directly from the burr - the position of brow tines in *Rangifer* and *Dama*; (f) antler beams showing only faint signs of longitudinally oriented vascular grooves; more like the vascular impressions in caribou, than the deep vascular grooves in wapiti; (g) adult male antlers with second anterior tines generally developing approximately 180 mm or more distal to the burr; (h) antlers which appear to rise high from the frontal plane, more like those of wapiti than barren-ground caribou antlers I have seen which tend to sweep back sharply, almost in the plane of the frontals, before curving forward. The largest antler fragments, which I consider represent adult males, suggest that this group of deer is large - perhaps reaching woodland caribou or nearly wapiti size when mature.

I know of no living or fossil American deer that have antlers with the above characteristics. Two late Pleistocene cervids, *Navahoceros fricki* (Wyoming, New Mexico, Mexico) and *Sangamona whitneyi* (Iowa, Illinois, Tennessee), should be considered in this respect. Kurtén (personal communication 1976) states that the former has simply-built forked antlers, and the antlers of the latter are not known. These genera must be described and illustrated in more detail before any decision can be made concerning their relationship, if any, with the undetermined Yukon Pleistocene deer.

Two fossils from deposits of pre- Wisconsin age that have previously been described as belonging to caribou, but that appear to have characteristics of the first group of Yukon cervids, are worth noting. BCPM 696 from Wingdam, British Columbia, described as the right antler of a female of "*Rangifer* sp." by Cowan (1941, p. 43, Plate II, Figure 2), has a brow tine projecting forward at the level of the burr, a compressed antero-posteriorly spreading beam below the second anterior tine, and a second anterior tine widely separated from the brow tine (as in NMC 27841 and 13619 from the Yukon). Unfortunately no measurements are provided for this fossil, and there is no scale on the photograph of it.

I consider that this specimen is of Sangamon or earlier interglacial age. SDSM 6421 from gravels of the Herrick Formation (?Nebraskan or Kansan) is a small fragment of antler attached to a cranial fragment. The antler has a low brow tine and a robust, laterally compressed beam like the Yukon fossils of the first group. The fossil was found with *Equus (Plesippus)* sp. and *Stegomastodon mirificus*. I am not sure that it referable to a woodland carib[illegible]en and Lillegraven (1965, p. 48) suggest.

Among living deer of Eurasia of which I am aware, the Yukon antlers are closest in conformation to those of fallow deer (*Dama* sp.), which Cornwall (1964, p. 69) characterizes as follows: "The antler is very smooth and the marks of the blood-vessels shallow {i.e. faint vascular grooves}. The brow tine springs from the beam directly above, almost in contact with the burr. A bez tine is generally absent and the antler tends to be markedly palmated above the trez." Unfortunately, no *Dama* antlers are available for comparison. Evidently the Yukon deer antlers of the first group differ from those of *Dama dama* in that a large brow tine was not always present, and I am not sure how the distal parts of the Yukon fossil antlers would compare, for they are not preserved. Among remains of extinct Eurasian deer, the

Yukon fossils should be compared to *Euctenoceros tetraceros* antlers (Azzaroli 1953, Figure 15), which, however, appear to have more stongly developed brow tines and more cylindrical beams.

Referred left antlers - NMC 20917 from Old Crow Locality 29 is the proximal part of an antler, the beam of which extends for 290 mm without any indication of a second anterior tine. The brow tine, which seems to have been triangular (apex up) in cross section at the base, has been broken off. The beam is attached to part of the left frontal. The surface of this fossil is deeply oxidized. NMC 23371 from Old Crow Locality 42 is a proximal portion of an antler attached to a small cranial fragment. An 80 mm segment of beam is preserved. Twin stubby projections are located in the brow tine region, originating at the level of the burr. Their centres are 43 mm apart The lateral one projects forward while the medial one is directed obliquely toward the cranial axis. The leading edge of the antler extends distally from the medial projection. The bone of NMC 23371 is stained dark brown.

Referred right antlers - NMC 27841 from Old Crow Locality 67 is the proximal part of a shed antler. A large area near the burr, where a brow tine may have been, is missing. A deep, laterally compressed second anterior tine (60 mm x 29 mm) extends 110 mm forward to the point where it was broken. A 280 mm segment of beam is preserved. The surface of the specimen is heavily oxidized. NMC 14338 from Old Crow Locality 14N compares closely with NMC 27841, except that only a 190 mm segment of beam is preserved, a second anterior tine is not evident, and the beam is attached to a small part of the frontal. A triangular scar marks the point where the brow tine has been broken off. This specimen shows the faintness of the longitudinal vascular grooves on the beam. NMC 13619 from Old Crow Locality 11A is an antler beam with twin stubs in place of the brow tine, and part of a laterally compressed second anterior tine. It is attached to a frontal fragment carrying 60 mm of the frontal suture, which enables it to be properly orientated. The antler must have risen at a sharp angle like that of a wapiti, rather than that of a male barren-ground caribou to which it was compared. The slightly eroded twin brow projections are like those of NMC 23371. Their centres are 39 mm apart. The leading edge of the antler beam extends distally from the medial projection. A 240 mm segment of beam is preserved. The fossil is brownish black. Its heavy permineralization suggests a relatively early geological age. NMC 24181 from Old Crow Locality 3 is an antler fragment with a single, inwardly directed nubbin in place of a brow tine (it may be an incipient brow tine). The antler appears to have been attached to the cranium, but the pedicel-burr region is obscured by heavy erosion. A 103 mm segment of antler beam is present. Perhaps because of the shortness of the beam preserved, there is no indication of a second anterior tine. Probably this fossil represents a young individual. NMC [illegible]4760 from Old Crow Locality 29 is a shed antler fragment with an inwardly directed nubbin in place of a brow tine. There is no evidence of a second anterior tine in the 90 mm of beam preserved. A sharp keel occurs distal to the nubbin on the leading edge of the beam. I suggest that this specimen is from a slightly younger animal than NMC 24181. As I envisage this group, successive chronological age classes from young to old may be exemplified by the following sequence: NMC 14760 - NMC 24181 - NMC 13619 - NMC 27841.

The second group is characterized by: (a) relative straightness of the antler when viewed from the front and side; (b) the high degree of lateral compression of the antler, which extends distally to the point where it is virtually a palmation; (c) brow and bez tines are separated like those of caribou; (d) as in caribou, surface vascular grooving is not deep; (e) relatively small antler bases, which could be related to the fact that the fossils represent female or young animals. Possibly these specimens are parts of aberrant caribou antlers. One of them is reminiscent of the unusual pattern of a stag's antlers in a herd of Quebec caribou (Bergerud 1973, Figure 4).

NMC 29139 from Sixtymile Locality 3 appears to be most of a shed right antler. The brow tine, which was small, is damaged. The second anterior tine is broken 50 mm from its point of origin, and is deep and highly compressed laterally (45 mm deep x 15 mm thick). The third and fourth anterior tines are approximately 45 mm apart. They are poorly developed and laterally compressed. The antler is broken near the tip, which probably extended only a short distance above the fourth anterior tine. There is no indication of a first posterior tine. The relatively thick posterior ridge of the antler forms its main support: it tapers forward creating a thin keel between the projecting tines. A 330 mm segment of beam is preserved. NMC 29139 is similar in some respects to antlers of stag 21 in a herd of caribou from Mount Albert, Quebec (Bergerud 1973, Figure 4). For example, there are no posterior tines, the main beam rises vertically with a slight backsweep, and there is a tendency to spatulation between the forward projecting tines. NMC 29139 is pale buff, and I suggest that it is of late Wisconsin age.

NMC 27999 from Old Crow Locality 95 is estimated to be the proximal half of a shed left antler. As in NMC 29139, the brow tine is poorly developed (17 mm deep x 13 mm thick), and is separated from the minute, laterally compressed second anterior tine by 90 mm. A damaged first posterior tine or keel occurs approximately 170 mm above the burr. As in the Sixtymile specimen, the main support for the beam is the posterior ridge, the anterior margin being keeled. A 210 mm segment of beam is preserved. The fossil is stained dark brown.

NMC 28202 from Old Crow Locality 116 is a small, laterally compressed basal portion of a shed left antler. It seems to be from an older individual than either NMC 29139 or 27999, being more robust. The burr is well preserved. The stub of the brow tine (26 mm deep x 22 mm thick) and the beginning of a second anterior tine are present. As in other fossils of this group, the main support for the beam is a posterior ridge that tapers forward to a keel between the tines. A 150 mm segment of beam is preserved. The specimen is stained dark brown.

Discussion

In summary, the antler remains of the first group, unless they are all aberrant caribou antler fragments, seem to represent a large deer that may have lived in the Yukon Territory earlier than most mammals represented in Yukon Pleistocene deposits. So far, specimens are confined to the Old Crow Basin. Antlers of the second group probably represent a smaller cervid more closely allied to *Rangifer*, if [illegible]ey are not aberrant *Rangifer tarandus* antlers. The [illegible]all basal size of these antlers may indicate that they are from young individuals. The staining of the antler fragments suggests that these animals occupied Eastern Beringia during pre- Wisconsin and late Wisconsin time.

Family Bovidae

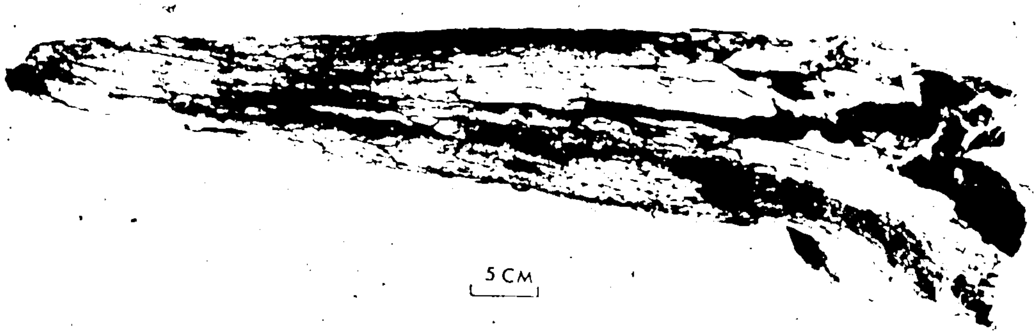
Bison alaskensis (Alaskan bison)

Two specimens from Yukon Pleistocene deposits are referred to the Alaskan bison (Figure 76A-C, Table 86). This species had larger horns than any other bison known from Eastern Beringia, and may be close to the stock that first arrived in North America from Eurasia.

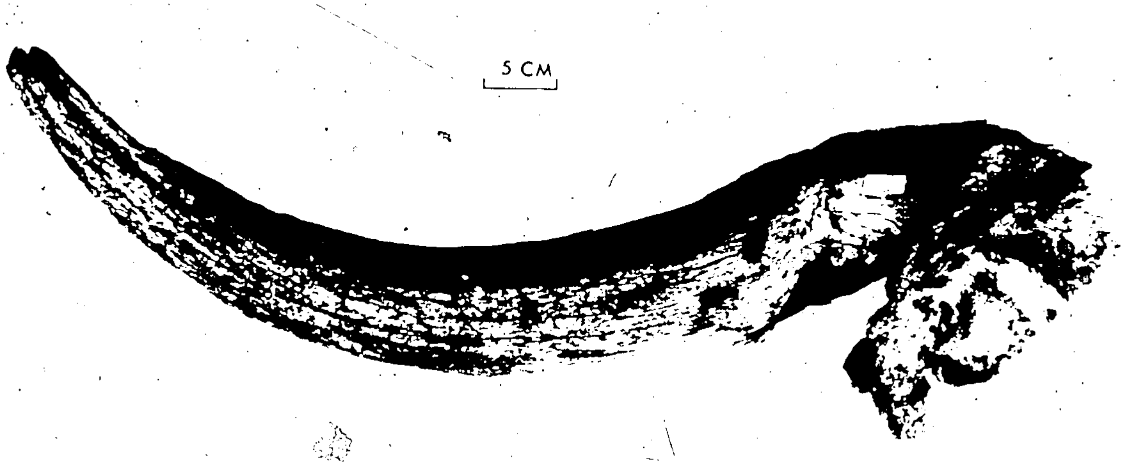
Before proceeding with a description of the Alaskan bison fossils and a summary of the dispersal history of bison, I wish to point out that my rather conservative use of names such as *Bison alaskensis* and *Bison crassicornis*, rather than *Bison priscus alaskensis* and *Bison priscus crassicornis* (e.g. Flerov 1972, Wilson 1974), is based on a desire to look carefully before leaping. Although the application of *priscus* seems reasonable and appropriate here, I consider that the name should not be formally used until adequate statistical comparisons have been published supporting the relationships between the Eurasian and North American bison in question.

Referred specimens

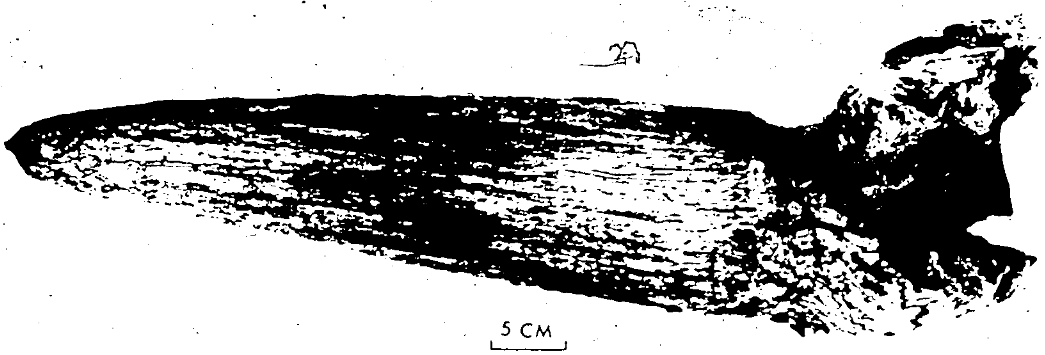
NMC 13506 from Dawson Locality 33 is an unusually large left horncore with damaged tip and attached cranial fragment (since removed for radiocarbon dating). It was



A



B



C

Figure 76. Left horncore with attached cranial fragment (NMC 13506, Dawson Locality 33) of a Pleistocene Alaskan bison (*Bison alaskensis*). The tip of the horncore is missing.

A. Dorsal view.

B. Posterior view.

C. Ventral view.

Bone from this specimen yielded a radiocarbon date of > 39,900 years B.P. (I-5405).

Table 86. Measurements of Pleistocene Alaskan bison (*Bison alaskensis*) crania from the Yukon Territory compared to those of Alaskan bison from Alaska, *Bison priscus gigas* from Asia and *Bison crassicornis* and *Bison latifrons* from North America.

SPECIMENS	SEX	ESTIMATED AGE												MEASUREMENTS (mm) *						
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Bison alaskensis. Pleistocene, Y.T.																					
NMC 13506 Dawson Loc. 32	♂	Adult	1330e	-	570e	590e	520e	108	135	380	-	-	-	-	-	-	-	-	-	-	
NMC 23349 Old C[illegible] Loc. 96	♂	Adult	1220e	1230e	547e	573e	465e	97	115	339	2[illegible]	142	1	106	154	310e	308	360	-	-	
Bison alaskensis. Pleistocene, Alaska (Skinner and Kaisen 1947, Table 18)																					
CMNH P 25226 Point Barrow area (type)	♂	Adult	1115	1130	475	528	400	95	129	355	311	160	-	-	163	-	339	402	-	-	
F:AM 46939 Cripple Ck.	♂	Adult	-	-	520	580	465	105	150	425	-	-	-	-	-	-	-	-	-	-	
F:AM 46940 Engineer Ck.	♂	Adult	-	-	-	-	-	113	135	402	-	-	-	-	-	-	-	-	-	-	
Bison priscus gigas. Pleistocene, U.S.S.R.**																					
PIN catalog number unknown	♂	Adult	-	-	603	-	515	99	127	350	-	-	-	-	-	365	301	360	252	-	
Bison crassicornis. Pleistocene, Alaska and Y.T. (Skinner and Kaisen 1947, Table 16)																					
M	♂♂	Adult	963	986	409	458	365	98	110	324	284	136	-	-	15	-	288	349	-	196	12
OR			7[illegible]5-1295	790-1322	295-610	310-650	280-530	82-118	90-137	272-388	250-314	115-159	-	-	141-185	-	255-332	307-408	-	177-213	11 13
N			118	108	208	207	207	207	291	286	131	150	-	-	153	-	156	110	-	21	
Bison latifrons. Pleistocene, Conterminous U.S. and Mexico (Skinner and Kaisen 1947, Table 19)																					
M	♂♂	Adult	1758	1724	830	934	810	144	162	481	323	157	-	-	176	-	370	397	-	219	12
OR			1422-2129	1560-1945	650-1115	800-1156	180-1020	123-164	140-184	420-546	306-340	140-175	-	-	151-188	-	348-402	357-434	-	218-220	-
N			10	6	12	9	8	15	15	16	6	8	-	-	7	-	10	4	-	2	

*1 - Spread of horncores (tip to tip).
2 - Greatest spread of horncores (on outside curve).
3 - Horncore length on upper curve (tip to burr).
4 - Horncore length on lower curve (tip to burr).
5 - Length (tip of horncore to upper centre of burr).
6 - Vertical diameter of horncore (at right angle to longitudinal axis).
7 - Transverse diameter of horncore (at right angle to longitudinal axis).
8 - Horncore circumference (at right angle to longitudinal axis).
9 - Greatest width (at auditory openings).
10 - Width across occipital condyles (disregarding occasional anterolateral expansions of occipital condylar bone).
11 - Basioccipital width (across posterolateral margins).
12 - Cranial depth (highest point of occipital crest to top of foramen magnum).
13 - Cranial depth (occipital crest to lower border of foramen magnum).
14 - Cranial width (between upper centres of horncore burrs).
15 - Cranial width (constriction between horncores and orbits).
16 - Greatest postorbital width.
17 - Anterior orbital width (at notch).

1of

18 - Width (at masseteric processes above M^1).
19 - Rostral width (at maxillary - premaxillary suture above P^2).
20 - Alveolar length (P^2-M^3).
21 - Alveolar length(M^1-M^3).
22 - Length (anterior alveolar margin of P^2 to tip of premaxilla).
23 - Basal length (lower lip of foramen magnum to tip of premaxilla).
24 - Condylobasal length (posterior border of occipital condyles to tip of premaxilla).
25 - Length (occipital crest to tip of nasals).
26 - Postcranial length (occipital crest to nasofrontal suture).
27 - Index of horncore curvature ($\frac{\text{measurement 4}}{\text{measurement 5}}$ X 100).
28 - Index of horncore compression ($\frac{\text{measurement 6}}{\text{measurement 7}}$ X 100).
29 - Index of horncore proportion ($\frac{\text{measurement 3}}{\text{measurement 8}}$ X 100).
30 - Index of horncore length ($\frac{\text{measurement 3}}{\text{measurement 15}}$ X 100).

NB - Most measurements follow those of Skinner and Kaisen (1947, pp. but many of the numbers designating them have been altered. Som measurements have been added and earlier ones have been omitted practical purposes.

** I am grateful to K.K. Flerov for allowing me to take measurements on a cranium of *Bison priscus gigas*, which is on display in the Paleontological Institute of the Academy of Sciences of the U.S.S.R., Moscow.

rania from the Yukon Territory compared
m Asia and *Bison crassicornis* and

MEASUREMENTS (mm) *

	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	113e	80	150	-
9	285	142	81	106	154	310e	308	360	-	-	-	-	-	-	-	-	-	267	118e	84	161e	178e
5	311	160	-	-	163	-	339	402	-	-	-	-	-	-	-	-	-	307	132	74	134	140
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	126	70	122	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	78	-	-
0	-	-	-	-	-	365	301	360	252	-	-	-	-	-	-	-	-	-	-	78	172	200
4	284	136	-	-	159	-	288	349	-	196	120	147	92	152	523	-	491	272	125	90	126	143
2- 8	250- 314	115- 159	-	-	141- 185	-	255- 332	307- 408	-	177- 213	112- 131	131- 166	72- 115	137- 161	487- 560	-	473- 503	235- 315	107- 153	81- 103	100- 166	110- 189
6	131	150	-	-	153	-	156	110	-	21	7	37	30	8	8	-	10	107	207	157	115	113
1	323	157	-	-	176	-	370	397	-	219	126	162	104	177	577	-	-	306	118	89	176	245
0- 6	306- 340	140- 175	-	-	151- 18	-	348- 402	357- 434	-	218- 220	-	-	97- 110	-	574- 580	-	-	301- 310	110- 131	80- 93	147- 210	209- 300
6	6	8	-	-	7	-	10	4	-	2	1	1	2	1	2	-	-	2	8	15	10	6

18 - Width (at masseteric processes above M^1).

19 - Rostral width (at maxillary - premaxillary suture above P^2).

20 - Alveolar length (P^2-M^3).

21 - Alveolar length(M^1-M^3).

22 - Length (anterior alveolar margin of P^2 to tip of premaxilla).

23 - Basal length (lower lip of foramen magnum to tip of premaxilla).

24 - Condylobasal length (posterior border of occipital condyles to tip of premaxilla).

25 - Length (occipital crest to tip of nasals).

26 - Postcranial length (occipital crest to nasofrontal suture).

27 - Index of horncore curvature ($\frac{\text{measurement 4}}{\text{measurement 5}}$ X 100).

28 - Index of horncore compression ($\frac{\text{measurement 6}}{\text{measurement 7}}$ X 100).

29 - Index of horncore proportion ($\frac{\text{measurement 3}}{\text{measurement 8}}$ X 100).

30 - Index of horncore length ($\frac{\text{measurement 3}}{\text{measurement 15}}$ X 100).

NB - Most measurements follow those of Skinner and Kaisen (1947, pp. 142-145), but many of the numbers designating them have been altered. Some new measurements have been added and earlier ones have been omitted for practical purposes.

priscus gigas, which is on display in the Paleontological recovered by L. Ross while placer mining on Gold Run Creek in the summer of 1968. It came from a depth of approximately 45 feet (13.7 m) below the surface. It is of larger grade then all other Yukon bison cranial specimens which I have examined, except for NMC 23349. Among described type specimens of bison, NMC 13506 approaches most closely *Bison alaskensis* (CNHM P 25226) from the Point Barrow area, Alaska, which was described by Rhoads in 1897. Similarities include: (a) relative straightness of the horncore when viewed from above; (b) the high degree of dorsoventral compression near the base of the horncore; and (c) great length. In tip to tip spread of the horncores, I estimate that NMC 13506 is greater than the type of *Bison alaskensis*, beyond the range for *Bison crassicornis*, and below the range for *Bison latifrons*. It is closer in size to two specimens (F:AM 46939 and 46940) from near Fairbanks that Skinner and Kaisen (1947, pp. 201, 203) have referred to *Bison alaskensis*.

NMC 23349 from Old Crow Locality 96 is a posterior cranial fragment with horncores. I estimate that the left horncore lacks approximately 70 mm at the tip, and that the right horncore lacks its distal quarter. Most bone anterior to the orbits is missing. The left orbit is complete, while the anterior third of the right orbit is lacking. The basicranium is slightly damaged. More than any other cranium in the Yukon Pleistocene bison collection, this one shows a marked depression of the horncore pedicels, which gives the frontals between the horncores a dome-like appearance. The horncores, although slightly shorter than that of NMC 13506, show a similar lack of curvature. They are slightly backswept so that their distal thirds lie posterior to the occipital plane. A similar backsweep, but not so strong as that common in *Bison crassicornis*, is seen in the holotype of *Bison alaskensis* (Skinner and Kaisen 1947, Plate 24-3). Horncore indices (which I feel are most important in comparing bison crania) of the two Yukon specimens match well.

Discussion

Only seven specimens of *Bison alaskensis* are known. They are from the Dawson and Old Crow areas of the Yukon, and the vicinities of Point Barrow, Fairbanks (Cripple and Engineer creeks), The Ramparts (Walson Creek) and Eschscholtz Bay in Alaska. Therefore, the species was widespread in Eastern Beringia, but evidently it did not last as long or reach such large numbers as *Bison crassicornis*. Little is known about the stratigraphic range of *Bison alaskensis*, but knowledge of-the approximate geological age of a closely allied Eurasian species suggests an early middle to middle Pleistocene age. NMC 13506 was derived from a deep sink in the bed of Gold Run Creek, and bone from it has yielded a radiocarbon date of >39,900 years B.P. (I-5405), suggesting, but not proving that *Bison alaskensis* occupied the Dawson Area before *Bison crassicornis.* All radiocarbon dates on Yukon *Bison crassicornis* lie between approximately 34,000 and 12,000 years B.P. (Table 5).

Although *Bison alaskensis* has not been recorded beyond Eastern Beringia, I wish to point out its affinities with species described from the southern refugium and Eurasia. NMC 13506 and 23349 are very close in indices of horncore curvature, compression, projection and length to the smallest specimens of *Bison latifrons*, which so far, is only known from the southwestern prairies of Canada, the southern and western United States and northern Mexico. If a North American ancestor for *Bison latifrons* is sought, *Bison alaskensis* would be a good choice (Harington and Clulow 1973, p. 735) - it was in the "right" place, at what appears to have been the "right" time, with the appropriate ancestral characteristics.

It is also apparent, when examining the Yukon

Bison alaskensis fossils side by side with a large sample of *Bison crassicornis* crania graded from small to large, that the former species cannot be separated readily from the largest specimens of the latter, except for the tendency of its horncores to be less curved, less backswept, and to be flatter dorsoventrally at the bases. Therefore, it is conceivable that a bison with the cranial characteristics of *Bison alaskensis* could have given rise to both *Bison crassicornis* (by reduction in size in northern regions), and to *Bison latifrons* (by an increase in size in southern regions).

A question arises concerning the origins of *Bison alaskensis*. Has it affinities with Eurasian bison? A specimen of *Bison priscus gigas* that I was able to examine in the Paleontological Institute of the Academy of Sciences of the USSR in Moscow is so like *Bison alaskensis* in size (Table 86) and shape that the two taxa may be synonymous. It is interesting to note that Flerov (1972, p. 85) mentions the similarity of *Bison priscus gigas* and *Bison latifrons*, but disregards the closer morphological and geographical relationships of *Bison priscus gigas* and *Bison alaskensis*. Evidently *Bison priscus gigas* was widespread in Eurasia during the middle Pleistocene (Mindel-Riss (?Yarmouth) interglacial to Riss-Würm (Sangamon) interglacial in Flerov's terminology).

Presumably *Bison alaskensis* was adapted to a cool grassland or parkland habitat.

As a framework for considering the relationships of the four kinds of bison that have been identified from Yukon Pleistocene deposits, I will attempt to summarize some of the major trends in the evolution and dispersal of bison. Much of this information is derived from reasonable discussions of bison phylogeny by Guthrie (1970), Flerov (1972) and Wilson (1974, pp. 140-142). I emphasize that what seems reasonable now is not necessarily correct, and that only more careful biostratigraphic and other geochronological control, coupled with solid statistical studies of bison fossils throughout their time and space ranges, will allow a clearer idea of the evolution of the genus. This, in turn, would provide scientists with increased knowledge of the stratigraphic value of bison fossils. To this end, I propose that an international working group be organized, using standardized procedures for morphological and stratigraphic description.

The earliest known bison greatly resemble *Leptobos* and seem to have diverged from that genus in the late Pliocene of southern Asia. Much of the evidence is derived from India, where *Probison dehmi* from the upper Pliocene Tatrot beds near Chandigarh is claimed to be the earliest representative of the group (Sahni and Khan 1968, p. 248). The drooping tips of the horncores of this animal seem most peculiar for an ancestral bison, and as there appears to be no contact of the fragmentary left horncore with the cranium (Sahni and Khan 1968, Plate 16-1, 2), perhaps the orientation of the horncore as it is presently restored is subject to doubt. The authors state that *Probison dehmi* is closest to *Bison sivalensis* and that it may be an ancestor of that species.

Bison sivalensis from later (Pinjaur) deposits in northern India, *Bison palaeosinensis* from late Pliocene (Nihowan) beds of China (north of Peking), and *Bison tamanensis* from late Pliocene sediments of the Tamansk Peninsula in the Caucasus are early representatives of this important group of bovids. They were small, slender, *Leptobos*-like animals compared to modern bison, and they may have occupied warm forest environments where forage was soft. In the course of time, the skull broadened, orbits became more tube-like and laterally directed, cheek teeth became longer, and bodies grew more hefty - possibly linked with adaptation to colder climates and tougher, grassy forage. Flerov (1972, p. 85) suggests that these species be considered as members of the subgenus *Eobison*.

During the early Pleistocene, relatively short-horned bison such as *B. tamanensis*, *B. voigtstedtensis*, *B. langenocornis* and *B. schoetensacki* occupied southern Europe and western Asia. The woodland bison, *Bison shoetensacki*, is known from Waalian interstadial (?mid-Nebraskan) to Würm I (early Wisconsin) time — mainly in Germany. Although this species has been considered as immediately ancestral to the wisent (*Bison bonasus*), recent studies indicate that *Bison shoetensacki* became extinct without issue, and that the modern wisent is a late immigrant from Beringia (Kurtén 1968, pp. 186-187).

During the early to middle Pleistocene, bison with much larger horns (e.g. *B. priscus priscus*, *B. priscus gigas*, *B. alaskensis*) spread widely with the expanding steppe grasslands into northern Eurasia (including northern China) and North America, simultaneously losing ground in southern Asia and ultimately becoming extinct there. Perhaps the "blossoming" of their horns is indicative of a new and well adjusted level of adaptation to northern grasslands (see V. Geist's "Dispersal Hypothesis"; Geist 1971, p. 287). *Bison priscus*, the steppe bison, was common in Europe, and has been recorded there from deposits of: the Günz II (?late Nebraskan) glacial (e.g. Süssenborn, Hundsheim); the Mindel (?Kansan) glacial (e.g. Mosbach); Holstein (?Yarmouth) interglacial; Riss (Illinoian) glacial; Eem (Sangamon) interglacial; and Würm (Wisconsin) glacial. Toward the end of the last glaciation, before becoming extinct, its range extended from Yorkshire in England to Spain, Italy, Palestine and Siberia.

In Siberia, large bison (*Bison* sp.) are known from the Olyor Suite of Mindel (?Kansan) age, and again occur in the Riss II (late Illinoian) Utka Beds of that region. During the late Pleistocene (Illinoian to Wisconsin) a bison with the characteristics of *Bison crassicornis* occupied Bolshoi Lyakhov Island in the New Siberian Islands, and the Kolyma Lowland during the early Wisconsin (Iedoma Suite), where it was very common (Sher 1971, p. 209). By this time, smaller-horned, *occidentalis*-like bison appeared. A skull like that of the wood bison, *Bison bison athabascae*, is known from early postglacial sediments on the Bolshaya Chukochya River. Thus, as in North America toward the close of the last glaciation, bison horncore size (and probably body size) was also reduced in Siberia.

For purposes of the following discussion, it is tentatively assumed that *Bison alaskensis*, and *Bison crassicornis* are subspecies of *Bison priscus*.

Large-horned bison are first recorded from Alaska in deposits that may be of Kansan age (Péwé 1975a, Table 11). Apparently they crossed the Bering Isthmus with many other mammals of Eurasian origin at that time. During the following (Yarmouth) interglacial they penetrated to the plains of southern North America (e.g. *Bison* cf. *latifrons* from Medicine Hat (Stalker and Churcher 1970)). However, bison do not seem to have established themselves on the Great Plains of the United States until early Illinoian time. *Bison latifrons*, the giant bison, evidently was commonest from Illinoian to mid- Wisconsin time in southern North America (Schultz and Lansdown 1972, pp. 398-399). I speculate that a bison like *Bison alaskensis (? = Bison priscus gigas)* was the first to enter North America, and that it gave rise to *Bison latifrons* on the southern North American plains toward the close of the Yarmouth interglacial. Again, development of the largest horns known among bison, suggests excellent adaptation to, and exploitation of a fresh, rich environment. The horncores of these giant bison reached a maximum span of 213 cm, compared to about 66 cm in modern *Bison bison*. A question worth asking is "What were the horncores of female *Bison latifrons* like?". Could some medium-horned fossils ascribed to *Bison chaneyi* and *Bison alleni* actually be females of *Bison latifrons*? Giant bison became particularly abundant and widespread during the Sangamon, ranging from Florida and South Carolina in the east to California and Idaho in the west and Alberta and Saskatchewan in the north. Mid-Wisconsin records are from Texas, California and Alberta (B. Kurtén and E. Anderson, personal communication 1976). *Bison latifrons* survived until late Wisconsin time in Idaho (McDonald and Anderson 1975).

In southern North America, bison began decreasing in size during the late Pleistocene. *Bison alleni* seems to have been derived from *Bison latifrons* toward the end of the Sangamon interglacial. I speculate that *B. alleni* became extinct - giving way to smaller horned bison from Beringia. These smaller horned bison of the *Bison bison "occidentalis - antiquus"* complex spread southward near the close of the Wisconsin glaciation. Perhaps during the hypsithermal period, about 6,000 years ago, most herds of the *Bison bison "occidentalis - antiquus"* complex in the north had undergone the transition to wood bison *(Bison bison athabascae)*, while southern herds had adapted to the prairie environment, becoming plains bison *(Bison bison bison)*.

In Eastern Beringia, *Bison alaskensis* seems to have given way to *Bison crassicornis* by Wisconsin time. As in Siberia, *Bison crassicornis* was very common in the unglaciated parts of the Yukon Territory and Alaska, before it became extinct there about 12,000 years ago. *Bison crassicornis* probably gave rise to the *Bison bison "occidentalis - antiquus"* complex, from which stemmed the modern wood bison, *Bison bison athabascae* in postglacial time. Perhaps the European wisent *(Bison bison bonasus)* and the wood bison *(Bison bison athabascae)* both arose from *"occidentalis - antiquus"* stock in Beringia - the wisent shifting its range westward and southward, finally adapting to life in the forest; the wood bison spreading eastward and southward along the eastern margins of the Cordillera. Wood bison are known to have lived in the Dawson Area about 1,350 years ago.

Bison crassicornis (large-horned bison)

Fossils of *Bison crassicornis* (called *Superbison crassicornis* by Frick (1937, p. 577) and *Bison (Superbison) crassicornis* by Skinner and Kaisen (1947, p. 187)) are among the most common in the Yukon Pleistocene deposits (Figures 77A-C, 78A-C, 79A-C, Tables 87-91). Obviously herds of these bison were numerous, and ranged widely throughout unglaciated parts of the Yukon, Alaska and Siberia during the late Pleistocene. Specimens described here include only the most complete cranial remains. Also described, and of particular interest, is a collection of well preserved material, including virtually complete crania of male and female *Bison crassicornis*, and postcranial material from a single, high level stratum of late Wisconsin age at Old Crow Locality 11(1). Descriptions of other *Bison crassicornis* cranial and postcranial material from the Yukon are provided by Clark (1927), Williams (1937), and Harington and Clulow (1973).

Referred specimens

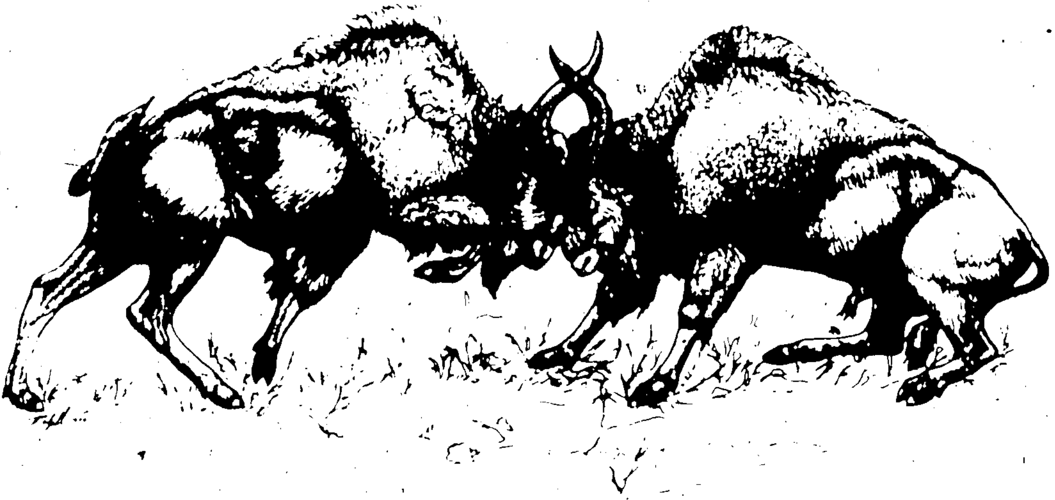
Adult male crania - NMC 17688 from Old Crow Locality 11(1) is complete except for the tip of

Figure 77. A. Restoration of large-horned bison *(Bison crassicornis)* males fighting. Ink sketch by Bonnie Dalzell.

Posterior of cranium with complete horncores (NMC 7392, Dawson Locality 32) of a male Pleistocene large-horned bison *(Bison crassicornis)*.

B. Dorsal view (anterior to bottom).

C. Posterior view.



A

B

C

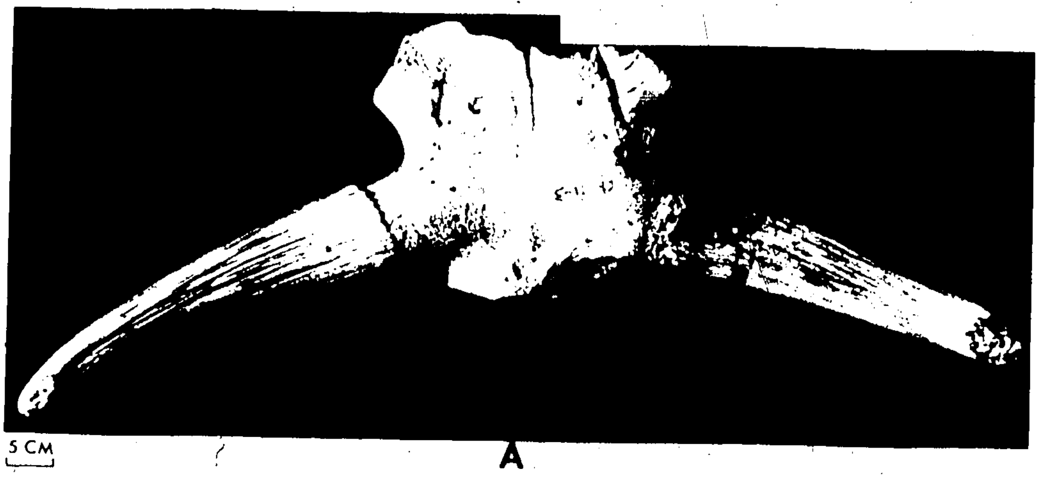
Figure 78. Posterior of cranium with horncores lacking tips (NMC 20634, Old Crow Locality 11(1)) of a male Pleistocene large-horned bison *(Bison crassicornis)*.

A. Dorsal view (anterior to top).

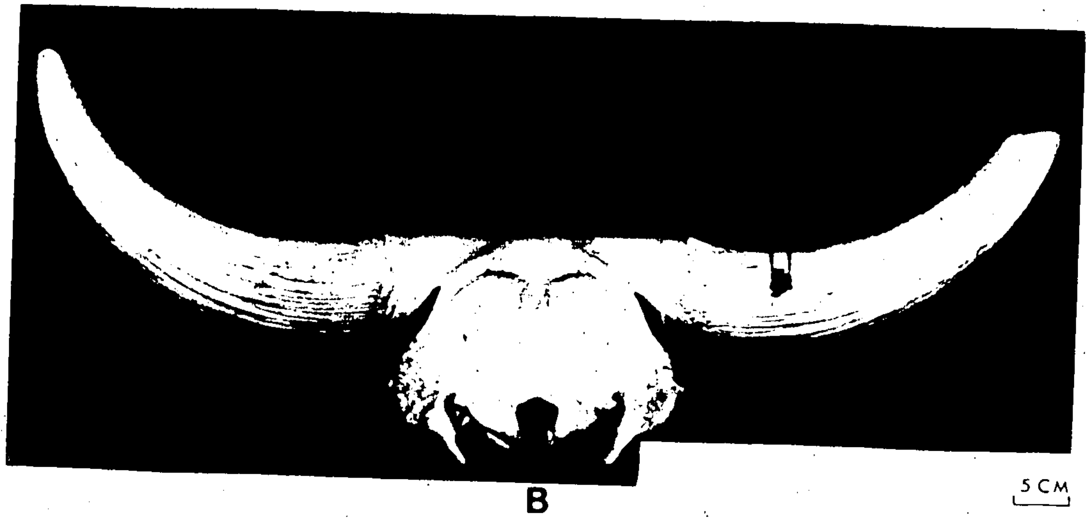
B. Posterior view. Sample cut from right horncore was used for x-ray diffraction analysis.

C. Ventral view (anterior to bottom).

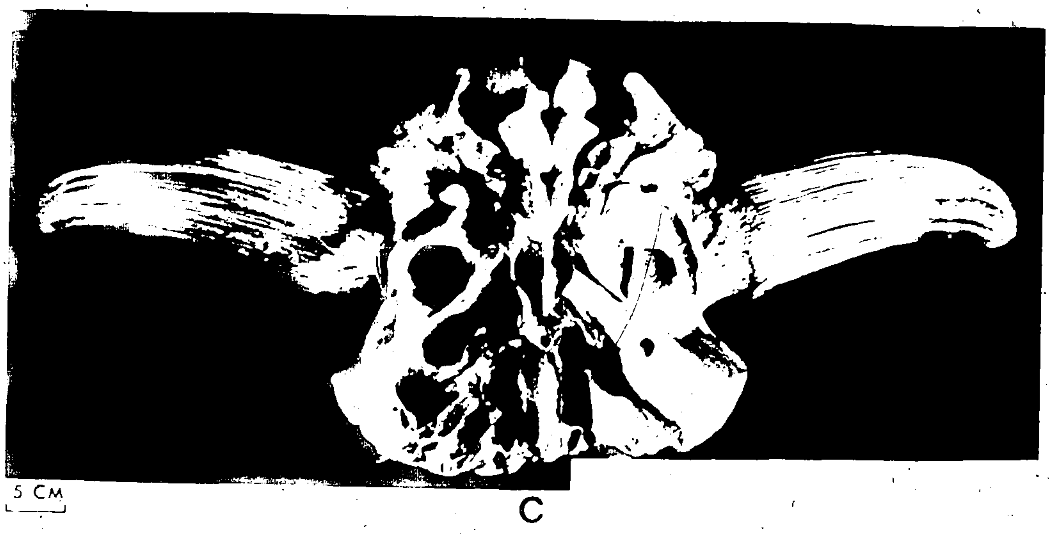
Radiocarbon dates on bone from this species at Old Crow Locality 11(1) indicate that this specimen is approximately 12,200 years old.



A



B



C

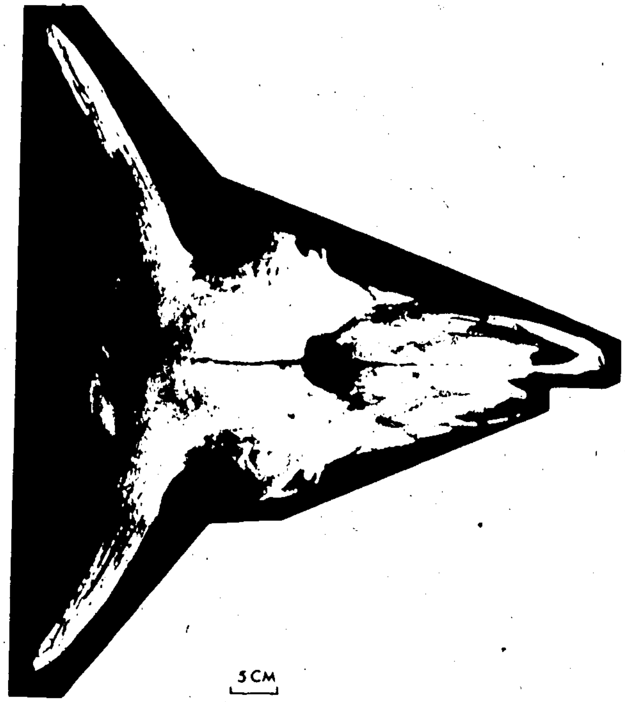
Figure 79. Cranium with horncores and partial hornsheaths (NMC 17687, Old Crow Locality 11(1)) of a female Pleistocene large-horned bison *(Bison crassicornis)*.

A. Dorsal view without hornsheaths.

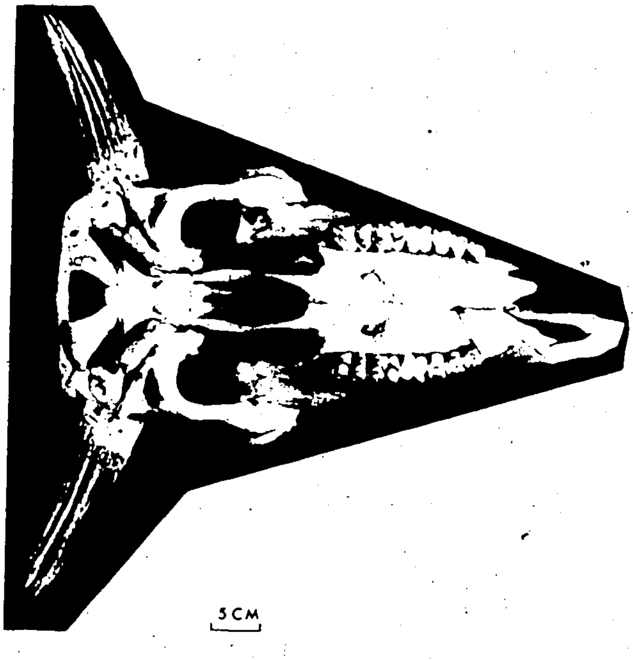
B. Ventral view without hornsheaths.

C. High posterior view with hornsheaths.

Radiocarbon dates on bone from this species at Old Crow Locality 11(1) indicate that this specimen is approximately 12,200 years old.



A



B

C

Table 87. Measurements of Pleistocene large-horned bison (*Bison crassicornis*) crania from the Yukon Territory.

SPECIMENS	SEX	ESTIMATED AGE	MEASUREMENTS (mm) * 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Bison crassicornis, Pleistocene, Y.T.																	
MALES																	
NMC 7392 Dawson Loc. 39	♂	Adult	946	985	463	520	400	99	120	350	291	-	77	108	151	-	309
NMC 31000 Dawson Loc. unknown	♂	Adult	975	1000	460	520	420	108	125	375	282	150	97	102	149	300	299
NMC 11675 Dawson Loc. 15	♂	Adult	1080e	1088e	452	480	423	100	112	340	-	-	-	-	-	-	300e
NMC 11646 Dawson Loc. 32	♂	Adult	-	-	440	503	39[illegible]	100	122	349	-	-	-	-	-	-	-
NMC 11674 Dawson Loc. 15	♂	Adult	-	-	439	510	390	101	118	350	-	-	-	-	-	-	-
NMC 8145 Dawson Loc. 3	♂	Adult	970	988	435	490	377	93	102	310	262	135	73	104	152	338	292
NMC 7393 Dominion Ck. (Dawson Area)	♂	Adult	996	1016	420	495	362	9[illegible]	105	320	-	-	-	-	-	373	301
NMC 10458 Dawson Loc. 12	♂	Adult	-	-	419	476	370	106	119	355	-	-	-	-	-	-	-
NMC 17330 Dawson Loc. 6	♂	Adult	1070	1074	415	460	375	101	121	358	-	154	85	113	157	346	-
NMC 8144 Dawson Loc. 3	♂	Adult	747	823	413	475	340	91	108	312	-	132	71	105	145	293	275
NMC 17602 Dawson Loc. 28	♂	Adult	-	-	410	474	353	10[illegible]	112	341	-	-	-	-	-	-	-
NMC 20634 Old Crow Loc. 11(1)***	♂	Adult	960e	1000e	410	460	380	96	107	322	271	133	91	114	155	302	272
NMC 17683 Old Crow Loc. 11(1)***	♂	Adult	880	890e	400	465	345	91	95	290	265	130	69	105	155	305	276
NMC 26192 Old Crow Loc. 11(1)***	?♂	Adult	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NMC 13507 Dawson Loc. 32	♂	Adult	-	-	400	445	370	96	106	321	-	-	-	-	-	-	-
NMC 24202 Old Crow Loc. 11(1)***	♂	Adult	940e	980e	390	440	350	88	94	293	-	-	-	-	-	-	-
NMC 24200 Old Crow Loc. 11A	♂	Adult	-	-	385	445	361	101	110	330	-	-	84	-	-	-	-
NMC 11683 Brewer Loc. 1	♂	Adult	-	-	380e	435e	335e	90	99	298	-	-	-	-	-	-	-
NMC 7700 Dawson Loc. 9	♂	Adult	990	995	380	419	352	91	98	295	-	149	74	104	150	333	288
NMC 11782 Dawson Loc. 28	♂	Adult	-	-	370	447	322	98	116	332	-	-	-	-	-	-	-
NMC 11352 Dawson Loc. 2	♂	Adult	-	-	365	410	336	93	111	324	-	-	-	-	-	-	-
NMC 8874 Indian R. (Dawson Area)	♂	Adult	960e	990e	360e	400e	330e	95	103	307	262	127	69	101	140	344	276
NMC 17689 Porcupine Loc. 40	♂	Adult	-	-	358	414	319	87	100	297	-	138	75	105	154	-	-
NMC 11351 Dawson Loc. 2	♂	Adult	-	-	354	373	332	81	108	300	-	-	-	-	-	-	-
NMC 9885 Dawson Area	♂	Adult	900	914	353	405	327	91	109	313	-	142		100	142	320	294
NMC 13503 Dawson Loc. 32	♂	Adult	-	-	350	430	300	89	101	302	-	-		-	-	-	-
NMC 11782 Dawson Loc. 28	♂	Adult	-	-	350e	400e	310e	96	117	334	-	-		-	-	-	-
NMC 13559 Dawson Loc. 32	♂	Adult	-	-	347	411	300	95	116	337	-	-	-	-	-	-	-
NMC 9923 Dawson Loc. 12	♂	Adult	-	-	338	365	320	85	109	304	-	-	-	-	-	-	-
NMC 8146 Dawson Loc. 5	♂	Adult	770	780	335e	375e	295e	89	106	309	270	133		93	138	182	279
FEMALES																	
NMC 17687 Old Crow Loc. 11(1)***	♀	Adult	622	625	205	235	203	66	63	207	229	134	74	91	131	262a	222
NMC 11783 Dawson Loc. 28	♀	Adult	-	-	190	215	184	59	60	193	-	-	-	-	-	-	-
FEMALES OR IMMATURE MALES?																	
NMC 13703 Old Crow Loc. 11A (probably derived from Loc. 11(1)***)	?♂	?Immature	720e	740e	295	343	280	77	79	248	-	-	-	-	-	-	-
NMC 17331 Dawson Loc. 7	?♂	?Immature	710e	715e	294	223	270	70	113	226	-	123	65	96	139	248	240
NMC 11360 Dawson Loc. 2****	-	-	-	-	278	310	260	57	65	187	-	-	-	-	-	-	-
NMC 11687 Stewart Loc. 3	-	-	-	-	258	303	235	61	58	189	-	-	-	-	-	-	-
NMC 25193 Dawson Loc. 16	-	-	-	-	248	283	234	61	68	209	-	-	-	-	-	-	-
NMC 17601 Dawson Loc. 28	-	-	-	-	230e	270e	220e	62	64	202	-	-	-	-	-	291	239
NMC 25169 Dawson Loc. 33	-	-	-	-	210	253	200	56	54	177	-	-	-	-	-	-	-
JUVENILE																	
NMC 25180 Dawson Loc. 16	-	Juvenile	-	-	102e	104e	102e	37e	44e	132e	-	-	-	-	-	-	-

---

* See measurements with Table 86.

** See Table 36 for comparative statistical measurements on adult male *Bison crassicornis* crania from the Pleistocene of Alaska and the Yukon Territory.

*** Specimens derived from a deposit of late Wisconsin age radiocarbon dated at approximately 12,000 years B.P.

**** This horncore is twisted approximately 90° forward from its normal position. It is measured as if it were in the usual orientation.

nia from the Yukon Territory.

MEASUREMENTS (mm) *																					
9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
271	-	77	108	151	-	309	365	274	-	-	-	-	-	-	-	-	280	130	83	132	150
282	150	97	102	149	300	299	356	-	-	-	147	99	-	-	-	-	-	124	86	123	154
-	-	-	-	-	-	300e	-	-	-	-	-	-	-	-	-	-	-	114	89	133	151e
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	127	82	126	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	131	86	125	-
262	135	73	104	152	338	292	-	-	-	-	-	-	-	-	-	-	-	130	91	140	149
-	-	-	-	-	373	301	352	276	-	-	-	-	-	-	-	-	-	137	91	131	140
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	129	89	118	-
-	154	85	113	157	346	-	-	-	-	-	-	-	-	-	-	-	-	123	84	116	-
-	132	71	105	145	293	275	-	-	-	-	-	-	-	-	-	-	-	140	84	132	150
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	134	90	120	-
271	133	91	114	155	302	272	340	-	-	-	-	-	-	-	-	-	-	121	90	127	151
265	130	69	105	155	305	276	333	-	182	129	153	92	158	532	566	490	267	135	96	138	145
-	-	-	-	-	-	-	-	-	192	-	147	90	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	120	91	125	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	126	94	133	-
-	-	84	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	123	92	117	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	130e	91	128e	-
-	149	74	104	150	333	288	-	-	-	-	-	-	-	-	-	-	-	119	93	129	132
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	139	85	111	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	122	84	113	-
262	127	69	101	140	344	276	-	-	-	-	-	-	-	-	-	-	-	121e	92c	117e	130e
-	138	75	105	154	-	-	-	-	-	-	-	-	-	-	-	-	-	130	87	121	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	112	75	118	-
-	142	70	100	142	320	294	-	-	-	-	-	-	-	-	-	-	-	124	84	113	121
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	143	88	116	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	129e	82	105	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	137	82	103	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	114	78	111	-
270	133	76	93	138	182	279	-	-	-	-	-	-	-	-	-	-	-	127e	84	108e	120e
229	134	74	91	131	262a	222	285	214	168	119	148	91	151	501	540	560	235	116	105	99	92
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	117	98	98	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	123	98	119	-
-	123	65	96	139	248	240	-	-	-	-	-	-	-	-	-	-	-	120	96	130	123
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	119	88	149	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	129	105	137	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	121	90	119	-
-	-	-	-	-	291	239	303	-	-	-	-	-	-	-	-	-	-	123e	97	114e	96
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	127	104	119	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	102e	84e	77e	-

Table 88. Measurements of Pleistocene large-horned (*Bison crassicornis*) maxillae and mandibles with teeth from Old Crow Locality 11(1), Yukon Territory.

SPECIMENS		SEX	AGE CLASS	MEASUREMENTS (mm) *																
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	1
Bison crassicornis. Pleistocene, Y.T.																				
MAXILLAE																				
NMC 17688		♂	S-3	16.6	15.4	21.9	20.5	19.5	18.4^{+}	19.5	21.4	20.0^{+}	27.7	24.5	21.9^{+}	33.3	23.9	21.8^{+}	32.9	24.0
NMC 17687		♀	S-3	18.2	14.3	6.9	19.6	20.9	8.0	17.1	23.1	8.8	24.5	25.7	10.1	29.7	27.7	21.0	33.8	27.0
NMC 26192		-	S-4	-	-	-	-	-	-	-	-	-	24.1e	26.1	10.6	30.3	29.2	16.6	32.2	28.0
MANDIBLES																				
NMC 23019		-	S-4	-	-	-	17.6	11.7	9.3	21.2	13.7	8.6	27.0	19.4	8.7	32.8	21.5	9.3	46.3	20.0
NMC 26107b	} same individual	-	S-3	12.4	9.8	13.3	18.9	11.9	11.5	22.5	15.4	12.2	25.7	18.9	11.9	31.2	21.9	14.0	46.3	20.2
NMC 26107a		-	S-3	12.6	9.9	11.6	19.0	12.3	9.6	22.2	15.0	12.0	25.0	18.9	12.2	30.5	21.8	16.0	46.7	19.9
NMC 26136		-	S-4	-	-	-	-	-	-	-	-	-	-	-	-	30.8	19.9	14.9	-	-

* 1. Maximum length P2. 2. Maximum width P2. 3. Maximum height P2 (from cingulum to crown on lingual side. Heights with a plus (+) sign indicate height of tooth crown above alveolar margin when cingulum is not exposed). 4. Maximum length P3. 5. Maximum width P3. 6. Maximum height P3. 7. Maximum length P4. 8. Maximum width P4. 9. Maximum height P4. 10. Maximum length M1. 11. Maximum width M1. 12. Maximum height M1. 13. Maximum length M2. 14. Maximum width M2. 15. Maximum height M2. 16. Maximum length M3. 17. Maximum width M3. 18. Maximum height M3. 19. Mandible length posterior of angle to anterior tip. 20. Distance from posteriormost surface of condyle to posterior alveolar margin of M_3. 21. Mandible depth below centre of M_1. 22. Mandible width below centre of M_1. 23. Length from anterior of P_2 alveolus to anterior tip of mandible. 24. P_2-M_3 alveolar length.

** Unusual shallowness results from pathological condition.

crassicornis) maxillae and mandibles with teeth from Old Crow Locality 11(1).

MEASUREMENTS (mm) *																			
5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
.5	18.4+	19.5	21.4	20.0+	27.7	24.5	21.9+	33.3	23.9	21.8+	32.9	24.0	23.3+	-	-	-	-	-	-
.9	8.0	17.1	23.1	8.8	24.5	25.7	10.1	29.7	27.7	21.0	33.8	27.0	17.3+	-	-	-	-	-	-
	-	-	-	-	24.1e	26.1	10.6	30.3	29.2	16.6	32.2	28.0	18.6+	-	-	-	-	-	-
.7	9.3	21.2	13.7	8.6	27.0	19.4	8.7	32.8	21.5	9.3	46.3	2	22.1+	456.0a	190.7	62.1	34.6	156.0a	164.2
.9	11.5	22.5	15.4	12.2	25.7	18.9	11.9	31.2	21.9	14.0	46.3	20.2	15.5	457.0a	195.2	52.5	29.9	153.0a	160.1
.3	9.6	22.2	15.0	12.0	25.0	18.9	12.2	30.5	21.8	16.0	46.7	19.9	19.4	457.0	195.6	53.3	24.3	153.0a	162.7
	-	-	-	-	-	-	-	30.8	19.9	14.9	-	-	-	440.0	190.9	38.0**	34.6	161.0a	153.5

(from cingulum to crown on lingual side. Heights with a plus (+) sign indicate
sed). 4. Maximum length P3. 5. Maximum width P3. 6. Maximum height P3.
. 10. Maximum length M1. 11. Maximum width M1. 12. Maximum height M1.
M2. 16. Maximum length M3. 17. Maximum width M3. 18. Maximum height M3.
ce from posteriormost surface of condyle to posterior alveolar margin of M_3.
tre of M_1. 23. Length from anterior of P_2 alveolus to anterior tip of

Table 89. Measurements of Pleistocene large-horned bison (*Bison crassicornis*) vertebrae from Old Crow Locality 11(1), Yukon Territory.

Specimens	Measurements (mm)*				
	1	2	3	4	5
Bison crassicornis, Pleistocene, Y.T.					
<u>Atlas</u>					
NMC 26114	110.3	227.0e	135.0	50.1	39.0
NMC 23338	103.7	198.9	135.5	49.8	43.2
<u>Axis</u>					
NMC 17170	189.0	150.5	135.8	132.4	102.0
NMC 26115	176.0	142.0	131.8	116.0e	83.1
<u>Fifth Cervical</u>					
NMC 17196	189.2	186.2	-	34.8	77.9
<u>?First Thoracic</u>					
NMC 26125	619.0	131.0	-	77.0	545.0
<u>?Third Thoracic</u>					
NMC 26126	629.0	125.9	-	76.7	551.0
<u>?Fifth Thoracic</u>					
NMC 26171	496.0	119.6	-	75.9	438.0
<u>Sacrum</u>					
NMC 17159	185.4	293.8	-	293.5	99.1
NMC 26178	180.2	244.4	-	237.0†	77.2

* 1 - Maximum height.

2 - Maximum width.

3 - Maximum width across occipital condylar facets (atlas) or anterior articular processes (axis).

4 - Straight-line, mid-ventral length below the neural canal.

5 - Height of dorsal tubercle (atlas) or neural spine from anterior dorsal surface of neural canal to top of tubercle or neural spine.

Table 90. Measurements of Pleistocene large-horned bison (*Bison crassicornis*) scapulae from Old Crow Locality 11(1), Yukon Territory.

Specimens	Measurements (mm)*					
	1	2	3	4	5	6
Bison crassicornis.Pleistocene, Y.T.						
NMC 22854	82.9	67.5	105.3	90.7	35.4	558.0
NMC 20444	84.0	70.2	105.5	93.0	40.5	536.0^{+}
NMC 17171	83.1	71.7	104.8	87.9	36.8	478.0^{+}
NMC 22886	76.1	66.3	92.6	79.8	33.9	469.0^{+}
NMC 26166	80.1	64.0	98.2	71.8	31.1	446.0

* 1 - Maximum length of glenoid fossa.
2 - Maximum width of glenoid fossa.
3 - Maximum length of scapula taken at a point between glenoid fossa and neck.
4 - Minimum length at neck.
5 - Minimum width at neck.
6 - Maximum height of scapula (anterior margin of glenoid cavity to vertebral border).

Table 9E. Measurements of Pleistocene large-horned bison (*Bison crassicornis*) limb bones from Old Crow Locality 11(1), Yukon Territory.

Specimens	Measurements (mm)*						
	1	2	3	4	5	6	7
Bison crassicornis: Pleistocene, Y.T.							
Humeri							
NMC 29273	424.0	130.8	127.3	55.7	70.0	105.5	106.6
NMC 29274	433.0	–	–	58.0	63.5	108.5	103.6
NMC 23020	361.0	114.0	110.2	48.1	57.9	92.3	95.0
NMC 26127	357.0	110.2	113.8	[illegible]	56.4	94.3	94.7
Radii							
NMC 17160	389.0(505.0)**	117.4	59.8	60.8	40.6	108.5	67.3
NMC 29276	386.0(504.0)**	115.0	63.4	64.7	42.1	106.5	66.7a
NMC 17194	385.0	112.8	58.3	57.2	39.0	102.5	67.0
Metacarpals							
NMC 29272	230.0	84.8	51.1	55.2	34.5	88.4	45.0
NMC 22851	228.2	84.7	49.3	50.1	36.4	84.7	45.0
NMC 20439	218.7	71.2	44.2	42.1	30.7	75.0	40.5
Femora							
NMC 26108	502.0	164.5	75.2	48.8	55.5	128.6	167.0
NMC 22853	427.0	131.6	61.1	41.1	43.3	104.1	143.5
Tibiae							
NMC 26168	436.0	134.1	120.7	54.3	45.8	82.6	62.1
NMC 17178	431.0	122.8	115.9	49.5	41.5	78.7	58.0
NMC 26167	422.0	122.2	113.7	50.0	46.1	75.8	58.4
NMC 26177	414.0	125.0	115.1	50.0	45.2	76.6	60.0
Metatarsal							
NMC 20437 (immature)	228.6+	50.1	49.6	29.9	30.6	–	–
First Phalanges							
NMC 26182	82.4	42.1	46.7	34.8	24.3	38.0	30.1
NMC 17188	78.2	43.4	44.0	38.8	26.4	41.1	31.7
NMC 26113	75.4	39.8	43.4	36.1	[illegible]	40.8	31.8

* 1 - Total length.
2 - Proximal width.
3 - Proximal depth.
4 - Midshaft (minimum shaft in humeri) width.
5 - Midshaft (minimum shaft in humeri) depth.
6 - Distal width.
7 - Distal depth.

** Total length of entire radio-ulna.

the left horncore, RP^2, and damage to the anterior part of the left orbit. According to Skinner and Kaisen's (1947, p. 145) method of age classification for plains bison *(Bison bison bison)*, the individual represented by this specimen was at the beginning of full maturity (S-3). The fossil is generally fresh in appearance, being tan to rust colored on the surface. It is of late Wisconsin age. NMC 20634 from Old Crow Locality 11(1) is a cranial fragment with horncores. It lacks bone anterior to the orbits. Although the tip of the right horncore is missing, the spread from tip to tip of the horncore is much greater than that of NMC 17688. A small slice of bone was removed from the right horncore for x-ray diffraction analysis, in order to ascertain the types and relative concentrations of various elements in the bone. NMC 24204 from Old Crow Locality 11(1) is a left horncore with most of the left frontal attached. The upper part of the orbit is preserved. The bone varies in color between tan and rust. It is of late Wisconsin age.

NMC 31000 from an unknown locality in the Dawson Area is a cranial fragment with horncores, the right facial region including the orbit, chipped RM^2-RM^3 and alveoli for RP^2-RM^1, and adjacent palatal bone. A virtually complete left nasal (225 mm long x 60 mm wide) may belong with NMC 31000, but there are no contacts with the rest of the cranium, so this association must remain conjectural. NMC 8144 from Dawson Locality 3 is a posterior cranial fragment with horncores and the distal halves of both hornsheaths. Bone anterior to the orbits is lacking and the occipital and basicranial regions are damaged. The inward, backward curving tips of the hornsheaths, when in place, are 500 mm apart, and the greatest spread on the outside curve of the hornsheaths is 847 mm. NMC 8874 from Indian River near Dawson is a posterior cranial fragment with horncores and hornsheaths. The anterior margin of the right hornsheath is damaged. Most of the left orbit is lacking, whereas only the dorsal portion of the right orbit is preserved. The tips of the hornsheaths, when in place, are 790 mm apart, and the greatest spread on their outside curve is 1,062 mm.

NMC 7393 from Dominion Creek in the Dawson Area, was collected 30 feet (9.1 m) below the surface. It consists of the posterior dorsal portion of a cranium with horncores and complete hornsheaths. Most of the bone anterior to the nasofrontal suture is lacking. The left orbit is complete but only the dorsal half of the right one is preserved. The tips of the hornsheaths, when in place, are 795 mm apart, and the greatest spread on their outside curve is 1,070 mm. They are approximately 460 mm long on the inside curve from burr to tip. NMC 8145 from Dawson Locality 3 is a posterior cranial fragment with horncores and nearly complete hornsheaths. Bone anterior to the orbits is lacking and the basicranium is badly damaged. The left orbit is complete, but most of the right orbit is missing. The tips of the hornsheaths are 747 mm apart, and the greatest spread on their outside curve is 1,037 mm. They are approximately 530 mm long on the inside curve.

NMC 17330 from Dawson Locality 6 is a posterior cranial fragment with horncores. Bone anterior to the orbits is lacking, and part of the right upper section of the occipital region is damaged. The frontal suture is fused, indicating that the specimen represents an old male. NMC 7700 from Dawson Locality 9 is a posterior cranial fragment with both horncores and the distal half of the left hornsheath. Bone anterior to the orbits is lacking, and little of the orbits remains. Occipital and basicranial regions are slightly damaged. NMC 7392 from Dawson Locality 32 is a posterior cranial fragment with complete horncores and orbits. The right occipital condyle is missing. The fossil was collected by

R.G. McConnell in 1900. It came from muck 15 feet (4.6 m) below the surface on claim 17 of Gold Run Creek. Whiteaves (1903, p. 240) remarked that this specimen (designated as Museum of the Geological Survey No. 1 for convenience at that time) is larger and much longer-horned than skulls of Recent wood or plains bison, and stated that it is "apparently referable to the form which Mr. Rhoads describes and figures as the 'Great Alaskan Bison,' *Bison alaskensis*..." However, he noted that Lucas (1899) had placed *B. alaskensis* among the synonyms of *B. crassicornis* Richardson. Skinner and Kaisen (1947, p. 196), calling the specimen "Mus. Geol. and Surv. Canada 1," correctly referred it to *B. crassicornis*. NMC 9885 from the Dawson Area (exact locality unspecified) is a posterior cranial fragment with horncores. Bone anterior to the severely damaged orbits is lacking. The basicranial region is damaged.

NMC 8146 from the Dawson Area (exact locality unspecified) is a posterior cranial fragment with horncores. Bone anterior to the constriction between the horncores and orbits is lacking, the basicranium is damaged and the central part of the skull is partly split lengthwise. The fossil has relatively short horncores for an adult male - which it seems to represent according to the well defined horncore burrs. Yet other characteristics, such as the marked backsweep of the deeply-grooved, sharp-tipped horncores, and the indices of horncore curvature, compression, proportion and length, which are within the range of *B. crassicornis* (Skinner and Kaisen 1947, Table 16), indicate it is a small *Bison crassicornis* cranium.

Referred left horncores - NMC 13507 from Dawson Locality 32 is attached to the left half of a cranial fragment extending from the posterior of the left orbit to the occipital region. The bone is stained rusty brown. NMC 13508 from Dawson Locality 32 is attached to the left half of a dorsal cranial fragment extending from the orbit to the posterior margin of the frontal. It is stained dark reddish brown. NMC 11782 from Dawson Locality 28 is similar to NMC 13508 except that a heavily eroded hornsheath is attached. NMC 24200 from Old Crow Locality 11A is attached to the left half of the dorsal part of the braincase, including part of the left orbit. Bone on the inner surface of the orbit and on the left frontal is deeply pitted. Small parts of the right occipital region, including the right occipital condyle, are present. The specimen is stained dark reddish brown. It appears to be of late Wisconsin age.

NMC 17602 from Dawson Locality 28 is attached to large parts of both left and right frontals. Only small fragments of the orbits are preserved. The specimen is iron-stained and weathered. NMC 11646 from Dawson Locality 32 is attached to a left frontal. It is dark rust in color. Erosion on the upper surface of the burr partly accounts for its relatively high degree of compression.

Referred right horncores - NMC 11674 from Dawson Locality 15 is attached to the frontal, and includes part of the right orbit. NMC 10458 from Dawson Locality 12 is similar to NMC 11674. It is stained dark brown. NMC 17689 from Porcupine Locality 40 is attached to the right frontal and most of the occipital and basicranial regions. It is reddish brown. NMC 11683 from Brewer Locality 1 is attached to the posterior half of a right frontal. The tip of the horncore is slightly damaged. NMC 13559 from Dawson Locality 32 is attached to the right and part of the left frontals. It is reddish brown with black (manganese?) patches. NMC 11782 from Dawson Locality 28 is attached to the lateral half of the right frontal, including part of the orbit. Its heavily eroded and weathered hornsheath has the inward and backward twist at the tip that is characteristic of *Bison crassicornis*. The tip of the horncore is probably lodged in the anterior of the hornsheath. An abnormal (pathological?) depression is seen on the ventral surface of the horncore, between 50 mm and 110 mm from the burr. The specimen is stained rusty brown. NMC 9923 from Dawso[illegible]ality 12 is attached to a small fragment of the rig[illegible]ntal. It is iron-stained.

Adult female crania referred - NMC 17687 from Old Crow Locality 11(1) was derived from the same late Wisconsin stratum as the well preserved adult male cranium NMC 17688. This cranium is complete except that the right premaxilla and the medial halves of the hornsheaths are lacking. According to Skinner and Kaisen's (1947, p. 145) method of age classification for plains bison, the individual represented by the cranium was in full maturity (S-3). The loops of the lingual styles of M^1s have disappeared into the enamel borders of the roots, and the lingual styles of M^3s are moderately worn. Burrs are poorly developed. The horncores are shorter and more slender than those of males of the same age class from the same radiocarbon-controlled late Wisconsin deposit. When in place, the tips of the hornsheaths are 655 mm apart. They do not rise so high or curve so far inward and backward at the tips as do male adult *Bison crassicornis* horns. The greatest length across the outside curve of the hornsheaths is 705 mm. The length of a complete hornsheath along the upper curve is estimated to be 370 mm - about 45% greater than the same measurement of the horncores, and approximately 70% the length of an adult male *Bison crassicornis* hornsheath (NMC 8145). The surface of the bone of NMC 17687 is tan to reddish brown and has a very fresh appearance. NMC 11783 from Dawson Locality 28 is a right horncore with a small posterior fragment of the right frontal. A very deep groove exists on the ventral surface of the horncore. The fossil matches well the horncores of the adult female NMC 17682 and is referred to a female of *B. crassicornis*. The indices of horncore curvature, compression and proportion between NMC 11783 and 17682 are very close (Table 87). The specimen is stained yellowish tan.

Immature male or adult female crania referred - NMC 13705 was recovered from the surface at the upstream end of a gravel bar (Old Crow Locality 11A). The relatively fresh appearance of the bone matches that of other *Bison crassicornis* material from Old Crow Locality 11(1), and most likely it was derived from that site, which is a short distance upstream on the same side of the river.

The fossil consists of a right horncore and a right frontal fragment showing part of the frontal suture and extending forward to the orbit. The frontal suture appears to have been open when the animal died (this cannot be established with certainty), cranial bone is relatively thin, and while the horncore is smaller than any I attribute to adult male *Bison crassicornis*, it is more robust than any specimens that I think are assignable to adult female *B. crassicornis* (particularly in length, degree of burr development, and circumference of the horncore near the base). Therefore, I tentatively consider that the fossil represents an immature male of the large-horned bison. NMC 17331 from Dawson Locality 7 is a posterior cranial fragment with horncores and heavily eroded basicranial and occipital regions. The occipital condyles are worn. Sutures are open except for a small area near the juncture of the frontal and frontoparietal sutures. The length of the horncores and the relatively high indices of proportion and length indicate that the fossil represents an immature male rather than a female, and I tentatively refer it to an immature male of *Bison crassicornis*. The bone is light buff with occasional patches of iron staining.

I am not sure of the sex or age of the following specimens, but the horncore size and shape suggest that they are attributable to either immature males or mature females of *Bison crassicornis*. NMC 17601 from Dawson Locality 28 is the dorsal surface of a posterior cranial fragment with small horncores, the tips of which are missing. Sutures present are in the same condition of fusion as those of NMC 17331 but the horncores are rather smaller. NMC 25193 from Dawson Locality 16 is a left horncore with a small portion of the left frontal. It is stained light brown. NMC 25169 from Dawson Locality 33 is a left horncore with part of the left frontal, and most of the hornsheath. NMC 11687 from Stewart Locality 3 is a left horncore with part of the left frontal, including a lateral fragment of the orbit, and a small part of the parietal. The specimen is deep reddish brown. NMC 11360 from Dawson Locality 2 is an aberrant right horncore. It is twisted forward approximately 90° from its usual orientation, matching well the condition in a partial, referred femal *Bison crassicornis* cranium from Pleistocene deposits of Alaska. In that specimen the left horncore is normal, whereas the right one is twisted forward (Skinner and Kaisen 1947, Plate 23-4, 4a). I speculate that there is genetic control of the orientation of the horncore, which was not regularly expressed in these cases. The evidence also suggests that genetic control for one horncore can be autonomous from that for the other horncore. On the other hand it could be an embryogenetic abnormality. NMC 11360 is stained dark brown and may be older than most Pleistocene mammal specimens from the Dawson Area.

I tentatively refer NMC 25180 from Dawson Locality 16, a small, slightly damaged left horncore with part of the left frontal, to a juvenile of *Bison crassicornis*. The shortness of the horncore, which is best described as a "spike", indicates that the fossil represents a calf only a few months old. It belongs in Skinner and Kaisen's (1947, p. 143, Plate 8-2) "immature (I-S)" category, and suggests that large-horned bison calved in the Dawson Area during the late Pleistocene. The fossil is stained dark reddish brown.

Following are descriptions of the best preserved mandibles and postcranial elements of bison from Old Crow Locality 11(1). The specimens are of particular interest because they can be identified definitely as belonging to *Bison crassicornis*, and almost certainly they are members of a single population - perhaps a single herd. Further, they are the last known representatives of *Bison crassicornis* the Yukon Territory, having been radiocarbon dated at approximately 12,000 years B.P.

Unless otherwise specified, the bones are tan in color and fresh in appearance. Cranial material from this site has been described above with the other large-horned bison crania.

Before describing the mandibles and postcranial material, it is advisable to provide some geochronological background. Radiocarbon analyses of bison bone from the site yielded dates of 11,910 ± 180 years B.P. (I-7765) and 12,460 ± 220 years B.P. (I-3574). A horncore from a *Bison crassicornis* cranium located near the surface of the first gravel bar (Locality 11A) downstream from Locality 11(1), and presumably washed down from that site during the spring flood, gave a radiocarbon date of 12,275 ± 180 years B.P. (I-7764). This concentration of fossils may have resulted from a herd of bison breaking through lake ice and dying, their bones eventually being transported a short distance downslope to the present locality. It is worth noting that in Wood Buffalo Park, many bison are known to have drowned by breaking through thin or rotting ice in early winter or late spring (Fuller 1962, p. 38), which may lend some credence to my suggestion.

Mandibles - NMC 23019 is a left mandible with LP_3-LM_1 and the alveolus for LP_2. It is complete except for LP_2 and slight damage to the posterior margin of the angle, the tip of the coronoid process, and the anterior tip of the mandible. Enamel patterns are virtually obliterated on the occlusal surfaces of LP_3-LM_1. Using age class criteria established by Skinner and Kaisen (1947, p. 146) for plains bison mandibles (which I think are roughly applicable in this case), NMC 230 9 represents an animal in early part of the "old age (S-4)" category. NMC 26107b is a left mandible with LP_2-LM_3. It is complete except for slight damage to its anterior tip. The specimen articulates with NMC 26107a, a complete right mandible with RP_2-RM_3, forming an entire lower jaw. It belongs in Skinner and Kaisen's "full maturity (S-3)" category. NMC 26136 is a right mandible with RM_2, the posterior root for RM_1 and alveoli for the remaining cheek teeth. The most remarkable feature of this specimen is the severe erosion of the mandibular bone in the RP_4-RM_1 region. Consequently, the depth of the mandible below the position of RM_1 is about half the depth below RM_2. This condition appears to be pathological, perhaps resulting from periodontal erosion following the loss of RP_4 and RM_1. As if in compensation for the shallowness of the mandible in this region, evidently the jaw thickened laterally, where a surficial vascular pattern indicates callus may have developed. Miller (1974, Figure 5-6) illustrates cases of dental malloclusion in 8-year-old caribou resulting from loss of anterior cheek teeth and tooth decay, which are reminiscent of the condition in NMC 26136. Disregarding possible pathological effects, the heavy wear on RM_2 suggests that the bison represented by the fossil was in the "old age (S-4)" category. The comparatively short RP_2-RM_3 alveolar length is also indicative of an old individual.

Vertebrae - Two atlas vertebrae are in the collection. NMC 26114 is damaged on the right lateral margin. Rootlet impression cover its surface, suggesting decay in a grassland environment. NMC 23338 is complete, but smaller than NMC 26114. Two axis vertebrae include: NMC 26115, which is complete except for the posterior epiphyseal plate of the centrum; and NMC 17170, which is complete and appears to represent a large animal. Other vertebrae in the collection include: a complete fifth cervical (NMC 17196); a ?first thoracic (NMC 26125), which may lack the tip of the neural spine; a complete ?third thoracic (NMC 25126); a complete ?fifth thoracic (NMC 26171). These fossil vertebrae were compared to their counterparts in a modern *Bison bison* skeleton (NMC 5552) from Alberta. All of the fossils were markedly larger. Two nearly complete sacral elements are present. NMC 17159 is the larger. The anterior margin of the first of the fused neural spines is slightly damaged. NMC 26178 seems to be from an immature or female according to its small size, and the relative thinness of the bone. The last (fifth sacral) vertebra has been broken off.

Scapulae - NMC 22854 is a complete right scapula (except, of course, for the scapular cartilage). NMC 26166 is a right scapula of a smaller individual. It lacks the acromion and bone near the central part of the vertebral border. The anterior angle is slightly eroded. NMC 20444 is a left scapula of comparable size to NMC 22854. It is complete except for part of the vertebral border. NMC 17171, a left scapula, is complete except for the tip of the acromion and the margins of the anterior angle and vertebral border. Unlike the other specimens, the left scapula NMC 22886 shows signs of weathering and surface cracking. It is damaged near the anterior angle, and along the vertebral border extending into the central part of the infraspinous fossa.

Humeri - Of four left humeri from Old Crow Locality 11(1), two are small (female?) and two are large (male?). NMC 29273, one of the larger specimens, is complete. NMC 29274 is of similar size, but lacks most of the head and medial part of the shaft at the proximal end. The smaller humeri, NMC 23020 and 26172, are both complete.

Radio-ulnae - In the collection are two complete left radio-ulnae (NMC 17610 and 29276), and one right radius (NMC 17194) with the distal end of the ulna fused to it.

Carpals - Four left carpals are in the collection. NMC 23018 is a lunate which measures 50 mm long x 39 mm wide x 38 mm thick. NMC 29277 is a scaphoid measuring 60 mm x 39 mm x 46 mm. NMC 26186, an unciform, measures 47 mm x 43 mm x 33 mm. NMC 29278 is most of a cuneiform.

Metacarpals - Two large left metacarpals (NMC 22851, 29272) and a smaller right metacarpal (NMC 20439) are present. All are complete. The first two fit into the upper limit of group B, while the last is close to the upper limit of group A in the tentatively sexed sample of *Bison crassicornis* (referred) metacarpals from Pleistocene deposits at Gold Run Creek (Harington and Clulow 1973, Figure 48). Therefore, I suggest that NMC 22851 and 29272 represent males, and that NMC 20439 represents a female.

Pelvis - A nearly complete pelvis (NMC 17164) lacks some bone between the obturator foramina, and on the right tuber ischii. The maximum diameter of the right acetabulum is 93.0 mm. Maximum and minimum diameters of the right obturator foramen are 111.4 mm x 71.5 mm. The width across the anterior margins of the acetabula is approximately 320 mm. The maximum anterior width of the pelvis is approximately 560 mm, and its greatest length from the posteriormost part of the ischium to the tuber coxae is 635 mm.

Femora - Two complete specimens are in the collection. NMC 26108, a right femur is much larger than a left one, NMC 22853. The epiphyses are fused to the shaft in both, and probably both represent adults. I suggest that the former represents a male and the latter a female. Size differences between the sexes in *Bison crassicornis* seem to have been great.

Tibiae - Four complete right tibiae (NMC 26168, 17178, 26167, 26177) vary in total length from 414 mm to 436 mm.

Tarsals - A right calcaneum (NMC 22597) measures 163 mm long x 46 mm wide x 67 mm deep, while a left calcaneum (NMC 22598) measures 175 mm long x 52 mm wide x 68 mm deep. Both are in good condition. A complete left naviculocuboid NMC 26180 measures 76 mm wide x 73 mm deep x 73 mm high.

Metatarsal - A right metatarsal (NMC 20437), lacking the distal epiphysis, probably represents a bison less than 3 years old — approximately the age when the distal epiphysis fuses to the metatarsal shaft in oxen (Silver 1969, p. 286).

Phalanges - Three complete first phalanges (NMC 26182, 17188, 26113) are in the collection from Old Crow Locality 11(1).

On the basis of the skeletal elements preserved, some of which are not described because of their fragmentary nature, I estimate that at least seven bison are represented at Old Crow Locality 11(1). They include both sexes, and subadult to very old animals.

Discussion

I have found no evidence that *Bison crassicornis* lived in the Yukon Territory before the mid-Wisconsin, although an earlier occupation is likely. No bison fossils are recorded from Unit 2 at Old Crow Locality 44, which is possibly of Sangamon age (>54,000 years B.P.). Radiocarbon dates on bone from seven Yukon large-horned bison specimens range in age from approximately 34,000 years B.P. to about 12,000 years B.P. (Table 5) - almost exactly the same range of dates on *Bison crassicornis* as those from Alaska (Table 6). The species is known from the Dawson, Old Crow and Sixtymile areas, as well as Herschel Island (NMC 17913).

In Canada, apart from the Yukon Territory, probably *Bison crassicornis* occupied parts of the Northwest Territories during the late Pleistocene. Mackay (1958, p. 25) states: "A skull (identified by two palaeontologists, upon the basis of photographs only, as probably that of an extinct bison, *Bison crassicornis*) was picked up from a sand beach 4 miles

(6.4 m) southwest of Tuktoyaktuk. As the skull is not waterworn and is in an excellent state of preservation, it was probably washed out of the sandy bluffs by cliff recession... A former Cape Bathurst trapper has stated that skulls similar to the bison skull of Tuktoyaktuk have been found at Cape Bathurst and from Maitland Point to the mouth of Anderson River." I (Harington 1971a, p. 82) have tentatively ascribed fossils from Baillie Islands, Northwest Territories to *Bison crassicornis*. Two cranial fragments of *Bison crassicornis* have been reported from the Edmonton area, Alberta (Fuller and Bayrock 1965, p. 55, Figures 15-16). The age estimate of 8,000 years B.P. for these specimens may be incorrect (Harington 1971a, p. 76). I have identified a specimen of *Bison crassicornis* (NMC 26050) from late Pleistocene gravels near Edmonton. Although Cowan (1941, p. 45) referred a fifth cervical vertebra from McCulloch Station and the base of a horncore and adjacent frontal bone from Victoria to "*Superbison* cf. *crassicornis*", I think the evidence is too slim yet to infer the presence of *Bison crassicornis* in British Columbia. A fragment of skull with partial horncores from deposits of probable Sangamon age at Fort Qu'Appelle, Saskatchewan, attributed to "*Superbison*" by McCorquodale (1957, p. 42), is best referred to a species with larger horncores, possibly *Bison latifrons* (Khan 1970, p. 59). I think two specimens of bison from Manitoba are probably referable to *Bison crassicornis*. MMMN P 586 is a cranial fragment with large horncores found in blue clay 16 feet (4.9 m) below the surface at Russell. The other, a posterior cranial fragment from the bed of the Roaring River (Pettipas 1971, p. 8) has horncores in the lower range of *Bison crassicornis*. From a clear photograph, the open sutures on the dorsal surface of the cranium and well developed burrs, suggest it represents a male of the large-horned bison that died in early adulthood.

In the conterminous United States, single crania referred to *Bison crassicornis* are recorded from Kansas, North Dakota and Massachusetts. Lilligraven (1967, pp. 298-299), who reported the specimen from Morris, Kansas, states that, according to its position relative to the Newman Terrace of the Kansas River, it could not be older than early Wisconsin. It should be noted that only one of the two crania from near Zap, North Dakota originally attributed to *Bison crassicornis* (Brophy 1965, p. 214) actually belongs in that species. Specimen 165 (now NDSU Geol. Dept. Z-1) fits the description of *Bison crassicornis*, and bone from it yielded a radiocarbon date of 7,840 ± 250 years B.P. (I-2536) (J.A. Brophy, personal communication 1974), which is the most recent record of the species in North America. Another cranium (formerly Specimen 166, now NDSU Geol. Dept. Z-2) from the same site and approximately the same depth is now referred to *Bison bison occidentalis*. Wood found in close association with the latter specimen gave a date of 5,440 ± 200 years B.P. (W-1537). Another highly unusual find was the discovery of a horncore of *Bison crassicornis* in a late Pleistocene deposit at Harvard, Massachusetts (Romer 1951, p. 230). [illegible]ly was it peculiar to find a fossil of this species in eastern North America, but this specimen constitutes the first record of an extinct bison from New England! The specimen yielded a radiocarbon date of approximately 21,200 years B.P.

In Alaska, perhaps the oldest record that could refer to *Bison crassicornis* is "*Bison (Superbison)* sp. (large bison)" from the Fox Gravel of possible Kansan age near Fairbanks (Péwé 1975a, Table 11; 1975b, p. 7). Hopkins (Péwé and Hopkins 1967, p. 269) considers that a skull of "*Bison (Superbison)* sp." was derived from deposits of possible Yarmouth interglacial age on Baldwin Peninsula. Other specimens designated "*Bison (Superbison)* sp." are reported from beds of Illinoian age near Fairbanks, and from a "forest bed" of Sangamon interglacial age near Tofty (Péwé and Hopkins 1967, p. 268). As no published descriptions of these fossils are available, it is difficult to know whether they should be treated merely as *Bison* sp., or whether they actually represent the large-horned bison, *Bison crassicornis*. Each specimen deserves careful examination. Every effort should be made to determine precisely the species of bison represented by a skull roof with horncores, and a single horncore found in deposits of possible Yarmouth age at Baldwin Peninsula. Evidently *Bison crassicornis* was the commonest large mammal in the Fairbanks area during the Wisconsin glaciation. Of 12 finite radiocarbon dates extending from approximately 32,000 years B.P. to approximately 12,000 years B.P., probably all (I consider "*Bison (Bison) preoccidentalis*" to be a junior synonym of *Bison crassicornis*) refer to *Bison crassicornis*. Therefore, radiocarbon evidence from both the Yukon and Alaska firmly support the idea that large-horned bison lived in Eastern Beringia from mid-Wisconsin time to 12,000 years ago. Earlier evidence is still tenuous.

Commenting on *Bison crassicornis*, Skinner and Kaisen (1947, p. 190) make an interesting point concerning the relationship between that species and Eurasian bison: "The situation, however, is quite different in Europe where *crassicornis* has not been recognized, but virtually all of the varying segments of the *crassicornis*-like population have been described as distinct species or as subspecies of the loosely defined *Bison priscus*." Later they (Skinner and Kaisen 1947, p. 232) state: "In Eurasia, *crassicornis* apparently ranged over most of northern Russia, Siberia, and down into Europe." They tentatively referred to *Bison crassicornis* the following Eurasian bison: *Bison priscus longicornis*, *Bison priscus fraasi*, *Bison priscus tscherskii*, *Bison priscus deminutus*, *Bison europaeus lenensis*, and *Bison uriformis*. It is important that Eurasian bison be surveyed and analyzed statistically, and that such observations be related to similar data from North American fossil bison.

To summarize, *Bison crassicornis* may have evolved from an ancestor like *Bison alaskensis* (? = *Bison priscus gigas*) in Beringia, where it was common from approximately Illinoian to late Wisconsin time. It spread westward to Europe during the late Pleistocene, and southeastward from Eastern Beringia through Alberta, possibly Manitoba, North Dakota and Kansas as far as the Atlantic coast of New England about mid-Wisconsin time or earlier. The species may have survived in central North America until early postglacial time (approximately 8,000 years B.P.), while it seems to have become extinct in Eastern Beringia about 12,000 years ago.

During the late Pleistocene, *Bison crassicornis* seems to have been Holarctic in distribution, occupying range from northern Europe through Siberia, Alaska and the Yukon to the North American plains and Atlantic coast. It was the most common ice age bison of northwestern North America. These animals were large in the body and horns compared to living *Bison bison*. They had long hind legs, more like those of the wisent *(Bison bison bonasus)* than the plains bison *(Bison bison bison)* (Figure 77A). A good idea of the appearance of this animal in life can be gained from a well preserved carcass from perenially frozen silt at Dome Creek near Fairbanks, Alaska. The specimen consists of a head complete with hide, hornsheaths, an ear, and the lower part of the body, including four legs with hooves (Péwé 1975a, Figure 44). Hide and hair from this carcass gave a radiocarbon date of 31,400 ± 2,040 years B.P. (ST-1721).

Probably this large-horned grazer preferred cool, loess-steppe or parkland habitat. Human hunters likely exploited this species during the late Pleistocene in the Yukon, as can be seen by examples of incised and spirally-fractured bison bone from the Old Crow Area, and by the posterior part of the bison cranium (probably referable to *Bison crassicornis*) with butcher marks from Sulphur Creek (Dawson Locality 17). Probably wolves and American lions also hunted the large-horned bison.

Bison bison occidentalis (western bison)

Western bison remains (Table 92) are about as rare as those of Alaskan bison (*Bison alaskensis*) in Yukon Pleistocene deposits. Two specimens from the Dawson Area are described. This species has been reported previously from the Yukon Territory on the basis of a single fragmentary cranium (USNM 2643), which was collected by Maddren on the Old Crow River in 1904 (Gilmore 1908, p. 34, Plate XII). I consider that nominal identifications of other crania from the Dawson Area (e.g. "*B. occidentalis*" (Gilmore 1908, p. 34) and "*Bison (occidentalis?)*" (Quackenbush 1909, p. 91)) are questionable.

Table 92. Measurements of Pleistocene western bison *(Bison bison occidentalis)* crania from the Yukon Territory compared to those Alberta and other parts of North America, and to crania of *Bison bison antiquus* from southern North America.

SPECIMENS	SEX	ESTIMATED AGE	MEASUREMENTS (mm)													
			1	2	3	4	5	6	7	8	9	10	11	12	13	
Bison bison occidentalis. Pleistocene, Y.T.																
NMC 2242 Dominion Ck. (Dawson Area)	♂	Adult	767	804	295	360	272	107	114	342	270	140	75	105	148	3
NMC 17333 Dawson Loc. 5	♂	Adult	775	790	315	377	284	100	111	329	284e	136	73	109	150	2
Bison bison occidentalis. Pleistocene, Alta.																
NMC 12442 Athabasca	♂	Adult	858	870	275	335	257	95	104	318	275e	140	72	110	152	3
Bison bison occidentalis. Pleistocene, N. America (Skinner and Kaisen 1947, Table 12)	♂♂	Adult														
M			747	782	279	340	243	91	98	290	275	131	–	–	158	–
OR			670–875	735–892	222–330	275–405	210–290	76–100	85–114	253–336	259–307	124–147	–	–	136–177	–
N			13	8	12	12	11	16	16	16	9	8	–	–	6	–
Bison bison antiquus. Pleistocene, N. America (Skinner and Kaisen 1947, Table 14)	♂♂	Adult														
M			881	–	281	336	245	98	107	320	–	–	–		–	–
OR			816–975	–	220–344	280–395	197–280	90–108	92–122	290–358	–	–	–	–	–	–
N			10	–	13	10	8	14	13	14	–	–	–	–	–	–

* See measurements with Table 86.

'ukon Territory compared to those from
outhern North America.

MEASUREMENTS (mm) *																					
9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
70	140	75	105	148	322	307	-	-	-	-	-	-	-	-	-	-	-	132	94	86	96
84e	136	73	109	150	278	288	-	-	-	-	-	-	-	-	-	-	-	133	90	96	109
75e	140	72	110	152	354	294	348	251	-	-	-	-	-	-	-	-	-	130	91	86	94
75	131	-	-	158	-	299	351	-	187	115	147	91	153	516	-	493	259	140	93	97	95
59–07	124–147	-	-	136–177	-	277–340	328–400	-	169–204	102–125	137–160	84–102	143–168	467–582	-	471–543	229–273	121–169	86–104	85–110	88–112
9	8	-	-	6	-	12	8	-	5	6	6	5	5	6	-	5	8	11	16	12	9
-	-	-	-	-	-	319	353	-	205	-	-	-	-	545	-	510	295	138	93	88	89
-	-	-	-	-	-	292–357	346–360	-	188–218	-	-	-	-	520–560	-	482–527	240–350	128–147	83–108	68–100	66–114
-	-	-	-	-	-	12	2	-	4	-	-	-	-	3	-	4	11	8	13	12	10

I wish to inject a note of doubt at this point. On the basis of the Yukon and Alberta specimens I have examined, I believe it is arguable whether they should be considered as *Bison bison occidentalis* or *Bison bison antiquus*. They approach the latter subspecies (using definitions of Skinner and Kaisen 1947) in that their horncores are not strongly backswept, and the former subspecies in the relative narrowness of their skulls at the constriction between horncores and orbits. In some of these specimens, the horncores rise well above the frontal plane (e.g. NMC 2242, 17333) as in the former subspecies, and in others (e.g. UA* 600), like the latter subspecies, they do not rise above the frontal plane. These specimens have neither sharp, back-twisted horncore tips (said to characterize *occidentalis*) nor very blunt, straight ones (said to characterize *antiquus*). Horncore indices of curvature and compression are virtually the same in *occidentalis* and *antiquus*; however horncore indices of proportion and length are higher on the average in *occidentalis*. In the index of proportion, NMC 2242 from Dominion Creek and NMC 12442 from Athabasca, Alberta are closest to *antiquus*, while NMC 17333 from Eldorado Creek is closest to *occidentalis* (Table 92). In the index of length, both Yukon specimens and the Athabasca specimen (NMC 12442) are closest to *occidentalis*. Ultimately, for practical purposes, it may be best to consider all *occidentalis* and *antiquus* specimens as belonging to a single subspecies *Bison bison antiquus* (which has priority), which had its origins in Beringia. Largely as a matter of convention, because the specimens described here are northern bison, I refer them to *Bison bison occidentalis*.

Referred specimens

NMC 2242 is from the upper part of Dominion Creek in the Dawson Area (exact locality unspecified). A note with the NMC catalog states that it was identified in 1947 as *Bison preoccidentalis* by M.F. Skinner. However, I think it is a much better fit for "*Bison occidentalis*" according to measurements of that species provided by Skinner and Kaisen (1947, Table 12). Again, I emphasize the value of Skinner and Kaisen's horncore indices for comparative purposes - while keeping relative sizes in mind, of course. The specimen is a posterior cranial fragment with rather short, stubby horncores compared to those of *Bison crassicornis*. The fossil lacks bone anterior to the orbits. The dorsal part of the right orbit is present: the left orbit is missing. The frontal region is slightly concave between the horncore bases. The horncores are neither depressed near their bases nor strongly backswept as in most *Bison crassicornis* crania, but extend laterally almost perpendicular to the cranial axis - approaching *Bison bison antiquus* in this respect. Approximately 27 mm left of the frontal suture, between the horncores, there is a 15 mm long aperture with signs that it was a healed or partly healed wound. Perhaps the opening was made by the tip of the horn of another bison during a fight in the rutting period, or by the weapon of an early human hunter. The fossil is stained brown, being darker than NMC 17333. It seems to be heavily permineralized.

NMC 17333 from Dawson Locality 5 is a posterior cranial fragment with horncores. The tip of the right horncore is slightly damaged. The specimen lacks bone anterior to the orbits. The dorsal part of the left orbit is preserved, whereas the right orbit is missing. Basicranial and occipital regions are damaged. The occipital condyles have been heavily eroded. According to G. Franklin, who collected the specimen, it was derived from muck just above the gold-bearing gravel. The specimen is pale buff and may be of late Wisconsin age. I intend to obtain radiocarbon dates on bone from these specimens in an attempt to determine approximately the time of origin of this subspecies, which seems to have stemmed from *Bison crassicornis* in

Beringia during the late Wisconsin.

Discussion

In Canada, apart from the Yukon, *Bison bison occidentalis* is known from Alberta, Manitoba, and possibly the Northwest Territories. B. Gordon (personal communication 1969) mentioned the discovery of a large "*Bison antiquus*" skull from near Nahanni Butte in the Northwest Territories. Knowing the possible confusion between the subspecies, the Nahanni specimen may well belong with the fossils described here. NMC 12442 (Table 92) is a posterior part of a cranium with complete horncores from near Athabasca, Alberta. The fossil was derived from 15 feet (4.6 m) below the surface of terrace gravels. It is very similar to the Yukon specimens and two other *Bison bison occidentalis* skulls that were probably derived from terrace gravels approximately 8,000 years old at Edmonton, Alberta (Fuller and Bayrock 1965, p. 56; Harington 1976 MS., p. 30). In Alberta other *Bison bison occidentalis* fossils are known from late Wisconsin gravels at Empress ("*Bison* cf. *occidentalis*"), Cochrane (approximately 11,000 years old) and Taber, and from early postglacial deposits near Three Hills (approximately 9,600 years old) (Harington 1976 MS., pp. 29, 32, 42). In Manitoba, *Bison bison occidentalis* crania have been collected from early postglacial deposits near Treesbank, and other fossils possibly belonging to this subspecies were found near Douglas (Pettipas 1971, p. 9).

In the conterminous United States, *Bison bison occidentalis* remains have been reported from Montana (Rasmussen 1974, p. 59), Wyoming (Wilson 1974b, p. 96), Minnesota, Nebraska, Kansas, Iowa, Texas and possibly California (Skinner and Kaisen 1947, pp. 172-173).

The holotype (USNM 4157) of *Bison bison occidentalis* is from Fort Yukon, Alaska, which is not far from the Alaska - Yukon border. Another specimen from Tatlo River, Alaska has been referred to this subspecies by Skinner and Kaisen (1947, p. 172).

In Siberia, relatively small-horned, *occidentalis*-like bison appeared toward the end of the last glaciation (Flerov and Zablotski 1961), where the transition from small *Bison crassicornis (= "Bison priscus crassicornis")* to *Bison bison athabascae (= "Bison priscus athabascae")* evidently occurred (Sher 1971, p. 209). This transition seems to have happened simultaneously in the eastern and western parts of Beringia.

In summary, *Bison bison occidentalis* probably evolved in Beringia. Evidently it arose from *Bison crassicornis* toward the close of the Wisconsin glaciation and had reached the eastern flanks of the Cordillera in southern Alberta (e.g. Cochrane) approximately 11,000 years ago, having spread southward via the "western corridor". Western bison apparently reached maximum numbers some 9,000 to 8,000 years ago in western North America. This subspecies can be recognized in deposits as late as 6,500 years old in Wyoming (Wilson 1974b, p. 96) and approximately 5,600 years old in Iowa (Hall 1972, p. 604). By that time (the hypsithermal), most herds of *Bison bison occidentalis* had undergone the transition to wood bison *(Bison bison athabascae)* in the north, while southern herds had adapted to the prairie environment, becoming plains bison *(Bison bison bison)*.

Bison bison occidentalis was Holarctic in distribution, ranging from eastern Siberia through Alaska and the Yukon to southwest-central North America during the late Wisconsin and early postglacial.

Likely the western bison was close in appearance to the modern wood bison, but it may have been a little larger. As *Bison bison occidentalis* seems to have been in a transition from a steppe-adapted bison to a woodland-adapted form, I speculate that it was in the process of accommodating to life in moister, more heavily wooded regions, such as the margins of subalpine forests, open forest and parkland. Analyses of pollen and mollusc shells associated with a complete, articulated skeleton of *Bison bison occidentalis* from a peat bed near Marion, Iowa support this contention. Pollen of oak and elm represent 54% and grass pollen represents 3% of the pollen sampled near the skeleton. Remains of snails (*Carychium exiguum, Carychium exile, Hawaiia minuscula, Strobilops labyrinthica* and *Triodopsis multilineata*) associated with the skeleton are typical elements of the present terrestrial molluscan fauna found in protected wooded areas of eastern Iowa (Hall 1972, pp. 604-606). I had the opportunity to examine and make a stratigraphic section of the locality near Treesbank, Manitoba that produced a number of *Bison bison occidentalis* cranial and postcranial specimens over the period 1915-1967 (Hay 1924, p. 200; Harington, Field Notes 1967II, pp. 23-24). I found bison material *in situ* (17 feet (5.2 m) below the surface in a gray, highly organic, sandy clay unit) near a log

1.4 feet (0.5 m) in diameter. Much leaf matter was compacted under the log and the fossiliferous unit contained many twigs. Wood from this unit yielded a radiocarbon date of 9,100 ± 110 years B.P. (Y-415). Evidently western bison occupied this area during the early postglacial when it was wetter and more heavily wooded than at present.

As a hypothesis for testing, I suggest that: (a) the hypsithermal (approximately 7,000 to 5,000 years B.P.) placed relatively great and sudden stress on the herds of western bison that were best adapted to woodland or parkland conditions; (b) that some of the herds were able to adapt to life on the arid plains *(Bison bison bison)*, which entailed a good deal of morphological and behavioral change; and (c) that other herds withdrew northward and westward following the retreating margins of the boreal and subalpine forests, or remained in those parts of northern and western North America *(Bison bison athabascae)*, retaining the basic form (except for smaller horncores) and habits of their ancestors.

Like other bison, this subspecies probably fed mainly on grasses, forbs and sedges. Its fossils could be useful paleoenvironmental indicators of rather moist, partly wooded terrain. Wolves were undoubtedly a common predator of western bison. People are known to have hunted these bison (e.g. Hawken Site, Wyoming, where skeletal remains were associated with side-notched points (Wilson 1974b, p. 96), and the Bayrock Site near Taber, Alberta, where a cobble chopper was found embedded in the braincase of an *occidentalis* cranium (Wormington and Forbis 1965)).

Bison bison athabascae (wood bison)

A single specimen of the wood bison (Figure 80A-C, Table 93) was collected at Quartz Creek in the Dawson area in 1969. Despite its relatively recent age, it is described here because it helps to round out the history of bison in the Yukon Territory. Evidently this subspecies was the last bison to occupy Eastern Beringia under natural conditions. Two other specimens of *Bison bison athabascae* have been recorded from the Yukon Territory by Skinner and Kaisen (1947, p. 167). In 1904, Preble collected a cranium with horncores and orbits (USNM 16861) from the Peel River, and a year later Sheldon picked up an "unfossilized" cranium with horncores (USNM 5513) from a locality 12 miles (19 km) upstream from the mouth of Pelly River.

Referred specimen

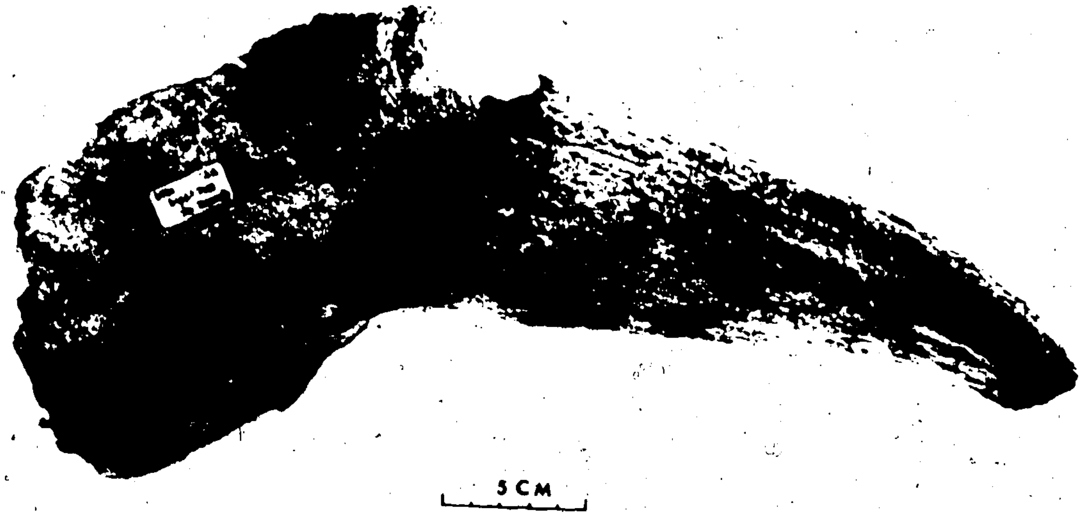
NMC 17519 from Dawson Locality 6 consisted of

Figure 80. Right horncore lacking tip with attached cranial fragment (NMC 17519, Dawson Locality 6) of a postglacial wood bison (*Bison bison athabascae*). Bone from this specimen has yielded a radiocarbon date of 1,350 ± 95 years B.P. (I-5404).

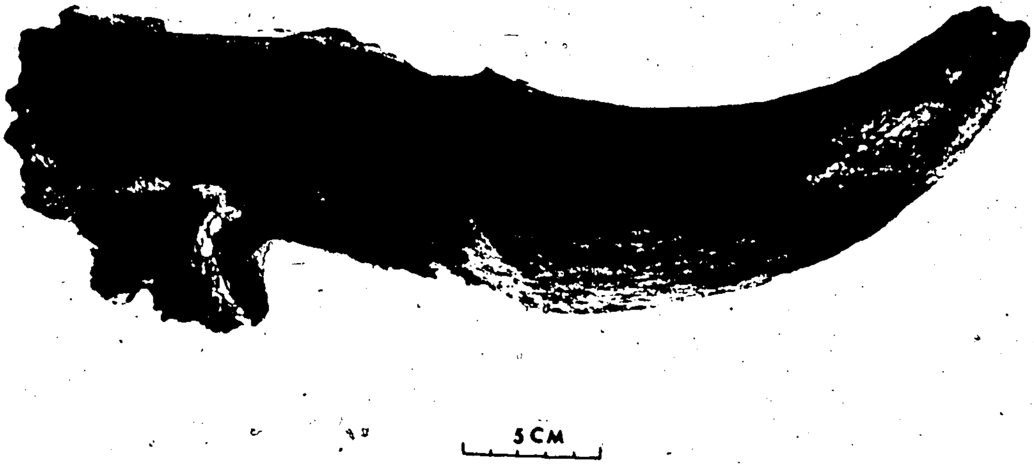
A. Dorsal view.

B. Posterior view.

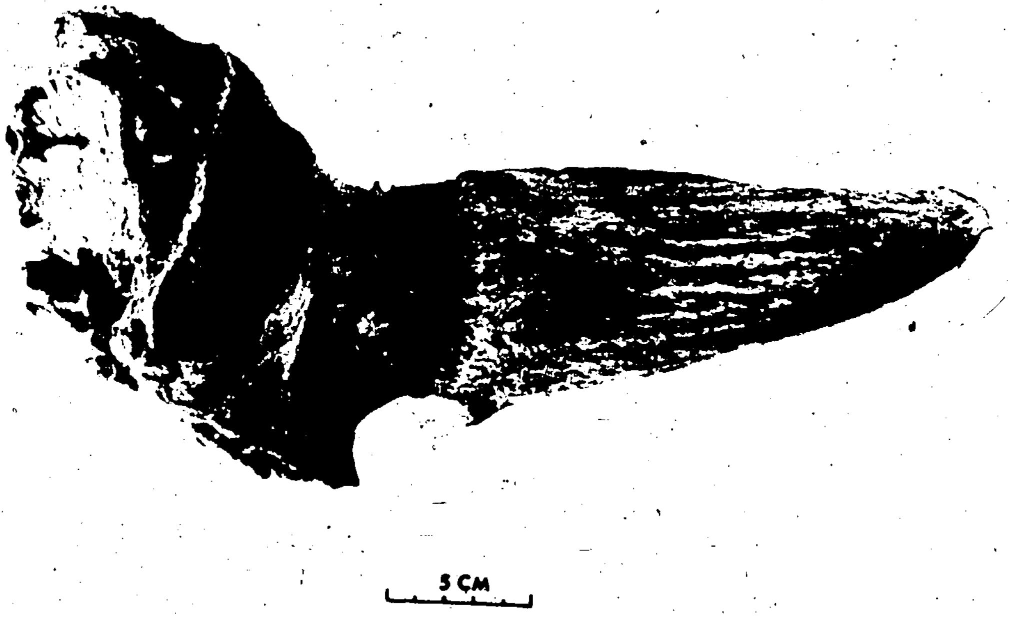
C. Ventral view.



A



B



C

Table 93. Measurements of a postglacial wood bison (*Bison bison athabascae*) horncore from the Yukon Territory compared to horncores from Recent North American wood bison.

SPECIMENS	SEX	ESTIMATED AGE	MEASUREMENTS (mm) *														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Bison bison athabascae, Postglacial, Y.T.																	
NMC 17519 Dawson Loc. 6	♂	Adult	–	–	208e	250e	196e	77	75	244	–	–	–	–	–	–	–
Bison bison athabascae, Recent, North America (Skinner and Kaisen 1947, Table 11)	♂♂	Adult															
M			665	683	216	255	189	85	92	271	263	130	–	–	149	–	288
OR			585–736	645–750	155–260	190–290	150–200	72–97	81–108	230–300	185–296	113–140	–	–	140–159	–	272–312
N			9	5	9	8	7	8	8	9	7	7	–	–	6	–	9

* See measurements with Table 86.

Light copy

ukon Territory compared to

MEASUREMENTS (mm)																					
9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	128e	103	85	-
263	130	-	-	149	-	288	355	-	195	121	148	92	160	537	-	477	271?	135	92	80	75
185- 296	113- 140	-	-	140- 159	-	272- 312	326- 384	-	179- 204	108- 130	143- 158	-	152- 170	525- 555	-	447- 507	248- 286?	126- 149	84- 98	62- 92	57- 90
7	7	-	-	6	-	9	4	-	3	3	3	2	3	3	-	3	5		8	9	9

Light copy

[redacted]

a right horncore attached to part of the right frontal. The horncore is deeply grooved, except on its dorsal surface. Matrix in crevices near the burr suggests that the specimen was derived from a silty peat deposit. The specimen is grayish in color. The pedicel and horncore are preserved, while the remainder was sacrificed to obtain a radiocarbon date. The bone yielded a date of 1,350 ± 95 years B.P. (I-5404), which may be close to the time when wood bison last occupied the Yukon Territory.

Discussion

In Canada, apart from the Yukon, herds of wood bison may still surviv in Wood Buffalo Park near Great Slave Lake in the Northwest Territories. It is questionable that they are pure *Bison bison athabascae*, because, during helicopter surveys of the range, L.P.E. Choquette (personal communication 1973) informed me that he saw trails connecting the habitat of the supposedly isolated herd of wood bison with the range of mixed herds of wood and plains bison farther south. Wood bison remains have been reported from Lake Athabasca (Skinner and Kaisen 1947, p. 166), Alberta. I have identified a skull with horncores collected by R. Moore near Rumsey, Alberta, and other cranial fragments with horncores from national parks on the border of Alberta and British Columbia.

Banfield (1958) states that wood bison occurred in Banff National Park until 1858, when apparently the last individual was killed in Pipestone Valley. Soper (1964, p. 376) comments that wood bison were found in suitable areas throughout northern Alberta. They formerly occupied the extreme northern parts of British Columbia. A Recent skull was found in muskeg near Atlin. Either the wood or the plains bison was common in grasslands along the Peace River, but the last of them were shot near Fort St. John, British Columbia in 1879 (Cowan and Guiguet 1965, p. 388).

In the conterminous United States, specimens of wood bison are recorded from Wyoming, Utah, Oregon and Colorado (Skinner and Kaisen 1947, pp. 167-168).

Two specimens have been identified from Alaska. An "unfossilized" cranium with horncores was collected near St. Michael near Norton Sound in the west, and a complete unweathered skull was found in a cut bank of a creek 30 miles (48 km) upstream from the mouth of the Tanana River in central Alaska (Skinner and Kaisen 1947, p. 167).

In the Kolyma Lowland of northeastern Siberia, Sher (1971, p. 209) states that a skull, from deposits dating to the close of the last glaciation or the beginning of the postglacial on the Bolshaya Chukochya River, corresponds to the wood bison "*Bison priscus athabascae*" (= *Bison bison athabascae*). Could wood bison have evolved simultaneously from the same basic *occidentalis* stock in both Siberia and North America? It is important to ascertain with precision the identifications and geological ages of the earliest wood bison in Siberia and North America to answer this question.

In North America, I speculate that *Bison bison athabascae* arose from *Bison bison occidentalis* on the forest and parkland margins, west and north of the plains that were becoming arid during the hypsithermal (which lasted from approximately 7,000 to 5,000 years B.P.). Wood bison were distributed from western Alaska to the Yukon, and south along the eastern flanks of the Cordillera from northern British Columbia and the western Northwest Territories to Colorado. Possibly increasing depths of snow, altering vegetation patterns, and human hunting in these areas from late postglacial to historic times resulted in decimation of these animals except in favorable habitat near Great Slave Lake, where a herd of approximately 200 pure, or nearly pure wood bison survives. This range is characterized climatically by long, cold winters, short hot summers and little precipitation, nearly half of which falls as snow (Fuller 1962, p. 11).

Wood bison are similar in appearance to plains bison *(Bison bison bison)*, but are generally larger and darker. In addition, they have longer, more robust horns and broader skulls. This subspecies stands about 5.7 feet (1.7 m) high at the shoulder and weighs up to 2,400 pounds (1,089 kg). Wood bison are gregarious, have keen senses of vision and smell, and are good swimmers. Occasionally violent fights occur between bulls during the rutting period, the peak of which occurs in mid-August. They prefer heavy mixed wood forest with scattered grasslands and ponds or lakes. In Wood Buffalo Park, small, scattered herds range over extensive areas of spruce - poplar forest, sandy pine ridges, meadows and patches of grassy uplands. In November and May they migrate from wooded hills to the Peace River valley, a distance of up to 150 miles (241 km). Intersecting trails, sand wallows, rubbing trees and water holes mark the favored parts of their range. Forage consists of sedges, grasses and forbs. In addition to human hunters, wolves, brown bears and occasionally mountain lions prey on, or may have preyed on wood bison (Soper 1941, Fuller 1962, Banfield 1974).

Soergelia cf. *elisabethae* (Soergel's muskox)

Several cranial and postcranial specimens from Pleistocene deposits of the Yukon Territory are referable to the genus *Soergelia* (Figures 81A-B, 82A-B, Tables 94-95). This genus has been described as a member of the Caprinae (Schaub 1951, p. 376) and has been informally called a steppe goat ("Steppeziegen") (Toepfer 1963, p. 156), but I agree with C.E. Ray (personal communication 1973) that it should be called a muskox, because of "the finely and uniformly vesicular structure of the horn cores throughout most of their length, in contrast to the more irregularly and coarsely vesicular or vacuous, truly 'cavicorn' structure of caprines; and the typically ovibovine, not caprine, dentition." I would also add that the horncores, if bent down by the cheeks, would look very much like those of the living tundra muskoxen (*Ovibos moschatus*). Furthermore, except for their relative slenderness, the metacarpals of *Soergelia* are remarkably like those of *Ovibos*.

Soergel's muskoxen are interesting and important because their fossils extend in a chain from Europe, through Siberia and the Yukon, to Kansas and Texas. I present evidence that specimens of this genus are index

Figure 81. Posterior cranial fragment with partial horncores (NMC 13601, Old Crow Locality 11A) of a Pleistocene Soergel's muskox (*Soergelia* cf. *elisabethae*).

A. Dorsal view.

B. Posterior view.

A

B

Figure 82. See Figure 81. Posterior cranial fragment with partial horncores (NMC 13601, Old Crow Locality 11A) of a Pleistocene Soergel's muskox (*Soergelia* cf. *elisabethae*).

A. Ventral view.

B. Anterior view.

A

B

Table 94. Measurements of Pleistocene Soergel's muskox (*Soergelia* cf. *elisabethae*) crania and horcores from the Yukon Territory compared to those of *Soergelia elisabethae* from East Germany, *Soergelia* sp. from Siberia and *Soergelia* cf. *elisabethae* from Texas.

Specimens	Measurements (mm)*								
	1	2	3	4	5	6	7	8	9
Soergelia cf. *elisabethae*. Pleistocene, Y.T.									
NMC 13601 Old Crow Loc. 11A	61.5	90.0	70.4	85.9	250.0e	79.3	-	-	27.5
NMC 23209 Old Crow Loc. 11A	-	-	56.1	62.3	188.0	-	129.0	186.0	-
NMC 20603 Old Crow Loc. 20	-	-	58.6+	-	-	-	-	178.0	28.0e
Soergelia elisabethae. Pleistocene, E. Germany **									
NMC 30502 (plaster cast of Weimar 1967/8991 = Mus. Basel D459) Rastenberg area	74.5	96.0	64.4	76.5	231.0	73.5	160.0e	184.0e	32.0
Soergelia sp. Pleistocene, Siberia ***									
NMC 31020 (plaster cast) Chukochya R.	77.7	90.4	64.3	77.8	219.0	96.2a	140.0	167.0	28.6
"OKC-157"	-	-	60.8a	82.4	235.0	-	-	-	-
"OKC-154"	-	-	51.4	70.4	199.0	-	-	-	-
Uncataloged cast Bobrovka-Irtysh region	-	-	-	81.4+	-	-	-	-	-
Soergelia cf. *elisabethae*. Pleistocene, Texas. (Troxell 1915, p. 481)									
YPM 10920 Rock Creek	75.0	-	?85.0	74.0	-	92.0	-	-	-

* 1 - Minimum distance between horncore burrs across frontals.
2 - Distance between horncore burrs at posterior margin.
3 - Vertical diameter of horncore at burr.
4 - Transverse diameter.
5 - Circumference of horncore at burr.
6 - Minimum width at cranial constriction posterior to horncores.
7 - Length of horncore on inner (anterior) curve.
8 - Length of horncore on outer (posterior) curve.
9 - Thickness of braincase between anterior margins of horncore bases.

** I am grateful to Dr. H.D. Kahlke of the Institut für Quartärpaläontologie, Weimar, East Germany for supplying this cast.

*** I am grateful to Dr. A.V. Sher of the Paleontological Institute, USSR Academy of Sciences, Moscow for supplying this cast.

Table 95. Measurements of Pleistocene Soergel's muskox (*Soergelia* cf. *elisabethae*) metacarpals from the Yukon Territory compared to those of *Soergelia elisabethae* from East Germany and *Soergelia* sp. from Siberia.

Specimens	Measurements (mm)*						
	1	2	3	4	5	6	7
Soergelia cf. *elisabethae*. Pleistocene, Y.T.							
NMC 20757 Old Crow Loc. 29	176.8	51.5	31.9	31.7	21.2	57.1	31.5
NMC 20137 Old Crow Loc. 74	-	-	-	-	19.0a	55.7	29.9
Soergelia elisabethae. Pleistocene, E. Germany							
Süss. 1965/2568 (cast) Süssenborn	180.6	49.	3.3	30.7	22.9	55.4	29.9
Soregelia sp. Pleistocene, Siberia							
"KCC-5"	168.9	48.0	30.0	30.7	19.8	53.5	27.3
"OCK-73-752"	170.6	50.9	29.2	30.8	22.2	55.5	27.4
"CH-30"	181.5	49.9	30.2	30.0	21.3	59.3	30.2
"S-100-329"	-	51.[illegible]	31.6	-	-	-	-

* 1 - Total length.
2 - Proximal width.
3 - Proximal depth.
4 - Midshaft width.
5 - Midshaft depth.
6 - Distal width.
7 - Distal depth.

fossils that provide support for cross-continental correlation of deposits of Kansan age in North America, with those of Mindel or Elster age in Eurasia. So far, the only remains of *Soergelia* from northern North America are from sediments in the Old Crow Basin of the Yukon Territory.

Referred specimens

NMC 13601 from Old Crow Locality 11A is an upper, posterior portion of a cranium, with horncores that lack the distal halves. The anterior parts of the frontals and horncores (near their bases) are missing. The specimen has the following characteristics of *Soergelia elisabethae*: (a) longitudinally-grooved horncores that rise laterally and forward; (b) horncores with well-defined burrs, which are separated across the frontals by a space of 60 to 80 mm; (c) solid horncores, except for large pneumatic cavities near their bases. It should be noted that the horncores of NMC 13601 are slightly lower set and more massive than those of *Soergelia elisabethae* from East Germany (NMC 30502 - cast) and *Soergelia* sp. (NMC 31020 - cast) from Siberia. The great age of the individual is indicated by the tightly fused (although somewhat eroded) sutures. NMC 13601 probably represents an old male. The grooving, which parallels the length of the horncore, is rather deep and coarse on the ventral surface compared to the dorsal surface. Details of the bone adjacent to the upper surface of the brain are well preserved. The fossil is black [illegible] brown in color, and seems to be deeply permineralized by iron oxide.

Apart from the slight downward deflection of the horncore about 50 mm from the burr, NMC 13601 is closer to *Soergelia elisabethae* (NMC 30502 - cast) from East Germany than *Soergelia* sp. (NMC 31020 - cast) from Siberia, and it is referred to *Soergelia* cf. *elisabethae*.

NMC 23209 from Old Crow Locality 11A is a short, complete left horncore with a small part of the adjacent cranial bone attached. It is more like horncores of NMC 31020 from Siberia in size, but it curves gradually forward rather than being flexed forward, attenuating rapidly, about 4 cm from the burr. It may represent a female or a subadult male. The large pneumatic cavity at the base of the horncore and the details of the surface sculpture are clearly seen. The fossil is stained brown.

NMC 20603 from Old Crow Locality 20 consists of most of a right horncore with an attached frontal fragment. The proximal two-thirds of the anterior surface is lacking. Except for its paler color, it is similar to NMC 23209, and it may represent a female or subadult male.

I suspect that the Siberian form belongs to a new species of *Soergelia*, because all five of the specimens I have examined from Siberia are more sharply tapered in their distal two-thirds than any other *Soergelia* that I have seen. All but one ("OKC-100") are bent forward more strongly in their distal portion than in the specimen of *Soergelia elisabethae* from near Rastenberg, East Germany, or than in NMC 23209 from the Yukon Territory.

Two metacarpals are referred to *Soergelia* cf. *elisabethae*. They look very much like *Ovibos* metacarpals, except they are more slender. NMC 207[illegible]7 from Old Crow Locality 29 is a complete left metacarpal. It matches well the cast of a right metacarpal of *Soergelia elisabethae* (Süss. 1965/2568) from Süssenborn, East Germany, and is close in size to "CH-30" from Siberia. It is worth noting that Siberian *Soergelia* metacarpals "KCC-5" and "OCK-73-752" are similar in shape to other *Soergelia* metacarpals, but average approximately 10 mm less in total length. Perhaps they represent females, while the remainder have been derived from males. The deep foramen in the central part of the proximal articular surface of NMC 20757 and the posterior channel leading to it, match those features on "S-100-329", the proximal half of a right metacarpal from Siberia. The Yukon fossil is stained dark brown, and has patches of iron oxide adhering to its surface. NMC 20137 from Old Crow Locality 74 is the distal third of a right metacarpal. It is like the distal end of NMC 20757 in every detail, except that it is slightly smaller and is stained black.

Discussion

There is no evidence of the geological age of these specimens, except that their dark staining indicates a pre- late Wisconsin age. Stratigraphic and paleoenvironmental evidence from *Soergelia* fossils found *in situ* elsewhere strongly suggests that the Yukon fossils are of Kansan age. Although *Soergelia* has not been reported from other parts of Canada, perhaps muskox ("Ovibovini") material from deposits considered to be of late Aftonian age at Wellsch Valley, Saskatchewan (C.S. Churcher, personal communication 1975), may be referable to one of the high-horned muskoxen, such as *Euceratherium* or *Soergelia*.

In the conterminous United States, a partial cranium from deposits of late Kansan age at Rock Creek, Texas was described as *Preptoceras mayfieldi* (YPM 10920) (Troxell 1915b, p. 479). C.E. Ray and I examined this specimen next to a cast of *Soergelia elisabethae* from East Germany, noticing only a few small differences between them. Consequently, I suggest that YPM 10920 is referable to *Soergelia* cf. *elisabethae*. In the summer of 1973, R.E. Eshelman (personal communication 1973) collected the posterior part of a cranium with half of the left horncore, all but the tip of the right horncore, and most of the occipital region from deposits of approximately late Kansan age in Cloud County, Kansas. From three clear, scaled photographs of the specimen, I tentatively refer it to *Soergelia* cf. *elisabethae*. It appears to differ little from the best East German cranial fragments. To my knowledge, it is the most complete cranial fossil of *Soergelia* discovered.

No *Soergelia* remains have been reported from Alaska, but, as specimens are known from northeastern Siberia and the Yukon Territory, it is reasonable to predict that they will be found eventually in Alaska.

When I visited Moscow in 1973, A.V. Sher kindly allowed me to examine and measure most of the specimens of *Soergelia* collected from Siberia to that time. The collection consisted of a dorsal posterior cranial fragment with nearly complete horncores, four horncores or horncore fragments (one was a cast), two cheek teeth, a magnum, three metacarpals and the proximal half of another, and the proximal half of a metatarsal. Some of these specimens are from the Olyor Suite of Mindel (?Kansan) age in the Kolyma Lowlands of northeastern Siberia (Sher 1971, pp. 233-235). The cast of a relatively large horncore with attached frontal and parietal bone, represents a specimen collected from Pavlodarsk-on-the-Irtysh in the southern part of western Siberia. A metatarsal fragment is known from the Kuznets Basin farther west (Sher 1971, p. 230). These fossils seem to be of similar age to those from the Olyor Suite (i.e. they belong to the Tiraspol faunistic complex (Gromov 1948)).

Soergelia remains were first reported from Europe (Soergel 1939, Schaub 1951). Kahlke (1969, pp. 543-544) discusses *Soergelia* fossils from four European localities: from gravels at Kapellenberg, a hill near Rastenberg, East Germany (German Democratic Republic) of probable early Elster (?early Kansan) age; from gravels at Süssenborn near Weimar, East Germany of early Elster (?early Kansan) age; from a fissure filling a Zlaty Kun near Koneprusy, Czechoslovakia of Mindel II ?late Kansan) age; and from fluvial and lacustrine deposits at Oltenia, Roumania of middle Pleistocene ("end of Cromer and Mindel") (?Kansan) age. All of these specimens are referred to *Soergelia elisabethae* by Kahlke (1969, p. 543) except for the metatarsal fragment from Oltenia, which is best referred to *Soergelia* sp.

I speculate that *Soergelia* evolved from a relatively small, very high-horned muskox belonging to the *Euceratherium* (including *Preptoceras*) - *Boöpsis* group in northern Asia prior to the Kansan glacial. The zoogeographic and geochronological evidence amassed so far presents a remarkably cohesive picture, indicating a rapid Holarctic dispersal of *Soergelia* in Kansan time - westward to Roumania, Czechoslovakia, and Germany, and eastward via the Bering Isthmus to the Yukon, Kansas and Texas. Sher (1971, p. 233) suggests that ..."*Soergelia* was very widespread in the Early Pleistocene and can serve as one of the characteristic 'guide' fossils for that stage". I think we can be more precise. In my opinion, the evidence is sufficiently strong to say that specimens of *Soergelia* are indicative of sediments of Kansan glacial age, and that *Soergelia* fossils are extremely valuable from a biostratigraphic viewpoint, allowing Kansan deposits of Texas and Kansas in North America to be correlated with deposits of the Olyor Suite and its equivalents in the Soviet Union, and with Mindel and Elster sediments in Europe. Also, I infer that there are (or were) unrecognized fossiliferous sediments of Kansan-age exposed within the Old Crow Basin of the Yukon Territory.

Soergelia probably looked like a cross between a tundra muskox *(Ovibos moschatus)* and a mountain sheep. A comparison of metapodials suggests that *Soergelia* was lighter and more slender-limbed than the tundra [illegible]ox, and that it had relatively long metatarsals. It seems to have preferred cool, tundra-like or cool, dry parkland habitat, and I think it is a paleoenvironmental indicator of those conditions. In northeastern Siberia it was able to live in tundra-like surroundings, with the addition of some steppe elements (Giterman 1973, p. 67). The fact that it was associated with steppe mammoth *(Mammuthus armeniacus)*, caribou *(Rangifer tarandus)* and giant moose *(Alces latifrons)* at Süssenborn in East Germany, suggests that *Soergelia* occupied cool steppe or tundra there. Faunal associates of *Soergelia* cf. *elisabethae* at Rock Creek, Texas were mammoths *(Mammuthus* sp.), large ground sloths (*Paramylodon* sp.), camels (*Camelops* sp.), and horses (*Equus* sp.), which suggest cool, parkland conditions. Probably Soergel's muskox fed mainly on grasses and shrubs. Perhaps wolves, which are members of the Rock Creek, Olyor, and Süssenborn faunas, were among its main predators.

Bootherium sargenti (Sargent's muskox)

A single specimen of Sargent's muskox (Figure 83A-C, Table 96) has been collected from Pleistocene deposits in the Yukon Territory. Probably all specimens referable to this species represent females of *Symbos cavifrons*. Facts supporting this contention are provided below.

Referred specimen

NMC 10536 from Old Crow Locality 9 consists of the proximal half of a right horncore with a large part of the adjacent frontal region. The following features characterize this specimen and *Bootherium sargenti*: (a) a definite burr at the base of the horncore; (b) a horncore, somewhat dorsoventrally compressed near the base which projects laterally for about 75 mm in the frontal plane, then curves down and forward in a graceful arc; (c) a broad space across the frontals between horncore burrs. Through the courtesy of C.E. Ray of the

Figure 83. Right horncore lacking tip with attached cranial fragment (NMC 10536, Old Crow Locality 9) of a Pleistocene Sargent's muskox *(Boötherium sargenti)*.

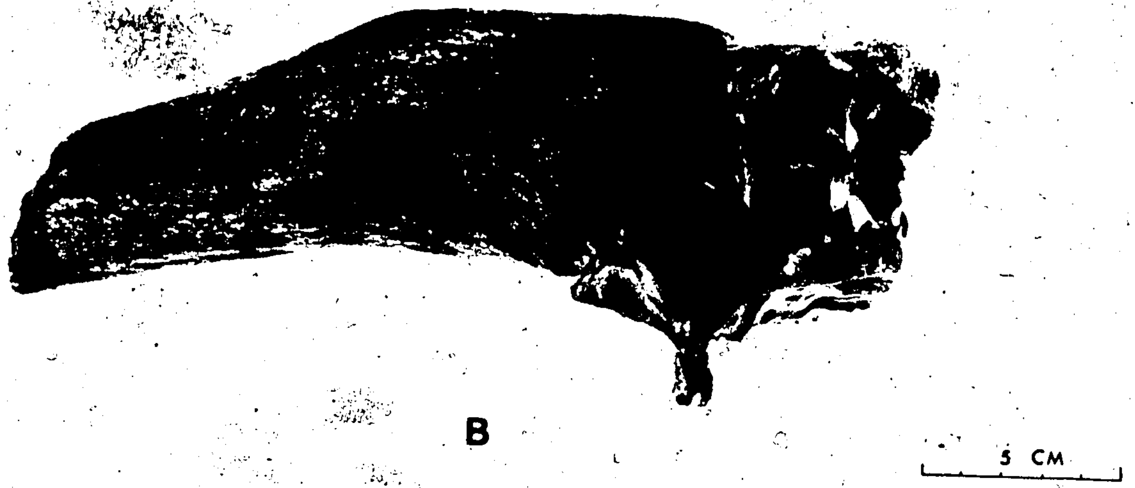
A. Dorsal view (anterior to bottom).

B. Anterior view.

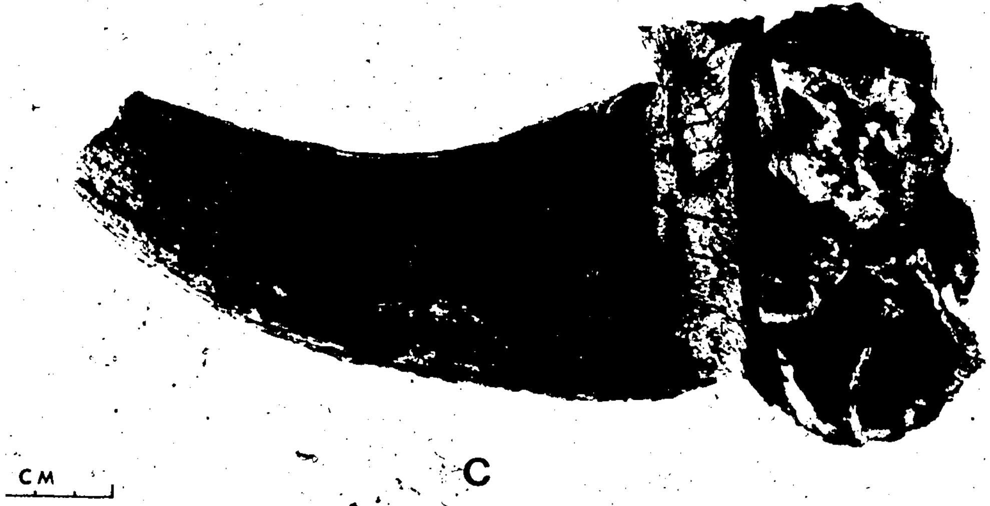
C. Ventral view (anterior to top).

Probably *Boötherium sargenti* is a female of the helmeted muskox *Symbos cavifrons*,

A



B



C

Table 96. Measurements of a Pleistocene Sargent's muskox (*Boötherium sargenti*) horncore from the Yukon Territory compared to horncores of *Boötherium sargenti* (= *Boötherium nivicolens*") from Alaska.

Specimens	Measurements (mm)*			
	1	2	3	4
Boötherium sargenti. Pleistocene, Y.T. NMC 10536 Old Crow Loc. 9	81.0	64.2	230.0	52.0
Boötherium sargenti. Pleistocene, Michigan GRPM 11 423 3101 (type) Grand Rapids	80.0	68.0	242.0	-
Boötherium sargenti. Pleistocene, Alaska. (= "*Boötherium nivicolens*" type). Eschscholtz Bay USNM 2324 Subadult?	63.0	58.0	200.0	46.0

* 1 - Transverse diameter of horncore at burr.

2 - Vertical diameter of horncore at burr.

3 - Circumference of horncore at burr.

4 - Thickness of braincase at frontal (between anterior horncore bases).

United States National Museum, I was able to compare the Yukon specimen with the types of *Boötherium sargenti* (GRPM 11 423 3101), "*Boötherium nivicolens*" (USNM 2324), and *Boötherium bombifrons* (ANSP 2994). In my opinion, NMC 10536 is not closely related to *Boötherium bombifrons*. Unlike the type specimen of the latter species, NMC 10536 has no pronounced pedicel, has less sharply dropping horncores, and is markedly larger. In shape and flare of the horncores NMC 10536 is close to "*Boötherium nivicolens*", but it is closest in size and general form to the type of *Boötherium sargenti* and I referred to that species. While comparing the specimens, I noticed that the type of "*Boötherium nivicolens*" from Alaska had unfused sutures, which, considering its smaller size, suggests that it may represent an animal that was not fully mature when it died. Because of this, and the fact that both it and ~~the~~ Yukon specimen are from Eastern Beringia, I consider "*Boötherium nivicolens*" to be a junior synonym of *Böotherium sargenti*.

Two other specimens from the Yukon Territory may pertain to *Boötherium sargenti*. NMC 17613 from Herschel Locality 1 is a right tibia, which is abraded on the lateral and posterior borders of the proximal articulation. Morphologically, it matches well a tibia of Recent *Ovibos moschatus*, but it is longer (total length 390 mm) and more slender than that species (total length 376 mm (Cornwall 1964, p. 169)). The Herschel Island fossil appears to have the proportions and features of a tibia of *Symbos cavifrons* (total length 455 mm (Semken *et al.* 1964, p. 839)), but it is shorter. Therefore, NMC 17613 is tentatively referred to *?Boötherium* sp. There seems to be no way of checking the identification at present, for no *Boötherium* or *Praeovibos* (which it could also represent) tibiae have been described.

Quackenbush (1909, p. 127) identified *Boötherium bombifrons* from "a very good photograph" (presumably of a skull fragment) taken by T. Obalski at Gold Run Creek (Dawson Locality 32) in July 1903. This photograph was in the possession of Henry Fairfield Osborn, but could not be located in his files (R.H. Tedford, personal communication 1972). Although Obalski (1904, p. 216) includes the muskox ("le Boeuf musqué") in a list of remains of Pleistocene mammalian species he had seen in the Yukon, he does not designate the species nor the exact locality where it was found. Species of *Boötherium* would be difficult to identify from a photograph alone, and because I have not been able to examine Obalski's photograph, I feel that the presence of *Boötherium* sp. in the Gold Run Creek fauna is questionable. The only definite report of *Boötherium* in Canada is from the Old Crow Basin, Yukon Territory.

Discussion

In the conterminous United States, *Boötherium sargenti* has been described from Nebraska, Utah, Missouri, Indiana, Texas and Pennsylvania. The type specimen of this species consists of most of a cranium with horncores from a postglacial bog near Grand Rapids, Michigan. *Boötherium* sp. has been reported from Saltville, Virginia; Douglas County, Nebraska; and Neeley, Idaho (E. Anderson, personal communication 1976). The Saltville specimen is particularly interesting because of its large size relative to the type of *Boötherium sargenti* (Ray *et al.* 1967, Table 5). Probably most of these specimens are of Wisconsin age.

Although *Boötherium bombifrons* has been reported from places other than the type locality, Big Bone Lick, Kentucky (e.g. Frankstown Cave, Pennsylvania, where the only parts of the skull preserved are the basicranial region and dentititon (Peterson 1926, pp. 260-261) - parts inadequate for specific identification in my opinion), I am aware of no other specimen like the type. Therefore, I consider that most records of *Boötherium* pertain to *Boötherium sargenti*. Presuming the specimen of *Boötherium bombifrons* does not represent an abnormal individual, that species is probably not closely related to *Boötherium sargenti* or *Symbos cavifrons*. In this respect, Allen (1913, p. 212) concluded: "*Boötherium* {*Boötherium bombifrons*} and *Preptoceras* { = *Euceratherium*} are not closely related, but more nearly [illegible] than is either to any other known genus."

A specimen referred to "*Boötherium* sp." was recovered from deposits of probable Illinoian age at Cripple Creek sump near Fairbanks, Alaska (Péwé and Hopkins 1967, pp. 268-269). It is the earliest record of the genus in North America. Several other cranial fragments of *Boötherium sargenti* (= *Boötherium nivicolens*) are known from that state. At least three have been collected from Pleistocene deposits in the Fairbanks area, and the type of "*Boötherium nivicolens*" is from Eschscholtz Bay on the west coast of Alaska. A nearly complete carcass of a small extinct muskox, possibly *Boötherium sargenti*, was preserved in muck on a creek near Fairbanks (Guthrie 1972, p. 300). Samples of hair and dessicated flesh from the specimen gave radiocarbon dates of 17,210 ± 500 years B.P. (SI-454) and 24,140 ± 2,200 years B.P. (SI-455), respectively. A hornsheath from *Boötherium sargenti* from Fairbanks Creek yielded a radiocarbon date of 22,540 ± 900 years B.P. (SI-292). These dates indicate that Sargent's muskox lived in Eastern Beringia during the peak of the Wisconsin glaciation.

Allen (1913, p. 215), Hibbard and Hinds (1960, p. 107), and Semken *et al.* (1964, p. 824) consider that *Boötherium sargenti* is a female of *Symbos cavifrons*. I think the evidence supporting this view is very strong. The similar basic conformation of the horncores (as far as orientation and curvature are concerned); the smaller, thinner-roofed cranium; and the broad space between the horncore bases in the former species parallel the differences between male and female *Ovibos moschatus*: thus Sargent's muskox resembles what a female *Symbos cavifrons* would be expected to look like. In addition, *Boötherium sargenti* and *Symbos cavifrons* had similar geographic and habitat preferences, for both are found in the same states or provinces (e.g. Alaska, Yukon Territory, Indiana, Michigan, Virginia (using *oötherium* sp.), Utah, Missouri and Nebraska), and sometimes even from the same site and deposit (e.g. near Great Salt Lake, Utah, in the Bonneville sands and gravels (Stokes and Hansen 1937, p. 63), and evidently in the Goldstream Formation of Wisconsin age near Fairbanks, Alaska). In the conterminous United States, both species are concentrated within the same latitudinal range — usually south of the late Wisconsin fossil localities of the tundra muskox, *Ovibos moschatus*. Unlike

Soergelia, Praeovibos, and *Ovibos,* which had Holarctic distributions during the Pleistocene, *Bootherium sargenti* and *Symbos cavifrons* are only known from North America. Geochronologically, both species appear during the Illinoian and become extinct near the close of the Wisconsin glaciation.

I estimate that *Bootherium sargenti* was about 25% smaller than *Symbos cavifrons.* Like *Symbos,* it probably had dark brown fur, and possibly a shorter coat than *Ovibos* (Harington 1968, p. 1162). The horns branched laterally, then curved downward and forward. They did not meet at the bases. A colored illustration of a group of Sargent's muskoxen is provided in a wall chart accompanying an article by Guthrie (1972). Probably these animals were primarily grazers and secondarily browsers, preferring cool steppe grasslands or parklands. Perhaps wolves were their main predators.

Symbos cavifrons (helmeted muskox)

Symbos remains are not uncommon in collections from Yukon Pleistocene deposits, but they are much rarer than bison fossils. Several cranial fragments (one from Alaska), three mandibular fragments and a metatarsal are described (Figures 84A-C, 85A-C, 86A-C, 87, Tables 97-99). A relatively small cranial specimen (USNM 2555) from Lovett Gulch on Bonanza Creek near Dawson was described as the type of a new species, *Symbos tyrrelli* (= "*Scaphoceros tyrrelli*"; Osgood 1905a, p. 174). Larger crania of adult males have been found at two localities within a mile (1.6 km) of the place where the type specimen of *Symbos tyrrelli* was collected. Evidently USNM 2555 lies within the lower range of measurements for adult crania of *Symbos cavifrons* (Table 97). It differs in no qualitative way from *Symbos cavifrons*, and I (Harington 1968, pp. 1163-1164) consider *Symbos tyrrelli* to be a junior synonym of *Symbos cavifrons*. The probability that *Symbos cavifrons* is a male and *Bootherium sargenti* is a female of the same species has been discussed under the latter heading.

Referred specimens

NMC 29229 from Dawson Locality 1 is the posterior half of a large cranium lacking the distal third of the left horncore, and the distal two-thirds of the right horncore. The upper parts of the orbits are present, but are

Figure 84. Posterior of cranium with compl~~ete~~ horncores (NMC 8837, Dawson Area - locality unknown) of a Pleistocene helmeted muskox *(Symbos cavifrons)*.

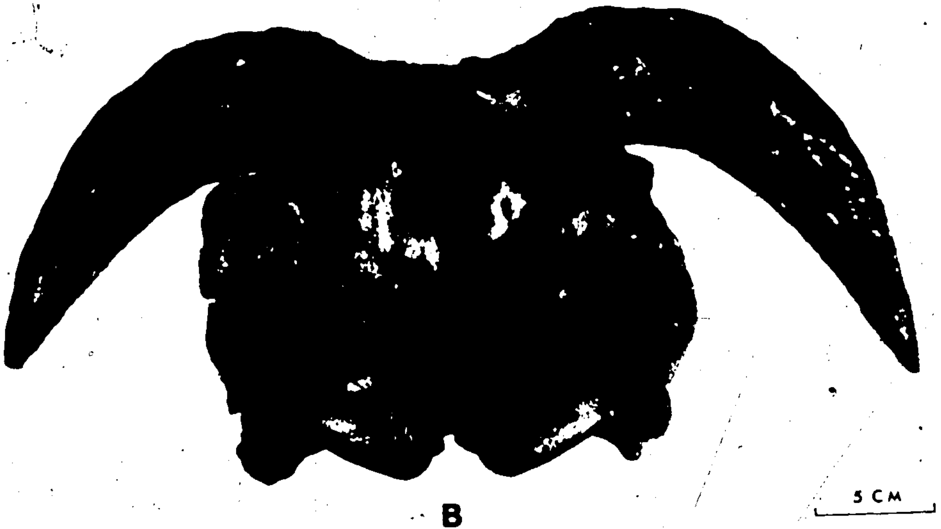
A. Dorsal view (anterior to top).

B. Posterior view.

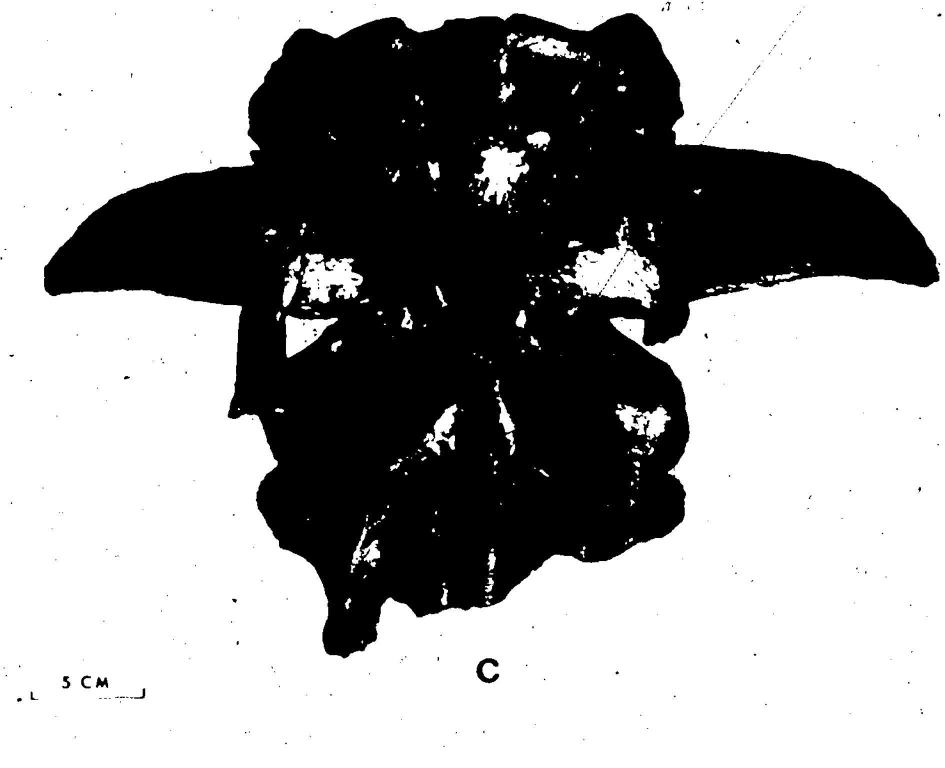
C. Ventral view (anterior to bottom).

Original pale colored bone is largely covered by dark brown shellac.

A



B



C

Figure 85. Posterior of cranium with partial horn-cores (NMC 29229, Dawson Locality 1) of a Pleistocene helmeted muskox *(Symbos cavifrons)*.

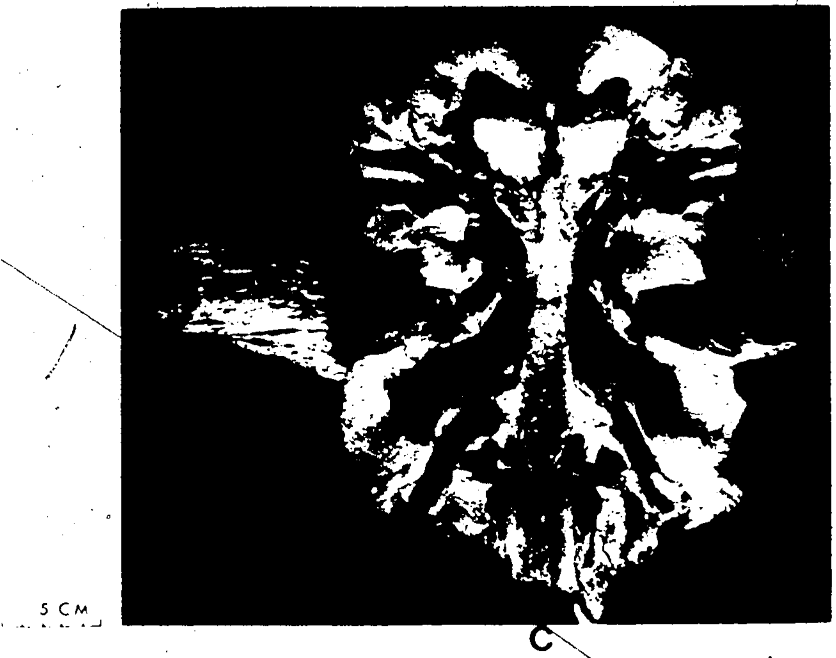
A. Dorsal view (anterior to top).

B. Posterior view.

C. Ventral view (anterior to bottom).

A

B



C

Figure 86. Right mandibular fragment with RP_3-RM_3 (NMC 14170, Old Crow Locality 11) of a Pleistocene helmeted muskox *(Symbos cavifrons)*.

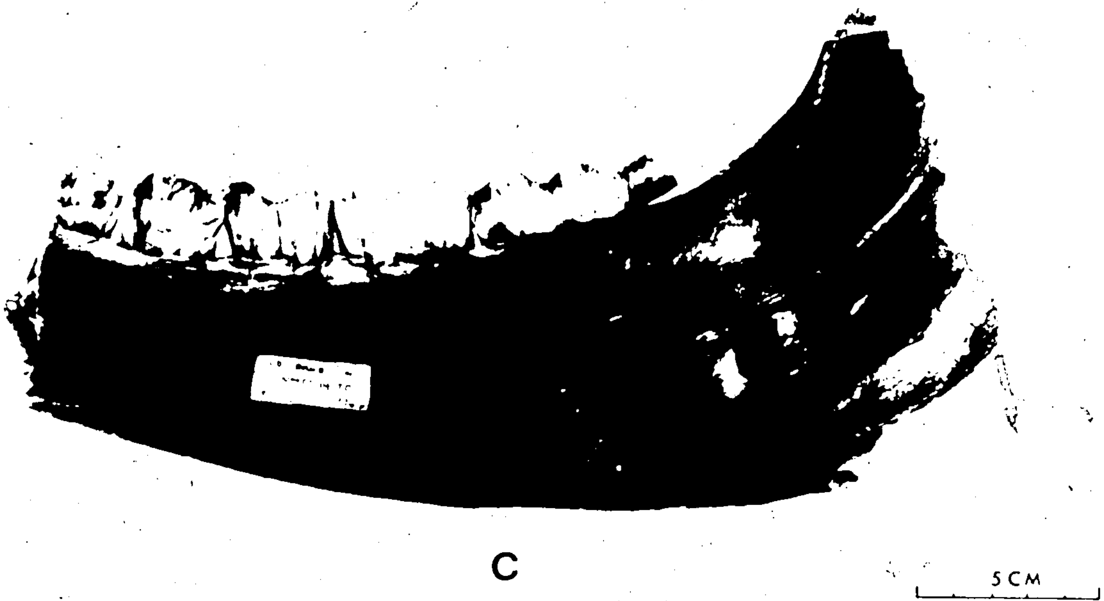
A. Lateral view.

B. Occlusal view.

C. Medial view.

A

B



C

Figure 87. Restoration of a helmeted muskox *(Symbos cavifrons)* tossing a wolf *(Canis lupus)*. Ink sketch by Bonnie Dalzell.

Table 97. Measurements of Pleistocene helmeted muskox (*Symbos cavifrons*) crania from the Yukon Territory compared to *Symbos cavifrons* crania from Alaska and Alberta.

Specimens	Measurements (mm)*																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Symbos cavifrons, Pleistocene, Y.T.																		
NMC 29229 Dawson Loc. 1	241.1	117.7	109.8a	59.0	-	-	132.0		123.2	165.0	192.1	102.9	41.0	42.4	145.4	57.2	202.0	75.9
NMC 8837 Dawson Area	230.3	117.1		55.7	195.0	280.0	124.0	421.5	133.9	130.5^{+}	162.5^{+}	110.5	43.0	47.9	150.4	52.3	208.0	87.3
USNM 2555 (type of "*Symbos tyrelli*") (Osgood 1905, p. 184) Lovett Gulch - adjoins Dawson Loc. 1	214.0	114.0		72.0	-	-	-	-	117.0	-	-	-	-	-	-	-	197.0	72.0
NMC 11370 Dawson Loc. 2	237.5^{+}	110.0a	115.6	71.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DCMP 10 Dawson Area	-	-	115.0a	-	227.0	287.0	-	-	-	-	-	-	-	-	-	-	-	-
NMC 26920 Old Crow Loc. 21	-	103.0^{+}	86.7^{+}	66.7	-	-	-	-	110.0	-	-	-	-	-	-	-	-	-
Symbos cavifrons, Pleistocene, Alaska																		
NMC [illegible] Lost Chicken Ck.	232.9	117.1	110.4	77.6	234.0	305.0	145.0	522.0e	124.3	129.1	172.6	95.5e	45.1	46.8	142.0	52.7	212.3^{+}	78.9
Symbos cavifrons, Pleistocene, Alberta (Harington 1975c, Table 2)																		
UA uncataloged Fort Saskatchewan	240.5	124.5	114.5	54.5	-	-	142.1	500.0^{+}e	117.5	146.5	191.0	101.2	42.0	49.8	152.9	53.4	201.9^{+}	[illegible]

*1 - Exostosis length.
2 - Exostosis width anterior to horncores.
3 - Anteroposterior diameter of horncore at base (where narrowing begins).
4 - Dorsoventral diameter of horncore at base.
5 - Length of horncore on lower curve (ridge to tip).
6 - Length of horncore on upper curve (edge of depression to tip).
7 - Width of cranium at constriction between horncores and orbits.
8 - Minimum width between horncore tips.
9 - Width of cranium at constriction above nuchal crest.
10 - Height from dorsal margin of foramen magnum to mid-line on dorsal surface of cranium.
11 - Height from ventral margin of foramen magnum to top of nuchal crest.
12 - Height from dorsal margin of foramen magnum to top of nuchal crest.
13 - Height of foramen magnum.
14 - Width of foramen magnum.
15 - Width across occipital condyles.
16 - Width of right occipital condyle.
17 - Maximum width of cranium above auditory meatus.
18 - Basioccipital width (across posterolateral margins).

Light copy

Table 98. Measurements of Pleistocene helmeted muskox (*Symbos cavifrons*) mandibles with teeth from the Yukon Territory.

Specimen	Measurements (mm)*																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Symbos cavifrons, Pleistocene, Y.T.																				
NMC 14170 Old Crow Loc. 12	21.3	14.4	19.0	27.5	17.8	23.8	31.9	22.0	20.4	38.1	21.8	21.5	54.2	19.0a	19.3	56.4	32.9	170.1	123.5	-
NMC 25171 Dawson Loc. 16	19.6a	-	-	21.5$^+$	15.3$^+$	-	27.4	21.5	21.3	32.4	25.3	23.0	53.6	22.2	22.8	60.3	34.3	161.0	118.5	173.0a

* 1 - P_3 length.
2 - P_3 width.
3 - P_3 height (from alveolar margin to highest point of tooth crown on lingual side).
4 - P_4 length.
5 - P_4 width.
6 - P_4 height.
7 - M_1 length.
8 - M_1 width.
9 - M_1 height.
10 - M_2 length.
11 - M_2 width.
12 - M_2 height.
13 - M_3 length.
14 - M_3 width.
15 - M_3 height.
16 - Depth below centre of M_1 (labial side).
17 - Thickness of mandible below centre of M_1.
18 - Alveolar length P_3-M_3.
19 - Alveolar length M_1-M_3.
20 - Alveolar length P_2-M_3.

Light copy

Table 99. Measurements of a Pleistocene helmeted muskox (*Symbos cavifrons*) metatarsal from the Yukon Territory compared to metatarsals of Pleistocene *Praeovibos* sp. from Siberia and Recent *Ovibos moschatus* from North America.

Specimens	Measurements (mm)*						
	1	2	3	4	5	6	7
Symbos cavifrons.Pleistocene, Y.T.							
NMC 14495 Old Crow Loc. 22	227.7	54.5	44.8	33.2	29.0	66.9	39.0
Praevibos sp. Pleistocene, Siberia (Sher 1971, Table 39)							
GIN $\frac{835-131}{21}$ Bolshaya Chukochya R.	199.0	52.4	49.0	34.0a	34.4a	68.0	39.0
GIN $\frac{835-498}{31}$ Bolshaya Chukochya R.	206.0	53.4	52.5	36.0a	35.4a	68.5	38.6
Ovibos moschatus.Recent, N. America (Sher 1971, Table 39)							
ZIN 27296 Greenland	163.0	45.0	43.0	28.0a	24.0a	56.3	32.0
ZIN 8690 Ellesmere I.	156.0	39.8	37.0	23.0a	23.0a	51.0	29.5

* 1 - Total length.
2 - Proximal width.
3 - Proximal depth.
4 - Midshaft width.
5 - Midshaft depth.
6 - Distal width.
7 - Distal depth.

heavily eroded. Bone is missing anterior to the forward ridge of the exostosis (the roughened central region of the cranium between the horncores). The surface is pale and slightly iron-stained. NMC 8837 was collected from an unknown locality in the Dawson Area about 1916. It consists of the posterior half of a cranium with complete horncores: the right one is slightly longer than the left. The fossil is like NMC 29229 except that bone above the nuchal crest is much thinner (disregarding some erosion that has occurred at this point), and the region between the horncore bases is deeply excavated and bowl-shaped. However, I have noticed that the thickness of bone above the nuchal crest varies greatly in the extant muskox, *Ovibos moschatus*, and I do not regard it as of taxonomic importance. The rough, trough-like areas between the horncore of *Symbos* are also irregular in form. The surface of NMC 8837 is covered with brown commercial preservative, but the underlying bone is fresh-looking.

USNM 555 from Lovett Gulch near Dawson is the type of "*Symbos [illegible]elli*". It is a relatively small, well preserved cranium with some parts missing from one side. LP_2-LM_3 and RM_2-RM_3 are intact. Evidently the cranium represents a very old individual, for the teeth are heavily worn. The bone is brownish in color, but is not heavily permineralized (Osgood 1905, p. 173). It is worth noting that this specimen was collected within half a mile (0.8 km) of the large cranial fragment from Trail Creek (NMC 29229, Dawson Locality 1). USNM 2555 and another fossil (USNM catalog number unknown), comprising the posterior part of a cranium with an attached horncore, were presented to W.H. Osgood by J.B. Tyrrell, the Canadian geologist and explorer, in 1904.

NMC 11370 from Dawson Locality 2 (within a mile (1.6 km) of the site where "*Symbos tyrrelli*" was found) is a heavily eroded upper portion of a posterior cranial fragment. The trough-like region between the horncore bases is preserved. The bone is dark brown, with buff mottling on the dorsal surface. NMC 26920 from Old Crow Locality 21 is the upper part of a posterior cranial fragment with stubs of the horncores. It has the basic characteristics of *Symbos*, but it is smaller than the other specimens. Heavy erosion has worn away most of the rough exostoseal bone in the central trough exposing the frontals and revealing that the frontal suture is open. Therefore, I consider it to represent a subadult male, and tentatively, refer it to *Symbos cavifrons*. The bone is stained dark, rusty brown, and may be of pre- late Wisconsin age. DCMP 10 from the Dawson Area is a virtually complete horncore. It is displayed in the Dawson City Museum.

Three mandibular fragments are in the Yukon collections. NMC 14170 from Old Crow Locality 12 is the central part of a right mandible with RP$_3$-RM$_3$. RP$_2$, bone anterior to RP$_3$, and the ascending ramus are lacking. The specimen probably represents an animal in early maturity, for RM$_3$ has not fully erupted, nor is the posteriormost cusp completely worn. It is somewhat smaller than the mandible of a large adult of *Symbos cavifrons* (= "*Ovibos giganteus*" – F:AM Field No. $\frac{4254}{1939}$) from near Fairbanks, Alaska to which it was compared. NMC 14170 has several interesting features. An unworn labial style is situated between the crescents of RM$_1$. RP$_3$ is highly developed in *Symbos* compared to *Ovibos moschatus* – possibly representing the more primitive condition in muskoxen. In the course of eruption and wear, an anterior chip of RM$_1$ was dislodged and preserved in a depression in the posterior lobe of RP$_4$. The surface of the chip was worn nearly flush with the occlusal surface of RM$_1$. The bone is dark brown, as is the dentine, suggesting a pre-late Wisconsin age. I am grateful to C.E. Ray for allowing me to compare this fossil with F:AM Field No. $\frac{4254}{1939}$, which was temporarily in his custody, and to M.F. Skinner for assisting me with the comparison.

NMC 25171 from Dawson Locality 16 is a right mandible lacking the ascending ramus, the anterior tip of the horizontal ramus, RP_2, and most of RP_3 and RP_4 above the roots. A symphyseal portion of the left mandible is attached. Occlusal wear on RM_1-RM_3 suggests that the animal represented was mature. The loops of RM_1 are greatly reduced. The bone is pale tan, and the enamel is rather fresh-looking. The specimen may be of late Wisconsin age. A more deeply stained diastema region of a right mandible, NMC 28547 from Old Crow Locality 144, compares well with that part of NMC 25171, and is referred to *Symbos cavifrons*. It is interesting to note that the diastema of *Symbos cavifrons* is unusually long: that of NMC 25171 (154.3 mm) is slightly longer than the diastema of a Recent moose (*Alces alces* , NMC 4412) from New Brunswick (152.2 mm). Did similar feeding habits result in this parallelism? In any case, the helmeted muskox had a relatively long snout compared to the living tundra muskox. Both NMC 28547 and 25171 have two large mental foramina (the lower one just anterior to the upper) which are situated in the upper half of the mandible approximately 100 mm in front of the anterior alveolar margin of RP_2. A keel is developed on the dorsal surface of the diastema regions of both NMC 28547 and 25171.

NMC 14495 from Old Crow Locality 22 is a complete right metatarsal. It is too long and slender to be a metatarsal of any other muskox known from Yukon Pleistocene deposits (e.g. *Soergelia, Praeovibos, Ovibos*), yet it matches well in all morphological features a metatarsal of *Ovibos moschatus* (NMC 29185). NMC 14495 with a total length of 227.7 mm is approximately 11% longer than *Praeovibos* sp. metatarsals from Siberia and approximately 30% longer than *Ovibos moschatus* (Table 100), and is referred to *Symbos cavifrons*. The fossil is stained dark brown and is probably pre- late Wisconsin in age.

Discussion

The helmeted muskox is known from both Dawson and Old Crow areas in the Yukon Territory. The degree of staining of the specimens suggests that most are of late Wisconsin age, and that a few are of pre- ~~late~~ Wisconsin age.

In other parts of Canada, *Symbos cavifrons* has been reported from British Columbia, Alberta and Saskatchewan. A well preserved cranium (NMC 11859, displayed in the National Museum of Natural Sciences, Ottawa) and two cranial fragments (SMNH 1280/4321, 1164/7750) have been collected from deposits probably of Sangamon interglacial age at Fort Qu'Appelle, Saskatchewan (Harington 1961, p. 460; Khan 1970, pp. 64-75). A posterior cranial fragment (UA* uncataloged) of this species was collected at Fort Saskatchewan, Alberta from a gravel and sand unit overlying grayish-blue bentonitic sandstone of the

Edmonton Formation (Cretaceous). It was overlain by a unit of postglacial silt and sand. The fossil was deposited following the initial glaciation of the region by Keewatin ice. Probably the specimen is of late Pleistocene age (Harington 1975c, p. 906). A heavily eroded posterior cranial fragment (BCPM 680) of *Symbos* sp. from near Dease Lake, British Columbia probably dates to a non-glacial phase of the Pleistocene. Tough, gray mudstone adhering to protected areas of the cranium may indicate a relatively great age for this specimen (Harington 1968, p. 1164). A cranial fragment (BCPM 69: 014) from gravels on the Saanich Peninsula of Vancouver Island indicates that helmeted muskoxen reached the island via a land connection during the Olympia Interglaciation, or possibly during glacial maxima of the late Pleistocene, when land may have been exposed between the mainland and Vancouver Island (Harington 1975c, pp. 911-915).

In the conterminous United States a total of 40 or more specimens are known from the following states: Arkansas, California, Colorado, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Missouri, Nebraska, New Mexico, North Dakota, Ohio, Oklahoma, Utah, Virginia, Washington (C.E. Ray, personal communication 1968), Wisconsin, and the continental shelf 40 miles (64.4 km) southeast of Atlantic City, New Jersey (D. Baird, personal communication 1961). Specimens from Mullen II on the

Middle Loup River, Nebraska (Jakway 1961, pp. 114-115) and from Conard Fissure, Arkansas indicate that *Symbos cavifrons* had reached western and south-central United States by early Illinoian time. Probably most specimens from the conterminous United States are of Wisconsin age. Bone of *Symbos cavifrons* from a marl deposit in Kalamazoo County, Michigan yielded a radiocarbon date of 13,200 ± 600 years B.P. (M-639) (Hibbard and Hinds 1960, p. 105). A radiocarbon date pertaining to a muskox from Scotts, also in Kalamazoo County, Michigan, is 11,100 ± 400 years B.P. (Semken *et al.* 1964, p. 833). Apparently the latter date is near the time of extinction of *Symbos cavifrons* in the southern refugium.

Perhaps 20 or more specimens of *Symbos cavifrons* are known from Alaska. Most are from the Fairbanks region and are preserved in the Frick Collection of the American Museum of Natural History in New York. Other specimens have been reported from Anvik in the west, (Osgood 1905a, p. 183), near [illegible] Barrow on the northern coast (Harington 1968, p. 1[illegible]) [illegible] from Lost Chicken Creek in the east. The specimen [illegible]2) from the last locality is very fresh-looking, a[illegible] probably of late Wisconsin age. It is a posterior [illegible] fragment with a complete left horncore and a third [illegible] the right horncore. The fossil lacks bone anterior to the orbits, which are partly preserved. The occipital region is eroded, particularly on the lateral margins and on the upper parts of the occipital condyles. Surface details of the rugose, central channel, and horncores are well preserved. The thickness of bone above the nuchal crest in NMC 25892 is intermediate between the great mass in NMC 29229 from Dawson Locality 1 and NMC 8837 from the Dawson Area, in which little bone is present above the nuchal crest. A *Symbos* specimen from deposits considered to be of Illinoian age at Cripple Creek sump near Fairbanks (Péwé 1975a, Table 11) is the earliest known from Eastern Beringia. Winter fecal pellets associated with hair and a skeleton of *Symbos cavifrons* from Little Eldorado Creek gave a date of >40,000 years B.P. (SI-291). Radiocarbon analyses of hornsheaths from two specimens of the helmeted muskox from near Fairbanks (Dome Creek and Upper Cleary Creek) yielded dates of 17,695 ± 445 years B.P. (SI-851) and 25,090 ± 1,070 years B.P. (SI-850), indicating that *Symbos* occupied Eastern Beringia during the peak of the Wisconsin glaciation.

Symbos cavifrons has not been reported from Eurasia. However, I suspect that the heavily eroded type specimen of *Ovibos recticornis* (Ryziewicz 1933, Plate 5-1a, b) is closely related to the genus *Symbos*, being like it in the following characteristics: (a) great depth from the lower lip of the foramen magnum to the dorsal surface of the cranium between the horncores: *Praeovibos* and *Ovibos* are shallower and broader in the occipital region; (b) the marked constriction of the occipital region near the level of the nuchal crest, unlike that of most *Praeovibos* and *Ovibos* skulls; (c) ridges near the bases of the horncores, bordering the area where the central channel or trough occurs in *Symbos*, and unlike the situation in *Praeovibos* in which the horncore bases tend to be narrower anteroposteriorly and encroach more on the frontals, or the situation in *Ovibos* in which horncore bases nearly meet at the frontal suture, leaving a narrow anteroposterior groove there; and (d) horncores departing from the cranium nearly level with the frontal plane before being deflected down, and therefore flaring more than the horncores of *Praeovibos* or *Ovibos*. It is interesting to note that in comparing the type specimen of *Ovibos recticornis* with crania of other fossil muskoxen, Ryziewicz (1933, p. 85) commented that it could be closer to the type specimen of "*Gidleya zuniensis*" (a heavily-worn *Symbos cavifrons* cranial fragment according to C.E. Ray, personal communication 1968) than to specimens of *Ovibos fossilis*. Evidently any rough bone that may have existed in the trough between the horncores of the type of *Ovibos recticornis* has been eroded. Apparently this specimen is from Mindel (?Kansan) deposits at Radotin, Czechoslovakia. Perhaps Kretzoi (1942) was correct in applying a new generic name "*Parovibos*" to this specimen, that is, if it does not belong to *Symbos*. In an effort to find out how well crania of *Ovibos recticornis* and *Symbos cavifrons* match, I have requested a cast of the type specimen of the former species.

Virtually nothing is known about the origins of *Symbos*. It undoubtedly had Eurasian ancestors, but the genus has not been reported definitely from that continent. I speculate that *Ovibos* and *Symbos* arose from the same basic, alpine-adapted ancestors; but *Symbos* has a few features that I regard as "less advanced" (e.g. higher set horns). Perhaps helmeted muskoxen evolved in broad intermontane valleys, dispersing onto the lower plains during the severe Illinoian glaciation as cool, steppe grasslands encroached on those areas, whence the animals spread through Alaska (Cripple Creek sump) and the Yukon to the south-central United States (Conard Fissure). Probably herds moved northward (Fort Qu'Appelle) as continental ice retreated during the Sangamon interglacial. *Symbos cavifrons* seems to have occurred in large numbers from the Pacific coast (e.g. California, Washington, British Columbia) to the Atlantic coast (e.g. continental shelf off New Jersey; Virginia) during the Wisconsin glaciation. Apparently the species was widespread in unglaciated parts of Alaska and the Yukon then, dying out toward the close of the last glaciation. The most recent radiocarbon date for *Symbos cavifrons* from Alaska is approximately 17,700 years B.P. (Table 6), whereas the latest date of its occurrence in the southern refugium is approximately 11,000 years B.P.

Symbos cavifrons was taller and had a more slender build than the living muskox *Ovibos moschatus*. Its longer, deeper skull supported higher, more flaring horns with massive, fused bases (Figure 87). Hair found with a well preserved skeleton from Alaska (F:AM Field No. $\frac{4254}{1939}$) indicates that *Symbos* had a dark brown coat like *Ovibos*, but from the sample I examined, its hair seems to have been shorter and finer. Another indication that *Symbos* had a thinner coat than *Ovibos* and was adapted to warmer habitat is its relatively slight degree of orbital protrusion (these observations should be quantified). Parry (1821, Appendix P) among others, thought that the projection of the orbits in *Ovibos* served the purpose of carrying the eye clear of the hairy coat. Guthrie (1966, p. 725) has given evidence supporting the contention that cold-adapted, northerly ranging forms of *Bison* have more protruding orbits than southerly ones; the hypothesis being that peripheral vision is facilitated in species requiring thick, cold-protective facial hair, by projection of the eye outward in a tubular socket. Perhaps for the same reason, orbits are prominent in tundra caribou, but not in woodland caribou, which are adapted to warmer environmental conditions (Banfield 1961, pp. 43, 70).

Little is known about the ecological requirements of *Symbos cavifrons*, but the distribution of their remains in southern North America (Kitts 1953; Harington 1961, Figure 25) shows clearly that these muskoxen were adapted to warmer (more southerly) conditions than *Ovibos*. In fact, *Symbos* was mainly confined to a belt across the central United States between 35°N and 43°N.

Hibbard (1951) considered that *Symbos cavifrons* was a woodland form, and concluded that the species foraged along lake and forest margins with woodland caribou in Michigan during the late Wisconsin. Kitts (1953) thought it possible that *Symbos* was a woodland or steppe form. Dillon (1956) suggested that *Symbos* and *Bootherium* were prairie rather than tundra animals because of the abundance of their remains throughout the grass belt of middle North America as far south as Texas. Benninghoff and Hibbard (1961), and Semken *et al.* (1964) reaffirmed the woodland habitat of the helmeted muskox using fossil pollen as evidence. Yet it is interesting to note the approximate coincidence of *Symbos* range with former loess-steppe areas in the central United States (Flint 1971, Figure 9-14) and Alaska (Péwé 1975a, Figure 17). It is also worth noting that during the late Wisconsin, when *Symbos cavifrons* is known to have occupied the Fairbanks area, analyses of plant and invertebrate macrofossils in a 27 m core from sediments of that period indicate that forests "disappeared from interior Alaska or were greatly diminished and much of the region was characterized by steppe-tundra vegetation" (Matthews 1974, p. 828). Matthews adds that steppe conditions may have been favored by rapid deposition of primary and reworked loess.

The nature of the evidence concerning the habitat of this species is equivocal. Because there is still room for doubt that *Symbos* was a "woodland muskox", I suggest the use of a more descriptive, environmentally noncommittal name "helmeted muskox". Analysis of fecal remains associated with a skeleton of *Symbos cavifrons* from Alaska suggests that the individual represented by the bones had fed on grasses and sedges during the winter (Harington 1968, p. 1165). Probably wolves were among its main predators.

Praeovibos priscus (Staudinger's muskox)

Twelve cranial fragments and two metapodials of Staudinger's muskox (Figures 88A-D, 89A-C, Tables 100-101) from Yukon Pleistocene deposits are described. They are the first records of this genus from the Yukon and Canada, and mark the easternmost limit of the species in North America. Historically, it is interesting that one of the first Pleistocene vertebrate fossils collected from the Yukon Territory was a partial cranium of *Praeovibos priscus*. Unfortunately it was identified as a specimen of the tundra muskox *Ovibos moschatus*, and its significance was overlooked (Lydekker 1885, p. 39). *Praeovibos* may be valuable as an index fossil of Illinoian age in Eastern Beringia. There is no evidence that it penetrated to southern North America.

Referred specimens

BM(NH) M 44070 is a posterior cranial fragment. Bone is lacking anterior to the orbits. Approximately two-thirds (150 mm) of the right horncore and half of the left horncore are preserved. Although the horncores are heavily eroded, their massiveness suggests that a male in early adulthood is represented. Only the upper portions of the orbits are preserved. The lateral margins of the occipital region are eroded. The frontoparietal and parietosquamosal sutures are not fused. The label on the

Figure 88. Posterior of cranium with partial horn-cores (BM(NH) M 44070, Porcupine River - locality unknown) of a Pleistocene Staudinger's muskox *(Praeovibos priscus)*. A. Posterior view. B. Dorsal view. C. Right lateral view. D. Ventral view.

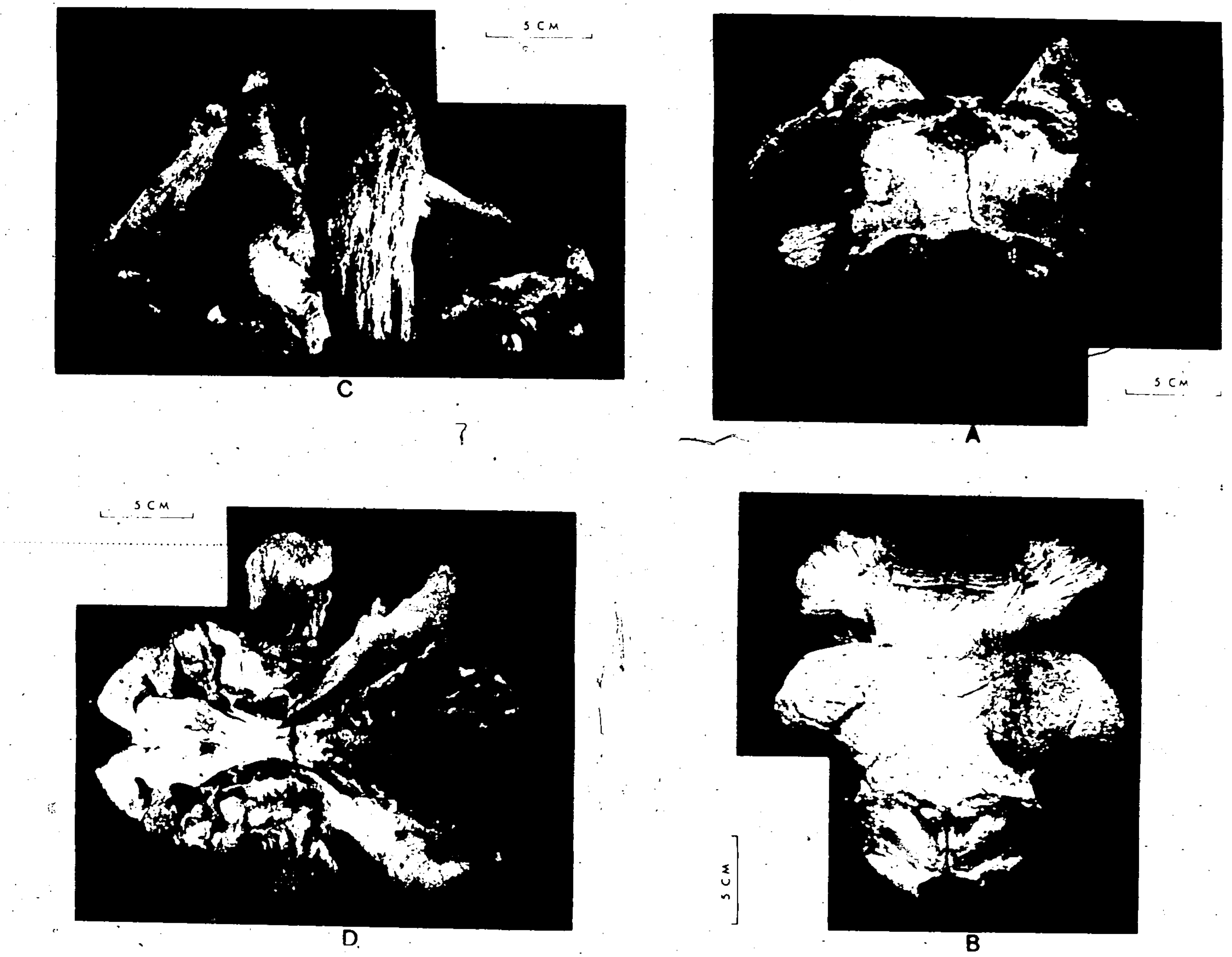
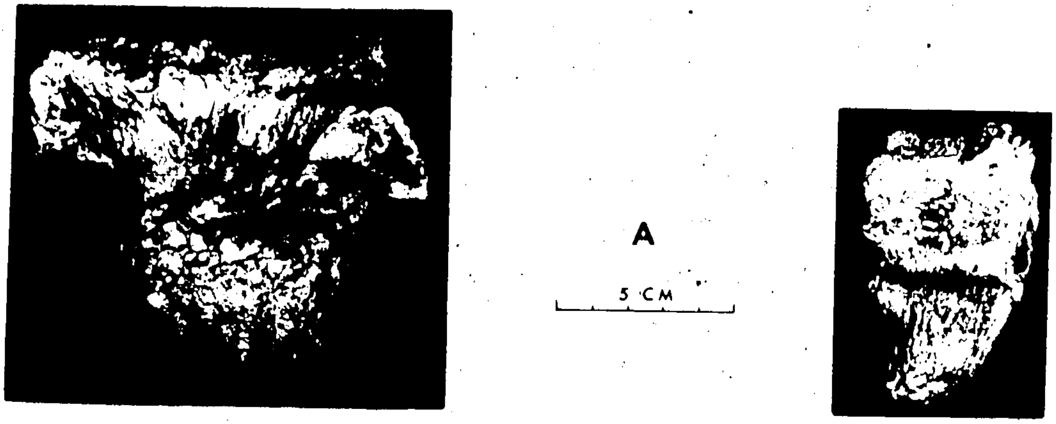

5 CM
C
7
5 CM
A
5 CM
D
5 CM
B

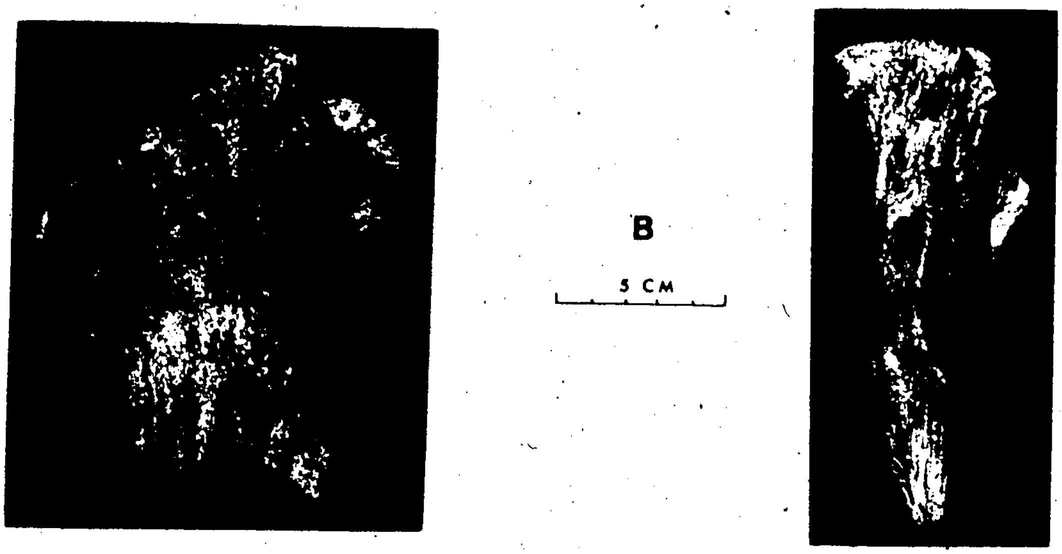
Figure 89. Partial left horncore with attached cranial fragment (NMC 20135, Old Crow Locality 74) of a male Pleistocene Staudinger's muskox *(Praeovibos priscus)* (left) and a partial right horncore with attached cranial fragment (NMC 20540, Old Crow Locality 22) of a ?female Pleistocene Staudinger's muskox *(Praeovibos priscus)* (right).

A. Dorsal view.

B. Lateral view.

C. Posterior view.


A
5 CM


B
5 CM

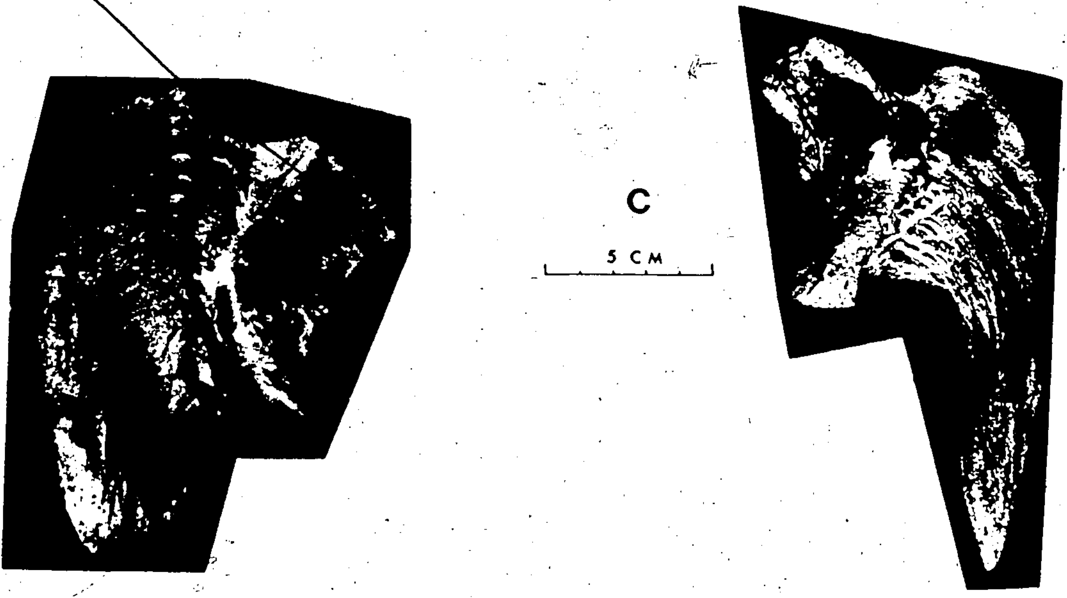

C
5 CM

Table 100. Measurements of Pleistocene Staudinger's muskox (*Praeovibos priscus*) crania and horncores from the Yukon Territory compared to those of *Praeovibos priscus* from Siberia and Germany.

SPECIMENS	MEASUREMENTS (mm) *																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Praeovibos priscus. Pleistocene, Y.T.																			
MALES (referred)																			
BM(NH) M 44070 Upper Porcupine R.	76.0	96.1	31.0+	57.5+	26.2	–	–	–	203.7+	97.1	45.4	103.3	98.0a	97.5	76.9	28.5a	32.4a	102.8	54.0
NMC 28100 Old Crow Loc. 109	–	–	–	–	–	–	–	–	–	–	–	–	–	105.4	84.1	27.4	33.3	109.5	61.0
NMC 20135 Old Crow Loc. 74	79.5	111.8	47.0	70.5	40.0	22.8	–	–	–	–	–	–	–	–	–	–	–	–	–
NMC 20607 Old Crow Loc. 20	77.7a	96.4	29.0	62.7	35.9a	16.0	–	–	–	–	–	–	–	–	–	–	–	–	–
NMC 27215 Old Crow Loc. 29	81.6	94.6	27.0	73.0a	35.0a	15.8	–	–	–	–	–	–	–	–	–	–	–	–	–
NMC 23057 Old Crow Loc. 11A	–	–	35.0+	72.4	41.6e	24.7	–	–	–	–	–	–	–	–	–	–	–	–	–
FEMALES (tentatively referred)																			
NMC 20540 Old Crow Loc. 22	54.3	67.4	18.5	38.1	21.6	18.0	99.0	169.0	–	–	–	–	–	–	–	–	–	–	–
NMC 15271 Old Crow Loc. 22	59.0	61.1+	18.0+	42.3	29.7	19.5a	78.0	151.0	–	–	–	–	–	–	–	–	–	–	–
NMC 27749 Old Crow Loc. 66	50.5a	74.3	19.0	41.8	27.1	13.3	–	–	–	–	–	–	–	–	–	–	–	–	–
NMC 19007 Old Crow Loc. 66	43.2	49.5	10.5	29.6	23.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Praeovibos priscus. Pleistocene, Siberia**																			
MALES																			
"OCX-73-761" exact locality unknown (very large cranium)	140.0+	–	–	–	–	–	–	300.0a	269.2e	121.3	48.2	120.4	–	118.7	89.8	–	–	130.6	72.8
GIN $\frac{741-1}{109}$ Kolyma R.	83.7	–	–	–	–	–	153.0	257.0	–	95.2	46.7	96.0	–	104.8	82.2	–	–	109.8	55.8
FEMALES (referred by A.V. Sher)																			
GIN $\frac{851-72}{8}$ Krestovka R.	51.0	–	–	–	–	–	–	163.0	–	98.0	50.5	78.7	–	–	–	–	–	–	–
"3100-920" exact locality unknown	61.3	–	–	–	–	–	–	–	–	98.0	49.0	88.2	–	–	–	–	–	–	–
Praeovibos priscus. Pleistocene, Germany																			
MALE (Sher 1971, Table 31) Catalog number unknown – Bad Frankenhausen (type)	100.0	–	–	–	–	–	–	287.0	252.0	115.0	40.0	102.3	–	–	–	–	–	110.0	–

---

* 1. Anteroposterior diameter of horncore at base. 2. Maximum diameter of horncore at base. 3. Approximate height of highest part of horncore base above frontal plane. 4. Anteroposterior diameter of horncore near mid-length. 5. Mediolateral diameter of horncore near mid-length. 6. Thickness of frontal taken in line with middle of horncore base near frontal suture. 7. Length of horncore on lower curve (ridge to tip). 8. Length of horncore on upper curve (base to tip). 9. Maximum distance across orbits. 10. Width at constriction between horncores and orbits. 11. Approximate minimum width between horncore bases. 12. Width at constriction between nuchal crest and posterior of horncores. 13. Height from dorsal margin of foramen magnum to mid-line on dorsal surface of cranium. 14. Height from ventral margin of foramen magnum to top of nuchal crest. 15. Height from dorsal margin of foramen magnum to top of nuchal crest. 16. Height of foramen magnum. 17. Width of foramen magnum. 18. Width across occipital condyles. 19. Basioccipital width (across posterolateral margins).

** I am grateful to A.V. Sher of the Paleontological Institute, USSR Academy of Sciences, Moscow for allowing me to examine and measure *Praeovibos* specimens from Siberia.

Table 101. Measurements of Pleistocene Staudinger's muskox (*Praeovibos priscus*) referred metacarpals from the Yukon Territory compared to *Praeovibos* (referred) metacarpals from Siberia.

Specimens	Measurements (mm)*						
	1	2	3	4	5	6	7
Praeovibos priscus (referred). Pleistocene, Y.T.							
NMC 28129 Old Crow Loc. 126	193.9	59.3	37.8	39.6	26.2	65.4	37.4
NMC 16199 Old Crow Loc. 45	184.0e (173.5+)	-	-	37.2	23.3	64.0e	-
Praeovibos sp. (referred). Pleistocene, Siberia**							
"OKC-75-254"	212.8	60.9	37.1	41.0	26.2	65.6	34.8
"26-231"	194.5	56.0	38.8	41.7	25.2	68.7	37.1
"OKC-73-255"	186.8	52.5+	32.4	34.7	21.5	60.2	31.1
"836-95" 47	184.4	58.6	37.7	38.3	22.9	66.4	35.2
"3347-635"	180.8	59.4	39.0	38.8	23.2	70.0	36.7
"3011"	176.2	56.0	37.4	36.0	21.7	66.2	33.6
"3100-597"	173.5	55.8	35.0	38.5	24.4	61.4	33.1
"835-29" 19	171.0	53.3	35.2	36.9	21.7	61.7	32.9

* 1 - Total length.
2 - Proximal width.
3 - Proximal depth.
4 - Midshaft width.
5 - Midshaft depth.
6 - Distal width.
7 - Distal depth.

** A.V. Sher of the Paleontological Institute, USSR Academy of Sciences, Moscow, kindly allowed me to examine and measure a series of metatarsals from Siberian Pleistocene deposits referred to *Praeovibos*, which were not officially cataloged.

specimen reads: "*Ovibos moschatus*; Gmel. Sp. Porcupine River, Arctic America. Pres'd. by the Revd. R. McDonald 1873." The exact locality is unknown, but it is almost certainly from the upper part of the Porcupine River system. It is the most complete specimen known of Staudinger's muskox from Canada. Features that characterize both *Praeovibos priscus* and BM(NH) M 44070 are: (a) the broad, smooth channel between the horncore bases; (b) the relatively narrow anteroposterior diameter of the horncore bases compared to *Ovibos*; (c) the great height of the horncore bases above the frontal plane – particularly near their posterior margins; (d) the narrow, flat frontal region between the flaring horncores and orbits; (e) the flare of the horncores (approximately 55° below the frontal plane), which lies between that of *Symbos cavifrons* and *Ovibos moschatus*. Three supraorbital foramina are present. The basioccipital is shield-shaped with well marked basilar tubercles directed anteriorly toward the mid-line of the cranium at an angle of approximately 30°. The basioccipital has a poorly developed median ridge that becomes a trough between the anterior ends of the basilar tubercles. This specimen and all other cranial and horncore fragments described here differ from *Praeovibos beringiensis* – the only other recognized species – in the shorter anteroposterior diameter of the horncore bases, and their rounder upper profile when viewed from the side. I am grateful to

A.J. Sutcliffe of the British Museum (Natural History) in London for allowing me to examine the original specimen, and for supplying a cast (NMC 13750) of it.

NMC 28100 from Old Crow Locality 109 consists of most of the occipital region and the posterior half of the basioccipital. Because of the small size of the occiput compared to *Ovibos*, and the fact that it matches closely the occipital region of BM(NH) M 44070, I tentatively refer it to *Praeovibos priscus*. The well developed posterior protruberances of the basioccipital suggest that an adult is represented. The fossil is deeply iron-stained, and like the remainder of the specimens described is probably of pre- late Wisconsin age.

The following horncore fragments are referred to males of *Praeovibos priscus*. The larger specimens are similar in size to the *Praeovibos priscus* cranial fragment GIN $\frac{741-1}{109}$ from the Kolyma River, Siberia; apparently slightly smaller than the type of *Praeovibos priscus* from Bad Frankenhausen, Germany; and much smaller than a massive cranium from Siberia "OCX-73-761" (Table 100). To my knowledge, there are no qualitative differences among the Canadian, Siberian and European fossils; therefore the Yukon specimens are referred to *Praeovibos priscus*.

NMC 20135 from Old Crow Locality 74 is the proximal half of a large left horncore attached to part of a frontal. The break on the frontal exposes a section of the bone near the cranial axis. Bone near the anterior margin of the horncore is 25.5 mm thick; that near the posterior margin of the horncore is 35.5 mm thick. The coarse grooving along the length of the horncore is subdued by erosion. [illegible] large size of the fossil suggests that an old male is represented.

NMC 27215 from Old Crow Locality 29 is the proximal half of a large left horncore attached to part of a frontal. Bone on the inner margin of the horncore base is deeply pitted, unlike the relatively solid surface of NMC 20135. The frontal bone is thinner: 14.2 mm thick near the anterior margin of the horncore, and 23.0 mm thick near the posterior margin of the horncore. I suggest that this fossil represents a male in early adulthood. The outer surface of the horncore is heavily eroded.

NMC 20607 from Old Crow Locality 20 is a left horncore fragment with part of an attached frontal. It differs in no substantial way from NMC 27215, except that a small part of the posterior margin of the horncore base has been broken away. A large pneumatic cavity is exposed below the base of the horncore. NMC 20891 from Old Crow Locality 3 is a heavily eroded anteroproximal fragment of a left horncore attached to part of the braincase. Evidently it was derived from a male. It is too poorly preserved to be worth measuring. NMC 23057 from Old Crow Locality 11A is a fragment of the right horncore attached to part of the frontal. The posterior quarter of the horncore base is lacking. The pneumatic cavity at the base of the horncore is clearly exposed. It extends 59 mm from a point below the horncore base into the proximal portion of the horncore, and has an anteroposterior diameter of 41 mm. The specimen is heavily permineralized, being reddish-black.

The following horncores and horncore fragments are tentatively referred to females of *Praeovibos priscus*. The few measurements that are comparable between them and specimens referred to females of Staudinger's muskox by Sher (1971, p. 217; personal communication 1973) are similar (Table 100). I wish to point out that a frontal fragment with attached horncores (GIN $\frac{851-77}{8}$) referred to "presumably a female" of *Praeovibos* from Siberia possesses rather poorly formed horncores, resembling those of an immature tundra muskox. Indeed, Sher (1971, p. 217) remarks: "...the body of the core is very irregular, with tuberosities and foramina", and "relief on the surface of cores weaker and developed only in individual places." Also, the frontal suture is open, suggesting that a subadult is represented. This does not deny the possibility that the specimen represents a female, but it could also belong to an immature male. The Yukon fossils are quite uniform in size and shape, being slightly less than half the size of the horncores attributed to males, and having thinner braincases. The small size of these horncores, compared to those of referred males, parallels the relationship between females and males of *Ovibos moschatus*. The strong development of surface grooves in the better preserved horncores contrasts with the poorly formed appearance of subadult *Ovibos* horncores; therefore, they are considered to represent adults.

NMC 20540 from Old Crow Locality 22 is a well preserved, complete right horncore attached to a fragment of braincase. The surface sculpture is clear. The largest grooves on the medial surface of the horncore lie nearest to its anterior border. NMC 27749 from Old Crow Locality 66 consists of proximal half of a left horncore attached to part of the braincase. The flatness of the frontal anterior to the horncore base, readily seen in the large cranial fragment BM(NH) M 44070, is observed in this specimen. The horncore has been smoothed by erosion. There is a deep pit approximately 20 mm from the horncore base on its lateral surface. A similar pit is seen about 31 mm from the horncore base in NMC 20540.

NMC 15271 from Old Crow Locality 22 is a complete left horncore attached to a small part of the braincase.

Six deep grooves are apparent on the lateral surface of the horncore, the deepest groove on the medial surface being near the anterior margin as in NMC 20540. NMC 19007 from Old Crow Locality 66 is the proximal part of a left horncore attached to a small portion of the braincase. It is heavily eroded and smaller than the other specimens that I tentatively refer to females of *Praeovibos priscus*.

NMC 28129 from Old Crow Locality 126 is a complete right metacarpal that matches well those in the upper range of *Praeovibos* (Table 101). The non-articular pit on the proximal articular surface is curved as in *Ovibos*. There is a well marked groove on the medial side of the posterior surface of the shaft that is evident in *Ovibos* but not in *Bison*. The specimen can also be differentiated from *Bison* by the fact that it flares less at the proximal and distal ends when viewed from the front. Also, the shaft widens gradually toward the distal end as in *Ovibos* but not as in *Bison*. NMC 28129 is more slender and approximately 12% longer than metacarpals of *Ovibos moschatus* (e.g. NMC 23579). It is referred to *Praeovibos priscus*. NMC 16199 from Old Crow Locality 45 consists of most of a right metacarpal that has been deeply gnawed by a carnivore on the distal articular surface. The proximal end has been broken off. The specimen has the same basic shape as *Ovibos* metacarpals, but is obviously longer and more slender. In these characters it approaches a cast of a left metacarpal (NMC 31021) from the Kolyma Lowland of Siberia, and the middle of the range of a series of uncataloged metacarpals from Siberia (Table 101), which Sher (personal communications 1973, 1976) refers to *Praeovibos*. NMC 16199 is tentatively referred to *Praeovibos priscus*, keeping in mind that it may also resemble a metacarpal of *Symbos cavifrons*, none of which is available for comparison. The fossil is stained brown.

Discussion

Praeovibos priscus fossils have not been found *in situ* in thick sections in the Old Crow Area, and therefore no estimate of their age can be made on stratigraphic grounds. The dark staining of all of the specimens, and signs of deep penetration of iron oxide to the interior bone of a few, suggest that they are of pre- late Wisconsin age. *Praeovibos* has not been identified from Pleistocene deposits south of Eastern Beringia.

In Alaska, five incomplete crania with horncores and two fragmentary specimens doubtfully referred to *Praeovibos* have been identified by C.E. Ray. The five definitely identifiable specimens are from Cripple Creek sump, and one of the other fragments is from Gold Hill. They are probably Illinoian in age according to

Péwé (1975a, p. 95). The last fragment, from Lower Cleary Creek, may be either of Illinoian or Wisconsin age. Possibly *Praeovibos priscus* is an indicator of Illinoian age in Eastern Beringia.

In Siberia, *Praeovibos priscus* was first identified by E.A. Vangengeim from specimens collected at Krasnoyarka on Irtysh River in western Siberia (Vangengeim and Zazhigin 1965). This locality forms a link between places where *Praeovibos* fossils have been found in northeastern Siberia to the east, and those of Europe to the west. Since then, *Praeovibos priscus* fossils have been reported from the lower part of the Kolyma River, and specimens referred to *Praeovibos* cf. *priscus* and *Praeovibos beringiensis* have been reported from the Krestovka and the Bolshaya Chukochya rivers, respectively - all in the Kolyma Lowland (Sher 1971, p. 218). The type specimen of *Praeovibos beringiensis*, a relatively complete cranium, was derived from sandy loam of the Olyor Suite of Mindel (?Kansan) age. A phalanx from the Lyakhovskiy Islands may be referable to *Praeovibos* (Sher 1971, p. 226).

Fossil remains of *Praeovibos priscus* are recorded from eight localities in Europe (Kahlke 1964, pp. 3-4): (a) late Elster or Mindel II (?late Kansan) gravels at Bad Frankenhausen, Germany - the type locality; (b) sands of Mindel I (?late Kansan) age at Mosbach, Germany.

I agree with Sher (1971, p. 216) that the cranium from this locality, the type of "*Praeovibos schmidtgeni*", lies within the range of variation of *Praeovibos priscus*; (c) sands suggested to be of "Early Middle Pleistocene" age at Bielszowice, Poland; (d) the lowermost layers of Pocket 718 of ?late Mindel I (?early Kansan) age at Koneprusy, Czechoslovakia; (e) a bone-breccia suggested to be of "Early Middle Pleistocene" age at Stranska skala near Brno, Czechoslovakia; (f) possibly the Cromer Forest Bed at Trimingham, England; (g) probably the Cromer Forest Bed at Walcot, England; (h) the Cromer Forest Bed at Eccles, England. The last three fossils are from Cromerian deposits (in the broad sense; see Bishop 1974, p. 312), and I suggest they are from the Beestonian cold phase deposits within the Cromer series (West 1968, pp. 246-249). Hopefully, *Praeovibos* specimens will be found *in situ* in beds along the Norfolk coast in the future. Heavy storm waves used to cause much coastal erosion, promoting the study of early middle Pleistocene vertebrate remains washed out of the high bluffs. Now coastal conservation measures, including extensive breakwaters, allow the faces of the bluffs to slump and become consolidated by vegetation, ironically resulting in a dearth of new paleontological knowledge.

Praeovibos probably originated in northern Eurasia, and may have shared ancestors with *Symbos*. *Praeovibos priscus* spread westward to Poland,Czechoslovakia, and Germany during the Mindel (?Kansan). I suggest the species reached England about that time, crossing a broadened isthmus from France and the Netherlands under periglacial environmental conditions (Flint 1971, p. 774). Staudinger's muskox also spread eastward to the Kolyma Lowland during the Mindel (?Kansan). *Praeovibos beringiensis*, with its distinctly *Ovibos*-like horncores and broad frontal region, seems to be transitional between *Praeovibos priscus* and *Ovibos moschatus*. I suggest that the transition occurred in northern Siberia during the late Mindel (?late Kansan), and doubt that *Ovibos* specimens at Süssenborn are as early as Mindel in age. In this respect, Sher (1971, p. 225) states: "It should also be mentioned that Süssenborn is a site with several horizons of different age... It is not ruled out that the *Ovibos* skull and metacarpals came from horizons of different age in the Süssenborn section." *Praeovibos priscus* may have crossed the Bering Isthmus during the Kansan glaciation, reaching central Alaska and the northwestern Yukon Territory, but Péwé (1975a, p. 95) considers it most likely that all Alaskan fossils are derived from sediments of the following (Illinoian) glaciation. I suggest that the Yukon fossils may be as old as Kansan or as young as Illinoian. *Praeovibos* specimens appear to be indicators of middle Pleistocene deposits.

It is difficult to understand why *Praeovibos* did not reach southern North America. Perhaps *Symbos cavifrons* (which burgeoned then and was evidently well adapted to steppe or parkland habitat) resulted in its exclusion by being more finely attuned to the warmer habitat farther south. In Eastern Beringia, a reason must be found for its apparent extinction at the close of the Illinoian glaciation. Was it a result of *Praeovibos* giving way to its better-adapted offshoot the tundra muskox *Ovibos moschatus*?

Compared to the tundra muskox, Staudinger's muskox, like *Symbos cavifrons*, was taller and more slenderly built, with a long snout. Its tubular orbits may indicate the presence of a thick coat (see the previous section on *Symbos cavifrons*), suggesting cold-adaptation. Paleoenvironmental evidence supports that suggestion. *Praeovibos priscus* remains have been found in periglacial sediments in Germany, and the species evidently lived under tundra-like conditions in northeastern Siberia. In central Alaska the species seems to have thrived in a cool, loess-steppe environment. Rootlet impressions are seen on the nasals of the type specimen of *Praeovibos beringiensis* (Sher 1971, Plate 20); I suggest they indicate that the animal died in grassland surroundings. The rather high, narrow hornbases, which lie to the sides of the frontals, suggest to me that Staudinger's muskoxen were not well adapted for butting, and possibly not so sophisticated in herd interactions and co-operation as are the living tundra muskoxen - or perhaps as were the helmeted muskoxen *(Symbos cavifrons)*. Probably *Praeovibos priscus* was mainly a grazer, but it may have browsed extensively. Wolves were probably its main predator. *Canis lupus mosbachensis* was a member of several faunas that included Staudinger's muskox (Kahlke 1973). Cave lions and American lions may also have preyed on this species.

Ovibos moschatus (tundra muskox)

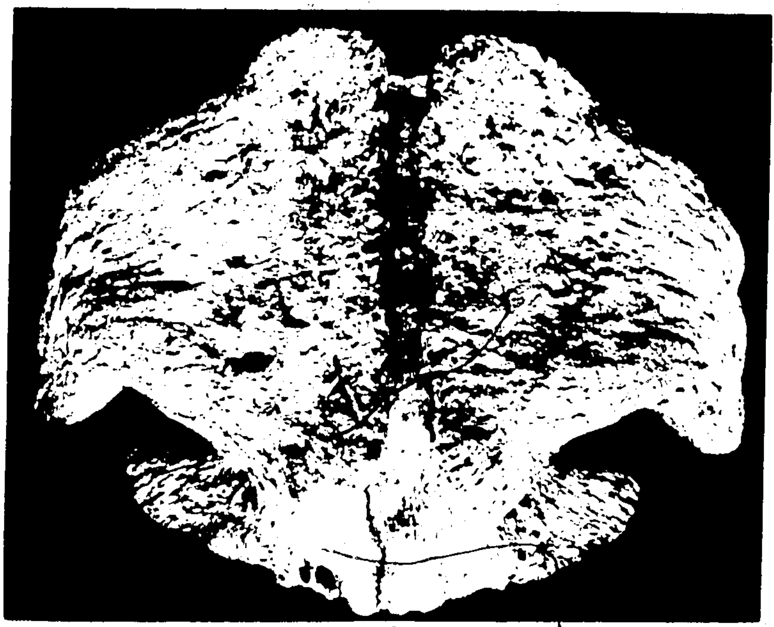
Eleven cranial fragments (one from Camden Bay, Alaska) and six complete metapodials (one from Norton Sound, Alaska) of the tundra muskox are described (Figures 90A-C, Tables 102-103). Approximately 40 cheek teeth (mainly from Old Crow Localities 29, 66, 11A and 14), vertebrae and fragments of limb bones representing *Ovibos moschatus* are also in the collection of Yukon Pleistocene mammals. *Ovibos* fossils are of particular

Figure 90. Posterior cranial fragment with horncores (NMC 17678, Herschel Island Locality 3) of a Pleistocene tundra muskox *(Ovibos moschatus)*.

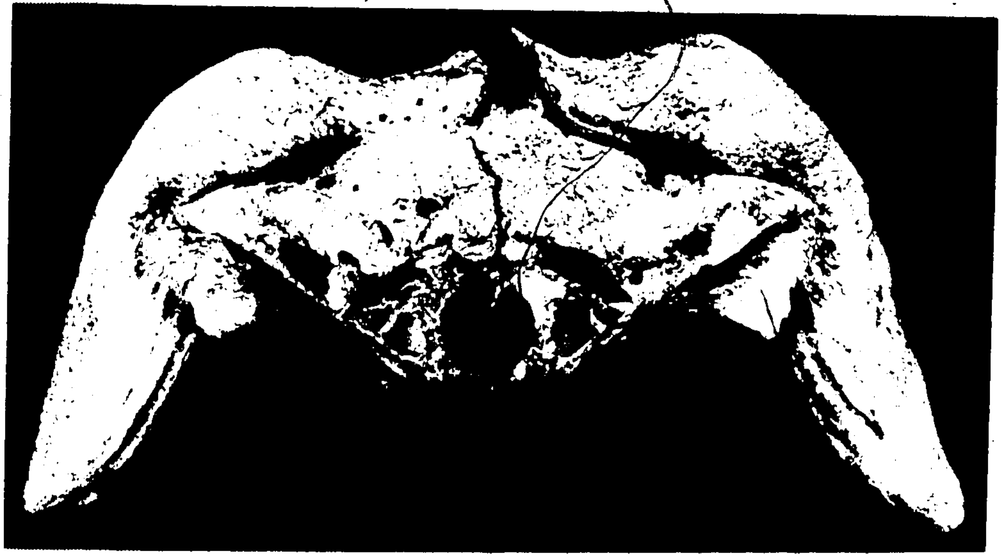
A. Dorsal view (anterior to bottom).

B. Anterior view.

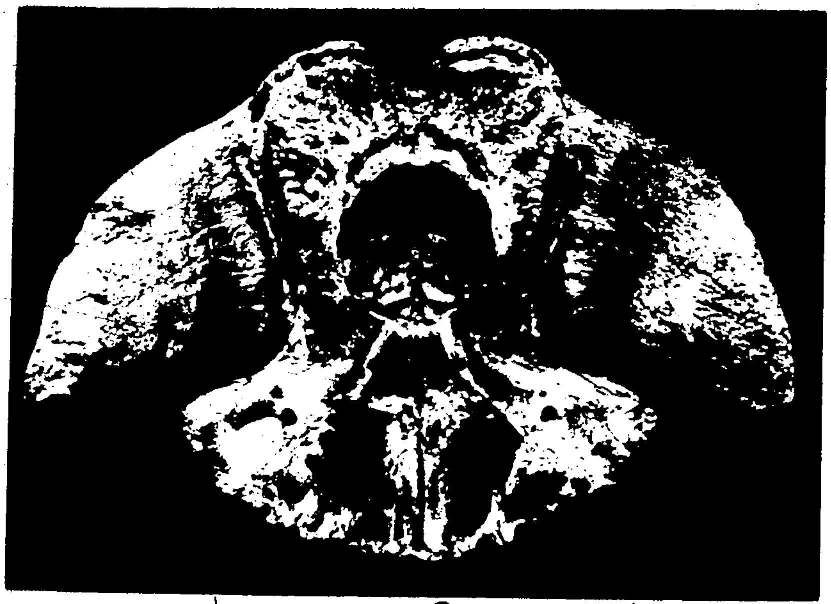
C. Ventral view (anterior to bottom).



A



B



C

Table 102. Measurements of Pleistocene tundra muskox *(Ovibos moschatus)* crania from the Yukon Territory and Alaska compared to thos *Ovibos moschatus* from North America.

Specimens	Measurements (mm)*												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Ovibos moschatus. Pleistocene, Y.T., Alaska													
Males													
NMC 15267 Old Crow Loc. 22	158.5	56.0	-	-	-	-	140.9	100.0	80.1	99.5	30.3	32.0	101.
F:AM 34609 Dominion Ck. (Dawson Area)	210.0	-	-	-	168.4	-	151.4	-	81.8	112.7	29.9	29.9	[illegible]
NMC 17678 Herschel Loc. 3**	225.9	84.0	183.0	305.0	143.7	352.0	147.5	-	-	-	-	-	-
NMC 18034 Old Crow Loc. 11a	173.0	71.7	-	-	143.3	-	124.0	-	-	-	-	-	-
NMC 28200 Old Crow Loc. 131	-	-	-	-	-	-	-	-	87.3	111.4	26.5	29.2	130.
NMC 20477 Old Crow Loc. 20	-	-	-	-	-	-	-	-	-	-	32.9	30.0	112.
NMC 2460 Camden Bay, Alaska	173.1	66.6	122.0	242.0	150.8	217.3	129.9	115.9	76.7	99.2	30.1	31.8a	117.
Females													
OCR 1175-1-9 Old Crow Basin	82.5	47.4	96.0	197.0	107.2	230.6	100.9	86.7	80.7	105.5	28.9	36.8	122.
NMC 14707 Old Crow Loc. 28	62.9	43.3	-	-	-	-	-	-	-	-	-	-	-
NMC 20601 Old Crow Loc. 20	64.5e	39.5$^+$	-	-	104.0e	-	-	-	-	-	-	-	-
Ovibos moschatus. Recent, N. America													
Males													
NMC uncataloged (from mounted skeleton)	192.0	72.4	162.0	280.0	134.4	297.7	133.1	106.2	77.8	103.5	27.3	30.8	107.
NMC 23320 Prince of Wales I., N.W.T.	204.7	64.4e	165.0	270.0	157.9	267.6	134.6	108.1	75.5	103.9	33.3	34.0	112.
NMC 23297 Prince of Wales I., N.W.T.	192.1	75.2	-	-	151.2	-	133.4	107.8	84.0	110.0	36.4	37.9	120.
NMC uncataloged Lookout Pt., N.W.T.	191.2	81.0	144.0	270.0	132.1	288.7	127.5	116.8	83.7	109.9	27.7	29.4	111.
NMC 34437 Beverly L., N.W.T.	184.8	68.9	-	-	144.6	-	134.2	116.1	75.4	103.0	30.0	31.7	110.
NMC 34438 Thelon L., N.W.T.	190.8	72.2	-	-	145.1	-	140.5	130.0	81.7	109.8	27.7	25.5	-
NMC 36295 Ellef Ringnes I., N.W.T.	198.7	68.6a	151.0	260.0	143.9	-	123.6	96.8	81.5	104.0	30.2	28.9	110.
NMC uncataloged Falcon Ck., N.W.T.	198.9	70.3e	167.0	268.0	135.3	-	130.2	111.1	82.7	108.9	28.1	32.9	-
NMC 23322 Prince of Wales I., N.W.T.	174.3	64.2a	150.0	270.0	154.9	-	121.4	103.2	80.1	103.9	29.6	30.6	120.
Females													
NMC 26478 N.W.T.	62.0a	-	-	-	122.8	-	106.4	116.2	79.6	102.9	24.3	30.6	100.
NMC 22059 Prince Patrick I., N.W.T.	51.0a	-	-	-	124.4	-	93.3	82.0e	74.2	101.2	33.4	40.7	112.4

* 1 - Anteroposterior diameter of horncore at base (maximum).
2 - Dorsoventral diameter of horncore on lower curve (ridge to tip).
3 - Length of horncore on lower curve (ridge to tip).
4 - Length of horncore on upper curve (middle of horncore base to tip).
5 - Width of cranium at constriction between horncores and orbits.
6 - Minimum width between horncore tips.
7 - Width of cranium at constriction above nuchal crest.
8 - Height from dorsal margin of foramen magnum to mid-line on dorsal surface of cranium.
9 - Height from dorsal margin of foramen magnum to top of nuchal crest.
10 - Height from ventral margin of foramen magnum to top of nuchal crest.
11 - Height of foramen magnum.
12 - Width of foramen magnum.
13 - Minimum width across occipital condyles.
14 - Maximum width of cranium above auditory meatus.
15 - Basioccipital width (across posterolateral margins).

**Tentatively referred to *Ovibos moschatus*.

of Pleistocene tundra muskox *(Ovibos moschatus)* crania from the Yukon Territory and Alaska compared to those of Recent
tus from North America.

	Measurements (mm)*														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ene, Y.T., Alaska															
2	158.5	56.0	-	-	-	-	140.9	100.0	80.1	99.5	30.3	32.0	101.6	181.8	64.9
(Dawson Area)	210.0	-	-	-	168.4	-	151.4	-	81.8	112.7	29.9	29.9	-	201.6	74.6
3**	225.9	84.0	183.0	305.0	143.7	352.0	147.5	-	-	-	-	-	-	-	-
1a	173.0	71.7	-	-	143.3	-	124.0	-	-	-	-	-	-	-	-
31	-	-	-	-	-	-	-	-	87.3	111.4	26.5	29.2	130.0	-	72.6
0	-	-	-	-	-	-	-	-	-	-	32.9	30.0	112.0a	-	63.7
ska	173.1	66.6	122.0	242.0	150.8	217.3	129.9	115.9	76.7	99.2	30.1	31.8a	117.1	172.7†	66.6
sin	82.5	47.4	96.0	197.0	107.2	230.6	100.9	86.7	80.7	105.5	28.9	36.8	122.0e	160.0	55.4
28	62.9	43.3	-	-	-	-	-	-	-	-	-	-	-	-	-
20	64.5e	39.5†	-	-	104.0e	-	-	-	-	-	-	-	-	-	-
N. America															
nted skel on)	192.0	72.4	162.0	280.0	134.4	297.7	133.1	106.2	77.8	103.5	27.3	30.8	107.5	180.7	-
I., N.W.T.	204.7	64.4e	165.0	270.0	157.9	267.6	134.6	108.1	75.5	103.9	33.3	34.0	112.7	188.8	72.2
I., N.W.T.	192.1	75.2	-	-	151.2	-	133.4	107.8	84.0	110.0	36.4	37.9	120.2	186.3	71.2
t., N.W.T.	191.2	81.0	144.0	270.0	132.1	288.7	127.5	116.8	83.7	109.9	27.7	29.4	111.2	172.1	62.1
.T.	184.8	68.9	-	-	144.6	-	134.2	116.1	75.4	103.0	30.0	31.7	110.0	186.0	66.2
T.	190.8	72.2	-	-	145.1	-	140.5	130.0	81.7	109.8	27.7	25.5	-	186.7†	61.4
., N.W.T.	198.7	68.6a	151.0	260.0	143.9	-	123.6	96.8	81.5	104.0	30.2	28.9	110.0	175.5	68.5
., N.W.T.	198.9	70.3e	167.0	268.0	135.3	-	130.2	111.1	82.7	108.9	28.1	32.9	-	184.8	63.3
I., N.W.T.	174.3	64.2a	150.0	270.0	154.9	-	121.4	103.2	80.1	103.9	29.6	30.6	120.3	174.2	63.9
	62.0a	-	-	-	122.8	-	106.4	116.2	79.6	102.9	24.3	30.6	100.2	148.6	55.3
I., N.W.T.	51.0a	-	-	-	124.4	-	98.3	82.0e	74.2	101.2	33.4	40.7	112.4	147.6	57.5

meter of horncore at base (maximum).

er of horncore on lower curve (ridge to tip).

on lower curve (ridge to tip).

on upper curve (middle of horncore base to tip).

constriction between horncores and orbits.

en horncore tips.

constriction above nuchal crest.

nargin of foramen magnum to mid-line on dorsal surface of cranium.

nargin of foramen magnum to top of nuchal crest.

margin of foramen magnum to top of nuchal crest.

gnum.

num.

occipital condyles.

nium above auditory meatus.

(across posterolateral margins).

Ovibos moschatus.

Table 103. Measurements of Pleistocene tundra muskox (*Ovibos moschatus*) metapodials from the Yukon Territory and Alaska compared to those of Recent *Ovibos moschatus* from North America and Greenland.

Specimens	Measurements (mm)*						
	1	2	3	4	5	6	7
Metacarpals							
Ovibos moschatus.							
Pleistocene, Y.T.							
NMC 13592 Old Crow Loc. 11A	169.8	54.1	33.0	37.5	20.5	68.2	33.1
NMC 23579 Old Crow Loc. 11A	170.0	55.6	35.3	41.4	21.8	65.7	34.8
NMC 29186 Sixtymile Loc. 3	162.8	55.1	34.5	37.4	21.1	65.8	33.8
Ovibos moschatus.							
Pleistocene, Alaska							
NMC 6758 Norton Sound	169.6	57.3	37.9	42.8	24.3	67.4	34.4
Ovibos moschatus.							
Recent, N. America, Greenland							
NMC uncataloged Canada	178.6a	54.6	35.5	36.6	21.3	[illegible]	3a
ZIN 8690 Canada (Sher 1971, Table 36)**	149.4	49.7	31.2	31.4a	17.3a	57.[illegible]	31.0
ZIN 27296 Greenland (Sher 1971, Table 36)**	154.0	56.0	37.1	37.0a	20.7a	65.0	34.4
Metatarsals							
Ovibos moschatus.							
Pleistocene, Y.T.							
NMC 29185 Sixtymile Loc. 3	194.3	48.0	43.8	32.7	28.0	63.7	35.4
NMC 22505 Old Crow Loc. 45	185.8	43.5	37.4	30.2	23.3	55.5	33.2
Ovibos moschatus.							
Recent, N. America, Greenland							
NMC 33549 Canada	180.0	46.5	41.5	29.6	25.1	58.2	34.4
NMC uncataloged Canada	188.0a	45.6	40.6	27.7	26.3	58.6	35.5a
ZIN 8690 Canada (Sher 1971, Table 39)**	156.0	39.8	37.0	23.0a	23.0a	51.0	29.5
ZIN 27296 Greenland (Sher 1971, Table 39)**	163.0	45.0	43.0	28.0a	24.0a	56.5	32.0

* 1 - Total length.
2 - Proximal width.
3 - Proximal depth.
4 - Midshaft width.
5 - Midshaft depth.
6 - Distal width.
7 - Distal depth.

**Sher seems to have measured total length from the main proximal articular surface, rather than on the most proximal projection of the metapodial, as I have done.

interest and importance because they are reliable indicators of tundra-like, or more rarely, cold loess-steppe environments.

Referred specimens

The following specimens are referred to adult males. NMC 15267 from Old Crow Locality 22 consists of a badly damaged posterior cranial fragment. Only stubs of the horncores are preserved, bone is lacking anterior to the horncore bases, and a large part of the upper occipital region, including the posterior part of the left horncore base, is missing. The basioccipital area is intact. The fossil is readily referred to an adult male of *Ovibos moschatus*, for large horncore bases cover most of the upper surface of the braincase, leaving a narrow median groove between them. The specimen is stained dark reddish brown. F:AM 34609, a large cranium with partial horncores of *Ovibos moschatus*, was collected at Dominion Creek in the Dawson Area in 1948. I am grateful to M.C. McKenna and M.F. Skinner for allowing me to examine and measure the specimen, which is preserved in the Frick Collection at the American Museum of Natural History in New York.

NMC 17678 from Herschel Island Locality 3 is the upper half of a posterior cranial fragment with complete, massive horncore bases. Bone is lacking anterior to the orbits. Heavily eroded upper parts of the orbits are preserved. The median groove between the horncore bases is deep. The specimen can be referred with confidence to *Ovibos*, but the massiveness of the horncores and the great spread between their tips are not typical of most male *Ovibos moschatus* crania I have seen. Therefore, NMC 17678 is only tentatively referred to *Ovibos moschatus*. The dark staining of the fossil suggests a pre- late Wisconsin age. V. Stefannson (Allen 1913, pp. 720-721) and R.M. Anderson (Allen 1913, pp. 186-187) mention that a skull of *Ovibos moschatus* was found on Herschel Island in 1908. Through the courtesy of K. Djukastein, a miner in the Dawson Area, I have been able to examine, measure, and sample for radiocarbon analysis an upper, posterior cranial fragment from Brewer Locality 1. Most of the right horncore and the stub of the left horncore are preserved, in addition to the upper parts of both orbits. The dorsal surfaces of the horncore bases are stream eroded. NMC 18034 from Old Crow Locality 11A is the upper half of a posterior cranial fragment. Most of the bone anterior to the horncore bases is lacking. The median groove between the horncore bases is slightly concave anteroposteriorly, and pitted centrally. The bone is stained rusty brown. NMC 2460 was collected from a "black earth sea cliff" on Camden Bay (10 miles (16 km) east of

Collinson Point) by E. de K. Leffingwell in 1914. It consists of the posterior part of a cranium with complete horncores. Bone is lacking anterior to the orbits (of which only the posterior margins are preserved). The lateral margins of the occipital region and the occipital condyles are eroded. The large horncore bases and the high degree of suture fusion indicate that the fossil represents a male in late adulthood. NMC 2460 is stained dark brown. NMC 28200 from Old Crow Locality 131 consists of the occipital and basioccipital parts of a cranium. The lateral margins of the occiput are strongly eroded. The great breadth of the basioccipital suggests that an adult male is represented (Harington 1964, p. 85). NMC 20477 from Old Crow Locality 20 is a heavily eroded posterior cranial fragment comprising part of the ventral half of the occiput, the basioccipital and portions of the pterygoid crest. The surface of the fossil is oxidized, being stained orange brown. The large basioccipital breadth suggests that a male is represented. The morphological features of the basioccipital (e.g. the shield shape, with the posterior channel becoming a ridge centrally and a channel again at the anterior end) match those of *Ovibos moschatus*.

The following specimens are referred to adult females. OCR 1175-1-9 from an unknown locality in the Old Crow Basin is a posterior cranial fragment with complete horncores. Bone anterior to the orbits, and in the region of the right occipital condyle is lacking. The relatively well developed horncore bases compared to Recent females of tundra muskoxen, the pronounced grooves paralleling the length of the horncores, and the obliteration of the frontal suture indicate that the fossil represents an extremely old female. In every morphological detail preserved, OCR 1175-1-9 corresponds to the same part of a modern female tundra muskox skull (e.g. NMC 26478). However, the width of the cranium between horncore and orbit seems unusually small (Table 102). Sex is readily determined by the wide (27 mm) space between the horncor ases (typical of females) compared to the narrow median grooves that separate the more massive horncore bases of adult male tundra muskoxen. The anteroposterior narrowness of the horncores compared to those of male tundra muskoxen, and the narrowness of the basioccipital also suggest that the specimen represents a female. The bone is stained brown.

NMC 14703 from Old Crow Locality 28 is a left horncore fragment attached to part of the braincase. The distal half of the horncore, and part of its posterior edge, are missing. The shape of the horncore base and the broad space that obviously existed between horncore bases indicate clearly that the fossil was derived from a female. The horncore base is smaller than that of OCR-1175-1-9, so NMC 14703 may represent a younger adult female. The bone is stained brown. NMC 20601 from Old Crow Locality 20 consists of three-quarters of a heavily abraded and weathered left horncore attached to the left half of the braincase. The surface of the specimen is oxidized.

Despite a few fundamental differences, the striking similarity of females of *Ovibos moschatus* to males of *Praeovibos priscus* is evident when the fossils are studied in sequence, prompting the thought that females among the low-horned muskoxen such as *Ovibos* and *Symbos* may be closer in appearance to their ancestors than the males, whose massive hornbases are exaggerated secondary sexual characteristics.

Three complete metacarpals from the Yukon and one from Alaska are referred to *Ovibos moschatus*. NMC 13592 from Old Crow Locality 11A is a left metacarpal. NMC 23579 from the same locality is a right metacarpal. Both are stained brown, and compare well with Recent tundra muskox metacarpals. NMC 29186 from Sixtymile Locality 3 is a complete right metacarpal. It is slightly smaller than the others. The bone is pale tan and has a fresh appearance. I suggest it is of late Wisconsin age. NMC 6758, a right metacarpal from Norton Sound, Alaska, is included for comparative purposes. It is similar in size to NMC 23579 from Old Crow Locality 11A. It is stained dark brown and, like NMC 13592 and 23579, is presumably older than late Wisconsin.

Two complete metatarsals are referred to *Ovibos moschatus*. The larger, NMC 29185 from Sixtymile Locality 3, is pale buff and fresh in appearance. It is probably of late Wisconsin age. NMC 22505 from Old Crow Locality 45 is smaller. It is stained dark brown and is probably pre- late Wisconsin in age.

Discussion

Tundra muskox fossils are widespread in the Yukon Territory, having been found in the Stewart River (Brewer Creek), Dawson, Sixtymile, Old Crow and Herschel areas. According to their dark staining, I suggest that most of the Yukon tundra muskox fossils are of pre- late Wisconsin age. NMC 16155, an unworn ovibovine LM^2 from Unit 2 at Old Crow Locality 44 probably represents

Ovibos moschatus. If so, it indicates that tundra muskoxen occupied the Old Crow Basin more than 54,000 years ago. The fresh looking metapodials from Sixtymile Locality 3 are probably of late Wisconsin age (Harington 1976 MS., pp. 63-64). Unspecified "muskox" (presumably *Ovibos moschatus*) bones from the upper part of humic sands at Engigstciak near the mouth of Firth River, may be about 3,250 years old (Mackay *et al.* 1961, p. 34). The cranial fragment from Brewer Creek indicates that tundra muskoxen lived south of the Dawson Area as late as approximately 2,800 years ago. The species no longer occurs naturally in the Yukon, but in July 1969 two muskoxen were sighted near King Point on the Yukon coast. They came from a "seed" herd introduced from Nunivak Island to the arctic coast of Alaska opposite Barter Island in April 1969 (Youngman 1975, pp. 169-170).

In other parts of Canada, mainly skull fragments of *Ovibos moschatus* have been recorded from: Ontario (eastern Toronto - the type of "*Ovibos proximus*" (Ber[illegible]ey 1913), now considered to be a junior synonym of *Ovibos moschatus* (Harington 1970b, p. 3); northwestern Toronto, [illegible]bar deposits of probable late Wisconsin age); [illegible]itoba ([illegible] [illegible]ew - a cranial fragment radiocarbon dated at 8,6[illegible]90 years B.P. (I-1623) (Harington 1970b));

Alberta (Ponoka, Edmonton, Cold Lake); and the Northwest Territories (Bernard River, Banks Island - a metacarpal fragment radiocarbon dated at >34,000 years B.P. (S-288) (Maher 1968, p. 261); Thesiger Bay, Banks Island - a pelvic bone from peat radiocarbon dated at 10,660 ± 170 years B.P. (GSC-240); near Alert, Ellesmere Island, from raised beaches probably of early postglacial age).

In the conterminous United States, approximately 12 cranial fragments of *Ovibos* are known from Illinois, Indiana, Iowa, Minnesota, Montana, Nebraska, New York, Ohio, South Dakota, and possibly West Virginia. Probably most specimens are of Wisconsin age; however, fossils from near Morrill, Nebraska, and Jinks Hollow, Illinois may be of pre- Wisconsin age (C.E. Ray, personal communication 1966).

Approximately 70 *Ovibos moschatus* specimens, mainly cranial fragments, are known from Alaskan Pleistocene deposits. The geologically oldest fossils consist of part of a skull from outwash gravels of Illinoian age near Nome in western Alaska, and two specimens from loess at Cripple Creek sump near Fairbanks, which T.L. Péwé considers to be of Illinoian age (Harington 1970c, p. 1329). Some of the specimens from Gold Hill may be of similar age. I am grateful to M.C. McKenna and M.F. Skinner of the American Museum of Natural History for allowing me to examine and measure *Ovibos* crania from the Fairbanks area, which comprise most of the fossils. The sites, in descending order of productivity of skull fragments, are: Cripple Creek (21), Engineer Creek (14), Fairbanks Creek (7), Gold Hill (6), Lower Goldstream Creek (5), Little Eldorado Creek (3), Dawson Cut (2), Cleary Creek (2), Dome Creek (1), Fox Creek (1). Other cranial fragments in the Frick Collection at the American Museum of Natural History are from: Elephant Point (Eschscholtz Bay) (3), Inmachuk River (Seward Peninsula) (2), Candle Creek (Eschscholtz Bay) (1), Fish Creek (1), Colville River (1). Additional specimens are known from the Kaolak River, Ikpikpuk River, and Camden Bay (NMC 2460).

Remains of *Ovibos moschatus* are widespread in northern Eurasia (Gromova 1935; Harington 1961, pp. 436-457, Figure 24). For reasons stated previously, I am not convinced that the tundra muskox occupied Europe as early as Mindel I (?early Kansan) (Kahlke 1964, p. 3): better evidence is required to demonstrate that the *Ovibos* material recovered at Süssenborn and Obergünzberg was not derived from units stratigraphically higher and more recent than those of Mindel (?Kansan) age. I suggest that there is evidence of a transition from *Praeovibos priscus* via *Praeovibos beringiensis* to *Ovibos* sp. toward the close of the

Mindel (?Kansan) glaciation in northern Siberia (e.g. Olyor Suite). A large cranium with heavy, high-rising horncore bases, with exostoses, but without the usual fossae may date to the end of the transition period. It was collected on the Upper Ob River (Sher 1971, p. 227). A well preserved skull from Rublevo south of Moscow is larger than late Pleistocene tundra muskoxen, and differs from them in proportions. The animal represented by this fossil probably lived near the edge of the advancing Dniepr ice (Saale = Illinoian (Flint 1971, p. 629)). NMC 17678 from Herschel Island, Yukon Territory, with its massive horncore bases and relatively large spread from tip to tip of the horncores, may have affinities with the Upper Ob and Rublevo fossils. Evidently the first major dispersal of tundra muskoxen occurred during the early Riss (early Illinoian) glaciation. *Ovibos moschatus* is not recorded in any of the major Siberian Pleistocene mammal faunas prior to Riss (Illinoian) time. The species is a member of the late Pleistocene (Illinoian to Wisconsin?) fauna from Bolshoi Lyakhov Island (Vangengeim 1961), and tundra muskox remains are known from the early Wisconsin Iedoma Suite in the Kolyma Lowland (Sher 1971),—and from late Pleistocene (?Wisconsin) deposits at Proliv Dmitriya Lapteva (Vereshchagin 1974). Vangengeim (1961, p. 145) remarks that the first appearance of the muskox in northeastern Siberia was during "the first stages of the maximal {Illinoian} glaciation," and that it was very common in Siberia from that time until the early postglacial.

Andrée (1933) discusses an interesting sample of European *Ovibos moschatus* remains. Of 28 tundra muskox occurrences in Germany, eight specimens are from Saale (Illinoian) deposits and 15 are from Weichsel (Wisconsin) sediments – presumably the remainder could not be dated stratigraphically. Soergel's (1942, p. 79) important study of the distribution of Pleistocene tundra muskoxen in Europe led him to conclude that "the deposits in which remnants of muskoxen are found show that they were common over central Europe only during glacial periods..." Evidence (E. Alendal, personal communication 1976; Heintz 1962, p. 208; Heintz and Garutt 1965, p. 78) indicates that muskoxen and woolly mammoths migrated to Scandinvaia during the interglacials of the late Pleistocene. Reynolds (1934, p. 10) notes that *Ovibos moschatus* occurred in various parts of Europe in Mousterian deposits of early Weichsel (early Wisconsin) age, but states, "It is not until late Palaeolithic (Magdelenian) times, when the tundra animals both in Europe and N. America spread far to the south, that *Ovibos* became a really characteristic member of the fauna." The southern limits of *Ovibos moschatus* in Eurasia, from west to east are: Dordogne, France; Lake Constance, Switzerland; Hungary (46°N); Kostienki (Don River, 51°N), and Lake Baikal, U.S.S.R. (Harington 1961, p. 150).

Prior to summarizing the dispersal history of *Ovibos moschatus*, I wish to comment generally on the origins of muskoxen and their evolutionary history. In 1961, I (Harington 1961, pp. 97-99) proposed an "Ontogenetic - Phylogenetic" hypothesis in an attempt to explain various stages in the evolutionary history of the muskoxen (Tribe Ovibovini). According to this hypothesis, the earliest muskoxen would have had high, small horns (like the "spikes" of young *Ovibos moschatus*) later evolved muskoxen would have had horns lying near the frontal plane (like those of 18-months-old *Ovibos moschatus*), and the most "advanced" forms would have large horns that drop tightly near the cheek bones (like those of adult *Ovibos moschatus*). Other trends in the course of evolution of the muskoxen were considered to be: (a) increasing body size; (b) increasing orbital protrusion and specialization (Harington 1961, pp. 100-102). The increasing degree of orbital projection is particularly noticeable in the later lowland muskoxen, such as *Symbos cavifrons*, *Praeovibos priscus*, and *Ovibos moschatus*. Evidently it occurred when muskoxen were adapting to colder environments. As mentioned previously, tubular orbits allow for development of thick insulating hair on the head, while maintaining a suitable field of vision. Thus, they promote cold survival and survival by retaining the ability to detect predators readily.

I advance for consideration the suggestion that the Ovibovini be divided into two subtribal taxa: (a) the "alticornis" group, including those genera with horncores lying mainly in the frontal plane, or rising above it (e.g. *Boöpsis*, *Euceratherium* (including *Preptoceras*), *Soergelia*, tentatively *Budorcas*, and possibly some more primitive genera ("stem muskoxen") as yet not clearly recognized as belonging to the Ovibovini); (b) the "depressicornis" group, including those genera with horncores mainly lying below the frontal plane (e.g. *Symbos* (probably including *Boötherium sargenti*), *Parovibos*, *Praeovibos* and *Ovibos*). Such a division may be useful in separating fossils of genera that probably arose during the Pliocene and early Pleistocene (Nebraskan), from those which may have arisen during the Kansan - Illinoian period. Excepting *Soergelia*, this division also seems to be useful in separating upland ("alticornis") muskoxen from lowland-adapted ("depressicornis") muskoxen.

Among a group of Eurasian lower Pliocene bovids (or "stem muskoxen") that have some affinities with later muskoxen are *Plesiaddax*, *Urmiatherium* and *Parurmiatherium*. Perhaps it was from an animal belonging to this basic upland stock with rather small, very high horns that the "alticornis" group arose. I suspect that *Budorcas taxicolor*, the takin, which presently survives in a zone extending from subalpine meadows to ground just above the tree-line in southeastern Asia, is an early offshoot of the "stem muskoxen". Evidently it is adapted to life in mountainous or hilly terrain, which may have been typical of early muskoxen, and it survives near the original dispersal centre of the Ovibovini in central Asia. Its horns are relatively high, but twist back near the tips rather than forward as in most muskoxen. *Budorcas* is very much like *Ovibos* in general body structure, and it is tentatively included in the Ovibovini. It is important that comparative serological and chromosome studies (Tietz and Teal 1967, p. 236; Heck *et al*. 1967, p. 178) be carried out on *Budorcas*, so that its relationship with *Ovibos* may be clarified.

Boöpsis, which first occurs in the fossil record in lower Pleistocene sediments (Choukoutien, Locality 9, China), seems to be closer to the phylogenetic line leading to *Ovibos* than is *Budorcas*. So far, *Boöpsis* is only known from two localities in northeastern China. Probably it diverged from the same stock as *Euceratherium* (including *Preptoceras*) during the Nebraskan glaciation. *Soergelia* also seems to have arisen from this stock. All have horncores on pedicels. The horncores spread laterally, bend forward and rise toward the tips, and generally lie near to or above the frontal plane. The relationships among these three genera deserve careful study. I (Harington 1961, p. 59) have previously noted the many similarities between *Boöpsis* and *Euceratherium*, but was unable to obtain a cast of *Boöpsis* from China – a necessity for meaningful comparisons. *Boöpsis* evidently became extinct toward the close of the early Pleistocene (?Nebraskan), while its close relative *Euceratherium* presumably moved into North America across the Bering Isthmus during the following Kansan glaciation, quickly spreading southward through the northern Cordillera and reaching California (Irvington) by late Kansan time. *Euceratherium*, like *Budorcas* and possibly *Boöpsis*, was probably adapted to subalpine life, and seems to have partly filled the environmental niche now occupied by North American mountain sheep. *Euceratherium*, which ranged as far south as Mexico, survived in the southern Cordillera of North America until Wisconsin time.

Soergelia appears to be the earliest known muskox adapted to lowland conditions. It may have originated toward the close of the Nebraskan time, dispersing rapidly from northern Asia westward into Europe and eastward across the Bering Isth[illegible]outhern North America (Texas) during the Kans[illegible]ation. It seems to have been confined to Kans[illegible]ime; therefore, it is probably a good Holarctic index fossil for that glacial phase in which muskoxen burgeoned and dispersed widely on the expanding steppe grasslands and tundra. I (Harington 1961, p. 129) have suggested that increasing competition from more specialized muskoxen, such as *Praeovibos* in Eurasia and *Symbos* in North America, may have resulted in its extinction.

The affinities and systematic position of *Bootherium bombifrons* are perplexing. To my knowledge no other specimen like the holotype from Big Bone Lick, Kentucky has been found. The species seems to be most closely related to *Soergelia* among known muskoxen. I base this observation on the well-developed longitudinally-grooved, horncore burrs and pedicels, the long, pronounced downslope on the upper surface of the cranium posterior to the horncores, and the smallness of the skull relative to *Symbos* and *Ovibos*. The major difference is in the low position of the horncores. According to Allen (1913, p. 210) the sutures are fused as in an adult, so presumably it cannot represent a muskox in an early stage of horncore development (e.g. a 3-year-old *Ovibos moschatus* (Allen 1913, Figure 10)), which otherwise would seem most likely.

Symbos, possibly the closely associated genus *Parovibos* (= the type of *"Ovibos recticornis"*), and *Praeovibos* seem to have diverged from the same ancestors as *Soergelia* in early Kansan time. Their horns were bent below the frontal plane, their orbits projected more than those of earlier muskoxen, and they were larger (particularly taller and more slender in the body) than *Soergelia*. Possibly co-operative herd interactions were not so well developed in *Praeovibos* as in *Symbos*, for reasons mentioned previously, which may account for its relatively short life in Eurasia.

Symbos had horncores lying mainly below the frontal plane, but higher than those of *Praeovibos*. It also had less tubular orbits, suggesting that it may have diverged from its *Soergelia*-like ancestors before *Praeovibos* — probably about Kansan time. Possibly *Parovibos recticornis* from "middle Pleistocene" deposits of Radotin, Czechoslovakia represents this type of muskox in Europe. This case deserves careful investigation.

The basioccipital of *Symbos* is wedge-shaped and "channeled" like that of *Soergelia*, rather than being shield-shaped and "ridged" centrally as in *Praeovibos* and *Ovibos*. Like *Praeovibos* and unlike *Ovibos*, *Symbos* had a long muzzle and was relatively tall and slender. There was a parallelism between *Symbos* and *Ovibos* males in the massive concrescence of their horncore bases, which perhaps coincided with a more sophisticated type of group organization. *Symbos* may have differentiated in Asia, reaching Alaska via the Bering Isthmus in early Illinoian time and quickly penetrating to favorable steppe or parkland habitat in south - central North America. It was able to move easily through mountainous country, and survived until the close of the Wisconsin glaciation in North America. Restriction of its natural habitat and the incursions of bison adapted to moister woodland (e.g. the western bison, *Bison bison occidentalis*) conditions may have contributed to its extinction.

There is no doubt that *Praeovibos* was well adapted to tundra-like conditions. Like *Soergelia* it radiated from northern Asia in Kansan time, spreading westward to Europe and eastward to the Kolyma Lowland of Siberia. If it did not reach North America earlier, it crossed to Alaska and the Yukon via the Bering Isthmus during the

Illinoian glaciation. I think that *Praeovibos beringiensis* evolved from *Praeovibos priscus* near the end of Kansan time. *Praeovibos beringiensis*, in turn, seems to have given rise to *Ovibos*. It has many similarities to *Ovibos* in the posterior of the cranium (particularly in the horncores, and position of the orbits), but is much longer and deeper in the muzzle – a "mosaic" type of evolution is postulated in this case. Apparently a shortening and broadening of the extremities, and a broadening of the cheek teeth occurred during the last part of the transition.

I now return to a summary of the dispersal history of *Ovibos*. By Illinoian time, *Ovibos moschatus* had spread westward to Europe and eastward across the relatively dry, cool grasslands of the Bering Isthmus to Eastern Beringia (where it seems to have out-competed the last herds of *Praeovibos priscus* in this marginal area) and possibly to the northern United States (Morrill, Nebraska; Jinks Hollow, Illinois). If *Ovibos* herds reached tundra-like areas south of the Illinoian continental ice, presumably they shifted northward as that ice sheet melted back during the Sangamon interglacial. With subsequent expansion of the Wisconsin ice, muskox herds were probably isolated in refugia on Banks Island, unglaciated areas of Alaska and the Yukon Territory (Eastern Beringia), and in a narrow, tundra-like belt, south of the ice.

Most *Ovibos moschatus* specimens in a zone from Montana to New York are probably of Wisconsin age. In eastern North America (e.g. Vestal, New York; Toronto, Ontario) the species survived until the close of the Wisconsin glaciation. But that region seems to have been a cul-de-sac for muskoxen: they were prevented from dispersing northward to the tundra areas of Ungava by non-accessibility, or lack of sufficient tundra-like range as the Labrador ice sheet melted back. It is important to recognize the rapid replacement of early late-glacial tundra vegetation by open spruce forests or woodlands as the ice sheet retreated from the region (Dreimanis 1967, p. 669). Farther west, however, herds that lived in Iowa, South Dakota, Minnesota and Montana probably were able to follow a narrow tundra-like zone northwestward and northward as Keewatin ice retreated, until they reached their present range in the Northwest Territories mainland. The Grandview specimen indicates that muskox herds ranged the western shore of Lake Agassiz about 8,600 years ago when the ice sheet was not much farther north. It seems to demonstrate the reality of a northward movement of muskoxen from the southern refugium.

Ovibos moschatus fossils from surface gravel deposits near Ponoka and Cold Lake, Alberta may also be of postglacial age. If so, they could represent ancestors of the muskoxen now occupying the tundra north of Great Bear Lake.

Considering the uncertainty of evidence for muskoxen in the Pearyland refugium during the Wisconsin glaciation, the present distribution of muskoxen in the Canadian Arctic Islands is perhaps best explained by postulating a northeasterly and easterly movement from the Banks Island refugium as the Innuitian and Laurentide ice sheets retreated (Blake 1970, pp. 660-661). Dispersal in this region was obviously achieved by herds moving from island to island over sea ice. Prince of Wales Island appears to be a zone of contact between muskoxen from Banks Island and those from the southern refugium (Harington 1970b, p. 5).

Evidently tundra muskoxen were common and widely distributed in Eastern Beringia during the Wisconsin glaciation. As postglacial warming progressed, muskox range contracted until herds were largely confined to the northern coastal region of Alaska and the Yukon. Yet it is interesting to note that *Ovibos moschatus* survived in the more southerly Stewart River area

(Brewer Creek) until approximately 2,800 years ago. The last muskoxen native to Alaska may have been killed west of Point Barrow about 185 (Allen 1913, p. 188). I ttribute the extinc tundra muskoxen in Eastern Beringia mainly to a combination of climatic change (from dry and cool to warmer and wetter), which depleted suitable muskox range, and increasingly effective human predation.

A radiocarbon date on tundra muskox cranial bone from Taimyr, the northernmost part of the Siberian mainland, is reported as 3,790 ± 80 years B.P. by N.K. Vereshchagin (personal communication 1968), who kindly supplied me with a bone sample from the same cranium. A date of 2,910 ± 95 years B.P. (I-4220) was obtained, which confirms the relatively recent extinction of *Ovibos moschatus* in Eurasia.

Ovibos moschatus was Holarctic in distribution during the Wisconsin glaciation, when its range extended from southern England in the west, via Siberia, Alaska and the Yukon Territory to New York in the east. In appearance, the tundra muskox is like a blunt-nosed, extremely large sheep with long, dark hair. It is characterized by whitish horns that bend downward close to the skull, sweeping forward, upward and outward at the tips. Adult males have large horn bases separated by a narrow median groove, whereas horns of females are relatively poorly developed, with fur growing between the widely separated, smaller horn bases. Whitish "saddle" markings and "socks" also characterize the species. Tundra muskoxen have short legs, necks and tails. Bulls are larger than cows, having a shoulder height of approximately 4.5 feet (1.4 m), and weighing 581 to 1,437 pounds (263 to 650 kg) under natural conditions.

Tundra muskoxen are gregarious, sometimes congregating in herds of hundreds. Average herd size is about 15. Effective social co-operation is seen in the various defense formations assumed when confronted by an attacker or attackers. Highly ritualized butting contests occur between adult males during the rutting period in August. Calves are born in late April or early May, and are very precocious. This species prefers areas of arctic tundra with sparse snowfall and dry, cold winters. Meadows rich in willows, sedges and grasses constitute suitable summer habitat. *Ovibos moschatus* fossils are good paleoenvironmental indicators of tundra, tundra-like or rarely cold, loess-steppe conditions. Their thick pelts, consisting of grayish underwool (qiviut) covered by long, coarse guard hairs, coupled with short extremities indicate excellent adaptation to cold. The animals browse and graze. Winter food consists mainly of browse such as willows, ground birch, crowberry, and bilberry. In summer, tundra muskoxen feed mainly on fresh willow shoots, sedges, blue grass, fescue and other grasses (Tener 1965; Banfield 1974, pp. 411-413).

Wolves are the main predators of the tundra muskox, but seldom are they able to penetrate the defensive formation of the muskoxen to kill a calf. Often old, or otherwise handicapped muskoxen are attacked and killed – particularly if they are alone. Brown bears sometimes attack muskoxen. Man has been an important predator. Although tundra muskoxen are known to have occurred in southern Europe during the last glaciation, their bones seldom appear in cave middens (Cornwall 1968, p. 188), and they feature rarely in Paleolithic art. A beautiful, free-standing sculpture of a head of a tundra muskox was found in Laugerie Haute (Ucko and Rosenfeld 1967, Figure 35), and a classic figurine of the head and shoulder of a tundra muskox made from cervid antler was found in Kesslerloch Cave near Thaingen, Switzerland (Harington 1961, p. 192, Figure 19). A frieze at Le Roc, depicting a man being charged by a muskox, probably records an incident that occurred thousands of years ago (Laming 1959, p. 27). The behavior of bulls attacking during the rut, or when approached too closely in a defensive grouping, has not changed, and people still record these incidents, only now in the form of writing.

Ovis ?dalli (Dall sheep)

Mountain sheep remains are not uncommon in Pleistocene deposits in the Dawson Area. The only specimens collected outside of that area are from Thistle Creek, Ogilvie River and the Sixtymile Area - all within the same region. Ten cranial fragments, three maxillae with teeth (one from Alaska), and a mandible with teeth and several limb bones are described (Figure 91A-D, Tables 104-106).

Referred specimens

NMC 26001 from Dawson Locality 10 is the most complete cranium collected from the Dawson Area. All cheek teeth are present except for RP^2-RP^3 and LP^3-LP^4. The teeth are very heavily worn, as indicated by the removal of the inner enamel patterns on the premolars. Most of the bone anterior to the P^2s is lacking, including the anterior tips of the nasals. The right

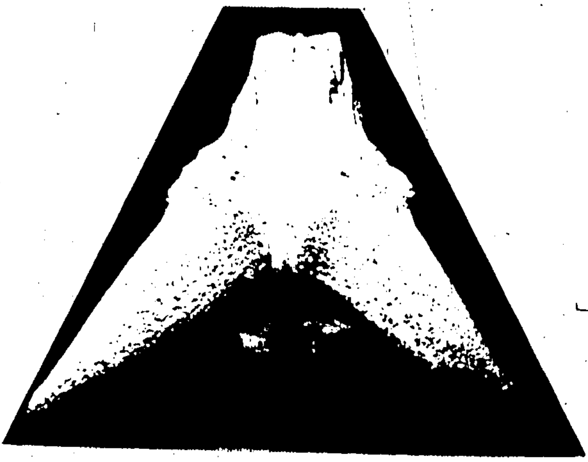
Figure 91. Cranial fragment with horncores lacking tips (NMC 26001, Dawson Locality 10) of a Pleistocene Dall sheep *(Ovis ?dalli)* (left) and a posterior cranial fragment with a nearly complete right and a badly damaged left horncore (NMC 11371, Dawson Locality 2) of a Pleistocene Dall sheep *(Ovis ?dalli)* (right).

A. Dorsal view.

B. Right lateral view.

C. Posterior view.

D. Ventral view.

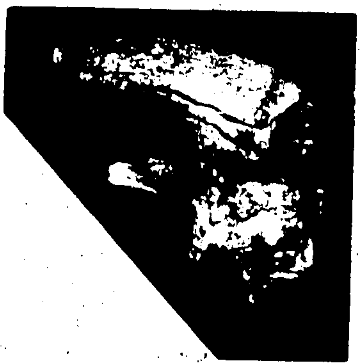


A

5 CM

B

5 CM



C

5 CM

D

5 CM

Table 104. Measurements of Pleistocene mountain sheep (*Ovis ?dalli*) crania from the Yukon Territory compared to those of Recent *Ovis dalli* and *Ovis canadensis* from North America.

Specimens	Measurements (mm)*														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ovis ?dalli. Pleistocene, Y.T.															
Males															
NMC 26001 Dawson Loc. 10	56.2	94.4	56.9	36.4	85.8	97.9	32.2	157.3	88.5	325.0	111.0	98.0	330.0a	228.0	70.0a
NMC 17387 Thistle Loc. 1	-	-	-	-	-	-	30.4	153.9	87.1	296.0	104.0	83.7	-	-	63.6a
NMC 7742 Dawson Loc. 9	-	-	-	-	-	-	32.4	151.8	87.8	298.0	101.3	87.8	-	-	-
NMC 11372 Dawson Loc. 2	-	-	-	-	-	-	-	139.9	84.8a	295.0	102.4	80.5	-	200.0+	-
NMC 11371 Dawson Loc. 2	-	-	-	-	-	-	30.0	142.6	86.1	285.0	100.7	78.8	-	175.0a	71.2a
NMC 11374 Dawson Loc. 2	-	-	-	-	-	-	-	-	-	243.0	84.7	65.5	-	168.0	-
NMC 17705 Ogilvie Loc. 1	-	-	-	-	-	-	27.0	132.7	81.6	255.0	88.7	70.1	-	160.0+	-
NMC 11373 Dawson Loc. 2	-	-	-	-	-	-	-	133.9	79.0a	248.0	87.0	66.0	210.0	166.0	-
Uncataloged specimen in personal collection of K. Djukastein Brewer Loc. 1	-	-	-	-	-	-	-	-	-	-	90.2	68.5	-	-	-
Female															
NMC 17411 Thistle Loc. 1	-	-	-	-	-	-	-	110.3	87.2a	114.0	41.6	32.2	93.0	50.0a	-
Ovis dalli dalli. Recent, N. America															
Males (Cowan 1940, Table 5)															
M	44.0	83.0	52.0	34.0	76.0	87.0	-	-	-	-	-	-	-	-	-
OR	38.0-46.0	75.0-90.0	48.0-56.0	28.0-36.0	72.0-82.0	81.0-97.0	-	-	-	-	-	-	-	-	-
N	7	17	17	18	17	18	-	-	-	-	-	-	-	-	-
Females															
NMC 1827	-	-	-	-	-	-	-	-	78.1	-	31.8	27.6	-	59.	-
NMC 36138	-	-	-	-	-	-	-	-	83.4	-	37.6	27.4	-	53.6	-
NMC 1850	-	-	-	-	-	-	-	-	83.3	-	36.3	26.7	-	71.0	-
NMC 17657	-	-	-	-	-	-	-	-	87.7	-	36.4a	29.2a	-	-	-
Ovis canadensis californiana. Recent, N. America															
Males (Cowan 1940, Table 19)															
M	55.0	95.0	55.0	33.0	88.0	90.0	-	-	-	-	-	-	-	-	-
OR	49.0-61.0	86.0-101.0	53.0-59.0	29.0-38.0	80.0-95.0	81.0-93.0	-	-	-	-	-	-	-	-	-
N	5	6	6	6	6	3	-	-	-	-	-	-	-	-	-
Ovis canadensis. Recent, N. America															
Females															
NMC 8784	-	-	-	-	-	-	-	-	89.0	-	37.8	25.5	-	66.0	-
NMC 36281	-	-	-	-	-	-	-	-	90.0	-	36.3a	28.2a	-	-	-

* 1 - Greatest width across nasals.
2 - Minimum width across rostrum behind maxillary protruberances.
3 - Maximum width of palate between re-entrant notches on lingual sides of M^3.
4 - Minimum width of palate between P^2 alveoli.
5 - Alveolar length P^2-M^3.
6 - Minimum length between M^3 alveolus and anterior margin of paroccipital process on same side.
7 - Minimum basioccipital width (between formina ovale).
8 - Width of cranial constriction between horncores and orbits.
9 - Width of cranium at constriction above nuchal crest.
10 - Circumference of horncore at burr.
11 - Maximum anteroposterior diameter of horncore at burr.
12 - Mediolateral diameter of horncore at burr.
13 - Horncore spread (tip to tip).
14 - Horncore length from burr to tip along middle of outer curve.
15 - Minimum width across across occipital condyles.

Table 105. Measurements of Pleistocene mountain sheep (*Ovis ?dalli*) maxillae and a mandible from the Yukon Territory and Alaska compared to those of Recent *Ovis dalli* from western Canada.

Specimens	Sex	Measurements (mm)*												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Ovis ?dalli.														
Pleistocene, Y.T., Alaska														
Maxillae														
NMC 29034 Dawson Loc. 10	-	6.7	7.0	9.4	9.4	10.6	10.0	17.7	13.5	20.2	13.5	20.6	12.3	84.8
NMC 29035 Dawson Loc. 10	-	8.0	7.3	9.9	8.3	10.4	9.4	17.2	12.5	20.0	12.8	19.8	10.8	84.8
NMC 26001 Dawson Loc. 10	♂	8.9	[illegible]	-	-	9.3	11.5	14.2	14.8	18.4	15.5	24.4	15.7	85.8
F:AM 34656 Upper Cleary Ck., Alaska		7.6	7.0	8.8	8.1	10.0	9.6	14.8	12.3	17.9	12.5	20.8	11.8	76.0
Mandible														
NMC 17703 Ogilvie Loc. 1	-	-	-	8.2	7.0	11.1	8.3	12.9	9.2	19.0	10.8	30.2	10.4	90.6
Ovis dalli.														
Recent, N.W.T., B.C.														
Maxillae														
NMC 29850 Dal L.	♂	6.5	5.0	5.9	7.4	7.6	9.6	14.6	12.7	17.7	13.1	21.2	11.4	69.9
NMC 1849 Teslin L. area	♀	-	-	8.0	9.0	8.9	9.8	15.3	12.8	20.0	14.0	20.0	13.0	77.5
Mandible														
NMC 1849 Teslin L. area	♀	-	-	7.1	5.9	8.7	7.6	13.2	8.9	19.6	9.9	25.0	9.3	80.5

* 1 - P2 length.
2 - P2 width.
3 - P3 length.
4 - P3 width.
5 - P4 length.
6 - P4 width.
7 - M1 length.
8 - M1 width.
9 - M2 length.
10 - M2 width.
11 - M3 length.
12 - M3 width.
13 - P2-M3 alveolar length.

Table 106. Measurements of Pleistocene mountain sheep *(Ovis ?dalli)* metapodials from the Yukon Territory compared to those of Recent *Ovis dalli* and *Ovis canadensis* from North America.

Specimens	Sex	Measurements (mm)*						
		1	2	3	4	5	6	7
Ovis ?dalli. Pleistocene, Y.T.								
<u>Metacarpals</u>								
NMC 29052 Dawson Loc. 10	-	202.6	38.4	25.7	23.3	18.6	41.0	25.8
NMC 7759 Dawson Loc. 9	-	200.8	36.8	25.6	23.2	17.7	39.1	24.8
NMC 29181 Sixtymile Loc. 3	-	205.2	34.1	23.8a	23.1	17.2	37.1	24.2
NMC 29053 Dawson Loc. 10	-	187.6	32.8	21.7	19.4	15.2	33.6	21.5
NMC 10457 Dawson Loc. 12	-	-	-	-	23.9	17.7	38.0	23.8
<u>Metatarsals</u>								
NMC 29015 Dawson Loc. 16	-	225.5	29.	19.0	19.2	20.8	[illegible]	24.0
NMC 29182 Sixtymile Loc. 3	-	-	30.	18.1	18.6	18.5	[illegible]	-
<u>Metacarpals</u>								
Ovis dalli. Recent, N. America								
NMC 30625 N.W.T.	♂	184.2	29.7	21.6	18.0	13.9	33.4	21.8
Ovis canadensis. Recent, B.C.								
NMC 13753 China Head Mt.	♂	192.0	33.4	24.2	21.5	16.7	37.0	23.0
NMC 13756 B.C.	♀	181.0	27.8	21.1	18.1	13.6	32.2	21.3
<u>Metatarsals</u>								
Ovis dalli. Recent, N. America								
NMC 30625 N.W.T.	♂	200.1	26.0	25.5	16.2	15.2	31.9	22.2
Ovis canadensis. Recent, B.C.								
NMC 13753 China Head Mt.	♂	211.0	29.6	27.4	18.7	18.9	34.0	24.2
NMC 13756 B.C.	♀	200.9	26.8	25.7	16.1	16.0	31.0	22.1

* 1 - Total length.
2 - Proximal width.
3 - Proximal depth.
4 - Midshaft width.
5 - Midshaft depth.
6 - Distal width.
7 - Distal depth.

[Light copy

horncore is slightly abraded at the tip, and approximately 30 mm is missing from the end of the left horncore. Most of the right malar and the inferior part of the right supraorbital process are lacking, leaving only the upper rim of the right orbit intact. The rim of the left orbit and the margins of the occipital region are eroded. The zygomatic arches are broken. The large size of the horncores, the heavy tooth wear and the fusion of both frontal and frontonasal sutures indicate that NMC 26001 represents an old male. The cranium is larger in six important measurements than the largest Dall sheep *(Ovis dalli dalli)* crania sampled by Cowan (1940, Table 5), and is close to the means of the same measurements that he took on several bighorn sheep *(Ovis canadensis californiana)* (Table 104). Because I am not aware of any qualitative means of differentiating Dall from bighorn sheep on the basis of cranial characters, I see no reason why the specimen could not be identified as *Ovis canadensis*. However, when the great variation in body size, and horn size and shape, of mountain sheep due to different levels of nutrition and population density (Shackleton 1973) are considered, and the present dispersal patterns of southern and northern mountain sheep are taken into account (evidently bighorn sheep and Dall sheep have not met in the Peace River region during postglacial time), it seems most likely that NMC 26001 represents a late Wisconsin large phase (chronosubspecies?) of mountain sheep presently known as *Ovis dalli stonei*. The same explanation may apply to other specimens in the collection, such as the unusually large metapodials. The light tan color and fresh appearance of NMC 26001 suggest it is of late Wisconsin age.

NMC 17387 from Thistle Locality 1 was collected in 1901 by R.G. McConnell. It consists of the posterior part of a cranium with horncores. The distal half of the right horncore and the distal third of the left horncore are missing. Most of the bone anterior to the orbits is lacking. The upper parts of the orbits are preserved, but their rims are heavily worn. The lateral margins of the occipital region, and the occipital condyles are heavily worn also. The large horncores and fused frontals indicate that this specimen represents an adult male. NMC 17387 has the fresh appearance of NMC 26001, and is probably of late Wisconsin age.

NMC 7747 from Dawson Locality 9 was collected by D.D. Cairnes in 1911. It consists of a badly damaged posterior cranial fragment. Micaceous sandy silt in the pneumatic cavities of the cranium suggests that the fossil was derived from muck deposits. The distal halves of the horncores, and bone anterior to the horncore bases are lacking. Both occipital and basioccipital regions are heavily eroded. The large size of the horncores, the obliteration of the frontal suture, and the exostoses along the midline above the nuchal crest indicate that NMC 7747 represents an old male. The fragment is tan to light buff and may be of late Wisconsin age.

NMC 11372 from Dawson Locality 2 is a posterior cranial fragment lacking the occipital and basioccipital regions and bone anterior to the horncore bases. Most of the left horncore is preserved, while only the proximal third of the right horncore is present. The fossil has weathered to a light buff color, except the oxidized posteromedial surface of the left horncore. The size of the horncore and obliteration of the frontal suture indicate that the specimen represents an old male.

NMC 11371 from Dawson Locality 2 is a posterior cranial fragment lacking bone anterior to the horncore bases and the anterior half of the left horncore. The tip of the right horncore is missing. The large size of the horncores and the fusion of the frontal suture indicate that the fossil represents an adult male. NMC 11371 is dark tan.

NMC 11374 from Dawson Locality 2 is part of the right side of a posterior cranial fragment. In addition to a virtually complete right horncore, the upper portion of the right orbit and segments of the right frontal (attached to part of the left frontal), parietal, temporal and squamosal are preserved. The frontal suture is open, except for a small area at the level of the orbits. The large size of the horncore and the low degree of fusion of the frontal suture indicate that the [illegible]men represents a male in early adulthood. It is dark t[illegible]

NMC 17705 from Ogilvie Locality 1 is a posterior cranial fragment that lacks bone anterior to the horncores. All but the tip of the right horncore is preserved, while most of the left horncore and the left frontal are missing. The borders of the occipital and basioccipital regions are heavily eroded. Only the lateral parts of the frontoparietal suture are fused. The small degree of fusion and the relatively large size of the horncore indicate that NMC 17705 represents a male in early adulthood. The surface of the specimen is heavily weathered, and is dark tan.

NMC 11373 from Dawson Locality 2 consists of both horncores and surrounding frontal and parietal bones. The tips of the horncores are slightly abraded. Frontal sutures are open. The condition of the sutures and the relatively large horncores indicate that NMC 11373 was derived from a male in early adulthood. The posterior surface of the fossil is heavily iron-stained.

NMC 29189 from Sixtymile Locality 3 is a fragment comprising the anterior part of the frontals and horncore bases. Frontal sutures are fused, and the parts of the horncores preserved are massive, suggesting that the specimen represents a large, adult male like NMC 17387. The bone is pale and fresh in appearance. The specimen may be of late Wisconsin age. No useful measurements can be taken on it.

NMC 17411 from Thistle Locality 1 was collected at Edas Gulch in 1901 by R.G. McConnell. It consists of fused frontals and attached, complete horncores. On the basis of its small horncores with their tendency to lateral compression and the obliteration of the frontal suture, I refer it to an old female. NMC 17411 is slightly larger in most measurements than the same region of six female *Ovis dalli* crania and two female

Ovis canadensis crania to which it was compared. Possibly McConnell's (1905) report of mountain goat *(Oreamnos americana)* remains from Pleistocene gravels in the Klondike district may be explained by this specimen. Its original label reads: "10. Horncores with frontal. Antelope ?? From Edas Gulch, Thistle Cr., Y.T. Collected by R.G. McConnell, 1901." This fossil with its small, straight horncores could easily be mistaken for a mountain goat. The significant points of difference between NMC 17411 and *Oreamnos* are the greater breadth of the cranium of NMC 17411 (including the distance between horncores — approximately 46 mm), and the pronounced lateral compression of the horncores of NMC 17411 compared to their roundness in *Oreamnos*. Only two other specimens collected by McConnell are in the collection: a cranial fragment of an adult male *Ovis ?dalli* NMC 17387 — mentioned previously) from Thistle Creek; and a partial cranium of *Bison crassicornis* (NMC 7392) from Gold Run Creek. Neither could be mistaken for a mountain goat fossil. If McConnell's report of Pleistocene mountain goat remains were not based on the erroneous identification of NMC 17411, it would still have to be dismissed for lack of solid evidence (Harington 1971b, p. 1093).

In 1967, K. Djukastein loaned me a braincase with horncores (tips missing) of a mountain sheep that he had collected from Pleistocene deposits at Brewer Locality 1. It [illegible] slightly larger in basal horncore dimensions than a Recent specimen of similar age of *Ovis dalli* (NMC 15387), but was closer to it than a Recent cranium of *Ovis canadensis*, with which it was compared at the same time. I have not examined a posterior cranial fragment with horncores (ROM 5304) of a mountain sheep collected by a Dr. Burwash from Pleistocene deposits at an unspecified locality in the Yukon Territory.

In the collections are two well preserved maxillae with teeth. NMC 29034 from Dawson Locality 10 is a left maxilla with LP^2-LM^3. It has the size, tooth pattern, and facial tuberosity above M^1 that characterize mountain sheep. The shape of the malar-maxillary suture is of diagnostic importance in separating mountain sheep from mountain goats *(Oreamnos)*, goats *(Capra)* and the North American prongbuck "antelopes" (e.g. *Antilocapra*, *Tetrameryx*). The maturely worn teeth and the well developed protruberance above M^1 suggest that NMC 29034 represents an adult. NMC 29035 from Dawson Locality 10 is a right maxilla with RP^2-RM^3. It is similar to NMC 29034 and has the same tan color, but there is no evidence that they fit together. The posterior cusp of RM^3 is less heavily worn than that of NMC 29034.

For comparative purposes, a right maxilla with teeth (F:AM 34656) from Upper Cleary Creek in the Fairbanks area, Alaska is described. I am grateful to R.H. Tedford of the Frick Laboratory, American Museum of ~~Natural~~ History for the loan of this specimen. Unlike the other two fossils, it has most of the malar bone. Its P^2-M^3 alveolar length is approximately 10% shorter than those of the Yukon fossils, but almost the same as that of a Recent female of *Ovis dalli* (NMC 1849), which may indicate that smaller mountain sheep (*Ovis dalli dalli* progenitors?) lived in central Alaska, while larger ones (*Ovis dalli stonei* progenitors?) lived in the southeastern extremity of the Eastern Beringian refugium during the late Wisconsin. Detailed comparison of Fairbanks area mountain sheep fossils, and those from the Dawson Area are required in order to test this hypothesis.

NMC 17703 from Ogilvie Locality 1 is part of a left mandible with LP_3-LM_3, the alveolus for LP_2, and most of the diastema. The inferior border of the jaw from below LP_4 to below LM_3 is lacking. The occlusal surfaces of the teeth are moderately worn, indicating that an adult is represented. The fossil is dark tan and has a weathered, finely-cracked surface.

Several mountain sheep limb bones are in the Yukon collections. USDG 11 from Sulphur Creek in the Dawson Area is the left humerus of a subadult. It is complete except for the proximal epiphysis, which evidently was not fused to the shaft. The animal may have been between approximately 3 to 3.5 years old when it died, according to the age when this epiphysis fuses to the shaft in domestic sheep *(Ovis aries)*. In morphological details, USDG 11 matches a humerus of a slightly older Recent male of *Ovis dalli*, (NMC 30625) from the Yukon, but it is about 23% shorter. The fossil is stained dark reddish brown and may be older than late Wisconsin. W.G.E. Caldwell kindly allowed me to borrow this specimen from the University of Saskatchewan, Department of Geology collection.

NMC 11375 from Dawson Locality 2 is a fragment of a right radio-ulna. The proximal half of the radius, and the proximal third of the ulna (near the semilunar notch, lacking the olecranon) are preserved. The maximum proximal width of NMC 11375 is 40.3 mm compared to 41.0 mm for the same measurement in a Recent *Ovis dalli* radio-ulna (NMC 3[illegible]). The fossil is light tan and very fresh looking. I suggest it is of late Wisconsin age.

The metapodials are interesting in that they give a good idea of the size of the late Pleistocene mountain sheep in the Dawson region of the Yukon Territory. Evidently all are from mature individuals, for the distal epiphyses are fused to the shafts, and the tuberosities on their anterior surfaces near the proximal ends are well developed. Four of the metacarpals and both metatarsals are probably from animals the size of Recent male bighorn sheep *(Ovis canadensis)*, while only one metacarpal corresponds in size to metacarpals of Recent Dall sheep *(Ovis dalli)*.

NMC 29052 from Dawson Locality 10 is a complete right metacarpal. It is larger than a Recent adult male bighorn sheep metacarpal (NMC 13753), and approximately 9% longer than a modern *Ovis dalli* metacarpal (NMC 30625). NMC 10457 from Dawson Locality 12, the distal half of a right metacarpal, is comparably large. NMC 29053 from Dawson Locality 10 is a complete right metacarpal that is similar in size to a metacarpal of a Recent male of *Ovis dalli* (NMC 30625), and a Recent female of *Ovis canadensis* (NMC 13756). Pyrolusite "stars" decorate the shaft. The fact that both large (NMC 29052) and small (NMC 29053) metacarpals were collected from the same muck deposit, at the same locality, in the same year, and that, according to their fresh appearance both are probably of late Wisconsin age, suggests that the former represents a male and the latter a female of the same species. Northern Dall sheep *(Ovis dalli dalli)* males are now about 30% heavier than females of that subspecies (Banfield, 1974, p. 417), which could explain the size differences between the fossils. More comparative material is required to obtain a clear picture of the variations in limb bone size between males and females of Recent mountain sheep.

NMC 7759 from Dawson Locality 9 is a large left metacarpal. A patch of bone is missing on the posterior surface of the shaft just above the distal articulation. A small projection of bone on the posterolateral margin near the middle of the shaft suggests that NMC 7759 was derived from an old individual. The dark brown surface staining is ~~due~~ to a covering of dark preservative. NMC 29181 from Sixtymile Locality 3, another left metacarpal, is longer than NMC 7759, and is damaged on the posterior edge of the proximal articulation. The posterior surface of the shaft is weathered, cracked and oxidized.

Two metatarsals are in the collection. NMC 29015 from Dawson Locality 16 is complete, and very fresh looking. It is approximately 11% longer than Recent *Ovis dalli* metatarsals with which it was compared - one of which (NMC 30625) is from a male - and is 6% longer than the metatarsal of a male bighorn sheep (NMC 13753). NMC 29182 from Sixtymile Locality 3 lacks the extremities, but seems to have been similar in size to NMC 29015. Modern northern Dall sheep *(Ovis dalli dalli)* males are approximately 6% longer in the hindfoot than females of that subspecies (Banfield 1974, p. 417), which provides an idea of the large size of some of the late Wisconsin mountain sheep. A single first phalanx (NMC 29033) from Dawson Locality 10 is 62.1 mm in total length. It was collected *in situ* from muck approximately 1 foot (0.3 m) above bedrock.

Discussion

So far, mountain sheep fossils from the Yukon Territory have been collected only in the Dawson region (Dawson Area, Sixtymile Area, and Thistle and Ogilvie localities). Evidently the margins of the Old Crow Basin were relatively poor mountain sheep range during the late Pleistocene. With one or two exceptions, all of the specimens are pale tan and fresh in appearance, suggestive of a late Wisconsin age. Bone from a horncore of *Ovis ?dalli* from Dawson Locality 2 yielded a radiocarbon date of 23,000 ± 600 years B.P. (I-4225), which supports the contention that mountain sheep occupied Eastern Beringia during the late Wisconsin glaciation. My impression is that the fossils are unusually large - more the size of modern *Ovis canadensis* than of *Ovis dalli* - although zoogeographically it is more probable that they represent Dall sheep, which, like *Ovis canadensis catclawensis* in the southern refugium (Harris and Mundel 1974, p. 679), attained great body size during the late Wisconsin.

The earliest mountain sheep ("*Ovis canadensis*") remains in Canada are from Sangamon interglacial deposits at Medicine Hat, Alberta (Stalker and Churcher 1971). A fragmentary metacarpal of *Ovis canadensis* from gravels at Cochrane, Alberta appears to be larger than a Recent metacarpal of *Ovis canadensis* to which it was compared. Radiocarbon analyses of *Bison bison occidentalis* bone from the same deposit at Cochrane gave dates of approximately 11,000 years B.P. (Churcher 1968b, pp. 1470-1471). The only other mountain sheep fossils from Canada have been found in British Columbia. A well preserved cranium of a male bighorn sheep (*Ovis canadensis*) was collected from a gravel pit near Finlay Forks. Bone from a horncore yielded a radiocarbon date of 9,280 ± 200 years B.P. (GSC-1497) (Rutter *et al.* 1972, p. 641). Several partial crania of *Ovis canadensis* were recovered from the bed of Tranquille Creek and adjacent Hanging Valley Creek in southern British Columbia. Cowan (1941, p. 47) considered them to be of Pleistocene or early postglacial age.

In the conterminous United States, *Ovis canadensis* remains have been identified from many localities in the west, such as: Jaguar Cave, Idaho; Little Box Elder Cave, Wyoming; Dry Cave, Isleta Caves and Burnet Cave, New Mexico; Gypsum Cave, Catclaw Cave, and Winnemucca, Nevada; Rampart Cave and Stanton Cave, Arizona; Glendale, California; and near Lake Bonneville, Utah. Most of the specimens are from deposits of Wisconsin age. Fossils from the Great Basin once assigned to "*Ovis catclawensis*", and now perhaps best considered as representing a large chronosubspecies of the bighorn sheep, *Ovis canadensis catclawensis*, are probably of early to mid-Wisconsin age (approximately 68,000 to 33,000 years B.P.) (Stock and Stokes 1969, p. 805). Organic material associated with remains of very large sheep comparable to "*Ovis catclawensis*" in Dry Cave, New Mexico yielded a radiocarbon date of

15,030 ± 210 years B.P. (I-6201). A specimen identified as modern *Ovis canadensis* from near Winnemucca, Nevada was considered to be about 6,500 years old by Stokes and Condie (1961).

The earliest records of mountain sheep in North America are from Alaska. "*Ovis* sp." has been identified from loess considered to be of Illinoian age by T.L. Péwé at Cripple Creek sump near Fairbanks (Péwé and Hopkins 1967, pp. 268-269). A metatarsal probably referable to mountain sheep ("cf. *Ovis* sp.") was collected from outwash sediments of Illinoian age in the Nenana Valley near Fairbanks (Péwé and Hopkins 1967, pp. 268-269). Most mountain sheep specimens, including several good crania, have been collected from the Fairbanks area (e.g. Fairbanks Creek, Engineer Creek, Cripple Creek, and Gold Hill) (Frick 1937, p. 555; Guthrie 1968b, Table 1). I have identified mountain sheep remains from late Wisconsin deposits at Lost Chicken Creek in eastern Alaska (Harington 1976 MS., p. 78) and from deposits of late Pleistocene age at Canyon Creek in the Big Delta area. Two specimens were derived from stream channel fill at the latter site. The distal half of a left metatarsal was comparable in size to the same part of a Recent female of *Ovis canadensis* (NMC 32243). A partial RM^3

was found to be slightly longer anteroposteriorly than RM^3s of *Ovis dalli* (NMC 29850, 1849). I am grateful to C.A. Repenning of the U.S. Geological Survey for sending these fossils for examination. Material identified as "Hypsodont bovid (sheep [illegible] goat)" from the Sullivan Pit near Tofty (Repenning *et al.* 1964, Table 1) probably pertains to mountain sheep.

Ovis fossils have not been recorded from any of the major northeastern Siberian Pleistocene vertebrate faunas, presumably because their lowland situations were not favorable for mountain sheep during the Pleistocene. However, *Ovis* specimens are known from late Pleistocene deposits of south central Siberia (near Krasnoyarsk and Irkutsk), Transbaikalia and central Asia. In China, *Ovis* has been recorded from upper Pliocene sediments (Gromova 1968, p. 544).

Farther west, in the Caucasus remains of large sheep of the argali type (*"Ovis* cf. *ammon"*) are very rare, and have been found only in middle and upper Pleistocene deposits of the Transcaucasian mountains and plains. Fossils of the Asiatic mouflon, *"Ovis gmelini"* *(Ovis orientalis gmelini)*, are rarer, having been collected only from Paleolithic deposits of the Lesser Caucasus and the Mesolithic of Dagestan (Vereshchagin 1959, p. 370).

In Europe, the earliest remains of *Ovis* occur in Villafranchian deposits (e.g. Senèze in southern France). *Ovis* fossils of middle Pleistocene age are known from Pont-du-Chateau in France and from the Cromer Forest Bed at Overstrand, England. During the late Pleistocene, the European mouflon (*Ovis musimon*) seems to have been fairly common in Italy and North Africa (Kurtén 1968, p. 180).

Ovis may have arisen from goat-antelope (Rupicaprinae) ancestors in mountainous country of Asia, whence, toward the close of the Pliocene, sheep spread rapidly eastward to China and westward toward southern Europe (Senèze). The urial sheep (*Ovis vignei*) of central Asia (northeastern Iran to Tadzhikistan and Afghanistan — a region that did not undergo severe glacial and climatic changes during the Pleistocene) are probably the most primitive. Cytogenetic data seem to throw a great deal of light on the pattern of evolution of *Ovis*. The urials of central Asia have the highest chromosome complement of 58. West of the urial range (Mediterranean to Iran), the Asiatic mouflon (*Ovis orientalis*) and

European mouflon *(Ovis musimon)* have 54 chromosomes, whereas east of the urial range (Pamirs, Tien Shan, and Altai mountains through Tibet and Mongolia to China), the argali or arkhar *(Ovis ammon)* has 56 chromosomes (Nadler *et al.* 1973, pp. 115-116). Still farther east, are the western Beringian snow sheep *(Ovis nivicola)* with a complement of 52 chromosomes. In western North America are Dall sheep *(Ovis dalli)* and bighorn sheep *(Ovis canadensis)* with 54 chromosomes (Korobitsyna *et al.* 1974, p. 235). Presumably the ancestral mountain sheep of Beringia that gave rise to American Dall and bighorn sheep and Siberian snow sheep had a chromosome complement of 54. The *Ovis nivicola* karyotype of 2n = 52 may have evolved from the 2n = 54 condition since the flooding of the Bering Isthmus about 12,000 years ago (Korobitsyna *et al.* 1974, p. 242), or, in my opinion, earlier. Robertsonian centric fusion appears to be the key cytological event responsible for creating this remarkable set of "prints", which seems to lead from the late Pleistocene of Beringia back to the late Pliocene of central Asia. Nadler *et al.* (1973, p. 116) state: "Considerable direct and indirect evidence suggests that fusion rather than fission is the predominant mechanism for changes in diploid number in cattle, sheep and goats, and it seems probable that the 2n = 58 or urial sheep is the most representative of the ancestral sheep chromosome complement and that the sheep with 2n = 56 and 2n = 54 karyotypes evolved from the former."

Mountain sheep of North America were derived from a western Beringian stock that first entered Eastern Beringia (Fairbanks) via the Bering Isthmus during the Illinoian glaciation. The flooding of the Bering Isthmus at the beginning of the Sangamon interglacial established a break between the ancestors of the snow and Dall sheep. Contact between these sheep may not have been renewed during the succeeding Wisconsin glaciation, allowing more time than Korobitsyna *et al.* (1974, p. 242) have suggested for chromosomal divergence of the snow sheep. During the Sangamon interglacial, the stock (which I postulate looked like Stone sheep (*Ovis dalli stonei*)) that gave rise to bighorn sheep had reached west-central North America (Medicine Hat). Like the first bison entering the region, favorable range and competitive advantage seem to have resulted in the development of very large animals with massive horns toward the close of the Sangamon interglacial (e.g. *Ovis canadensis catclawensis* in the Great Basin).

Harris and Mundel (1974, p. 679) postulate that sheep populations with relatively large-sized males were widespread in the western United States and northern Mexico during the late Wisconsin, and that there was a selection for smaller size at the close of the Wisconsin as a result of environmental deterioration. Further, they suggest that the smaller, modern bighorn subspecies were derived from *Ovis canadensis catclawensis* about 10,000 years ago. Therefore, it may be possible to use remains of extremely large male mountain sheep in the southern refugium as index fossils of "pre-postglacial" deposits. Thus, the larger, darker southern mountain sheep were isolated from their paler, ancestral brothers in the north during the Wisconsin glaciation.

Among the mountain sheep isolated in Eastern Beringia (Dawson region) were some that corresponded in size to modern *Ovis canadensis*. I speculate that those sheep occurring in the southeastern portion of Eastern Beringia during the late Wisconsin were derived from populations that had occupied the mountains of northern British Columbia during the Sangamon interglacial, and that had characteristics lying between northern Dall sheep and southern bighorn sheep (e.g. larger size and darker pelage). I postulate: (a) that as Cordilleran ice expanded, the northern British Columbian sheep were forced northward into the southern Yukon near the peak of the Wisconsin glaciation about 20,000 years ago; (b) that they were largely separated from smaller, paler *Ovis dalli dalli*, which may have been concentrated in central Alaska; and (c) that they may be identified as progenitors of the modern Stone sheep.

(Ovis dalli stonei). As the Wisconsin ice melted back, these sheep again moved southward, while *Ovis dalli dalli* spread toward their range, some intergradation occurring near the present Yukon - British Columbia border. This hypothesis combines elements of two others. The first, advocated by Geist (1971), is that Stone sheep survived the Wisconsin glaciation in the Alaska - Yukon refugium; and the second, put forward by Youngman (1975, p. 174), is that Stone sheep were "a southern (relative to Eastern Beringia) Rocky mountain isolate" (but where could they have been isolated according to our present knowledge that northern British Columbia was smothered by ice (Prest 1969)?).

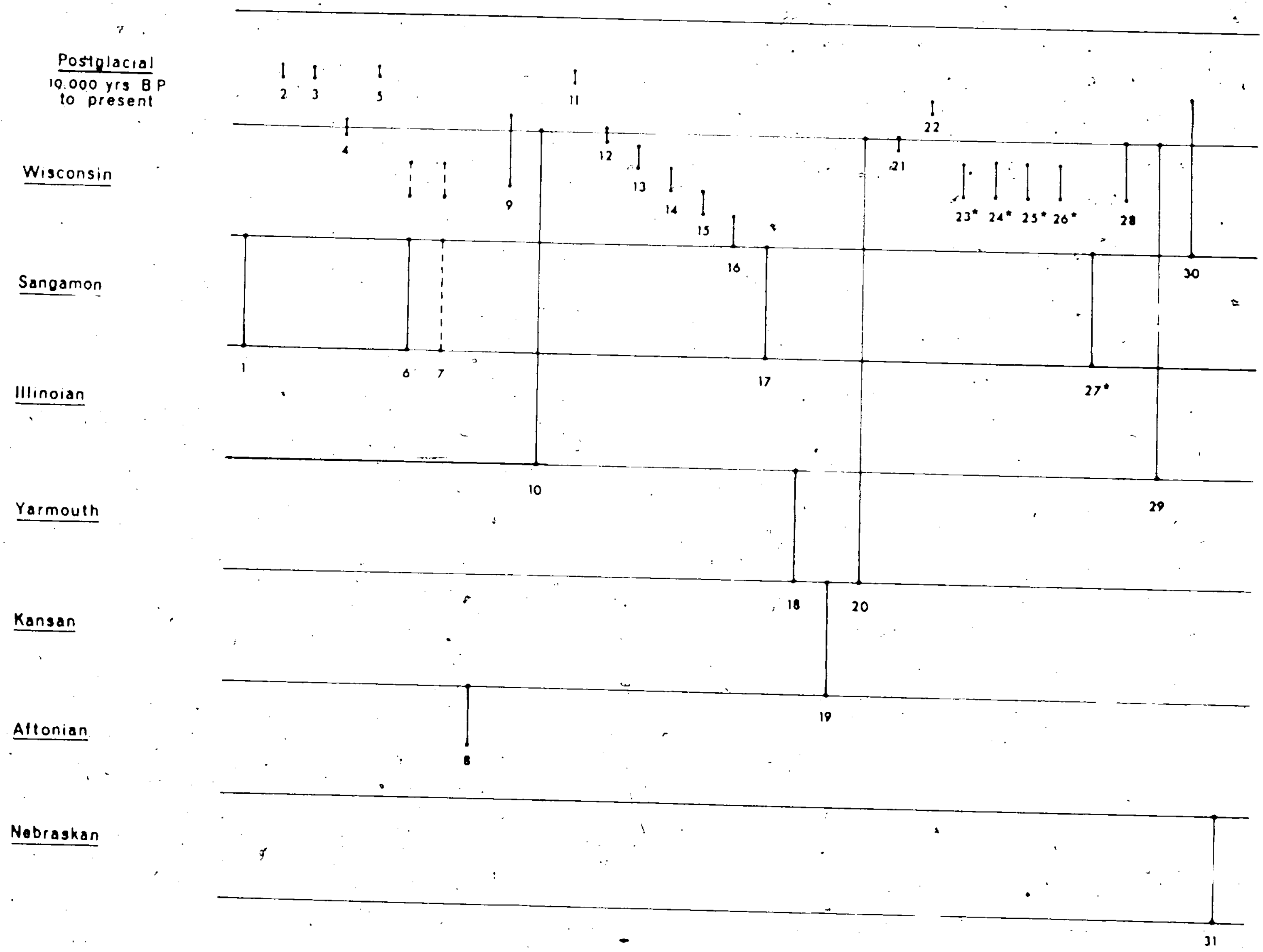
I think that the nomenclature of North American mountain sheep should be altered to more accurately reflect the following factors: (a) recent cytogenetic findings of Nadler, Korobitsyna and their colleagues that all North American mountain sheep have a chromosome complement of 54, whereas Siberian snow sheep have 52; (b) the great variability in body size, size and shape of horns, and color, depending on quality of range, population density and latitude (Gloger's "rule" seems to be operating as indicated by the darkening of mountain sheep pelage at lower latitudes, where warmer, moister conditions prevail); and (c) the existence of an intermediate variety of mountain sheep *(Ovis dalli stonei)* between Dall sheep to the north and bighorn sheep to the south. Consequently, I suggest that the name *Ovis nivicola* be retained for the snow sheep of Siberia, and that North American mountain sheep be designated as a single, rather variable species, *Ovis canadensis (canadensis* has priority over *dalli)*, including three subspecies: *Ovis canadensis canadensis* (bighorn sheep), *Ovis canadensis stonei* (Stone sheep), and *Ovis canadensis dalli* (Dall sheep).

Dall sheep occupy mountain ranges of northwestern North America from the west coast of Alaska through most of the Yukon Territory, and part of the Northwest Territories west of the Mackenzie River, to northern British Columbia. The Ogilvie River area, where the fossil mandible NMC 17703 was collected, is one of the most productive areas of Dall sheep range in the Yukon. Stone sheep *(Ovis dalli stonei)* range from northern British Columbia (north of the Peace River) into the south-central Yukon.

Dall sheep are smaller than bighorn sheep and have a shorter face. Their pale amber horns are more slender than those of the bighorn, and they flare more toward the tips. There are two well-marked color phases. The northern group *(Ovis dalli dalli)* is creamy white, except for a few dark hairs along the spine and tail. The southern group *(Ovis dalli stonei)* is slate brown, except for small white patches on rump and muzzle, and varying amounts of white on the insides of the legs and on the forehead. Intergrades between the two groups are sometimes mainly white with dark "saddles". The winter coat of Dall sheep is long, providing good insulation against the cold. Dall sheep are gregarious, forming bands led by old females, which usually comprise 10 animals, but often include more during the winter, when the rams join them. In autumn, during the rut, the males have butting duels, much like tundra muskoxen. They are superb climbers. Their hooves, with spongy centres and hard rims, ensure a firm grip on rock. They have keen senses of vision and smell.

In summer, Dall sheep males separate from the bands of females and lambs. All move to preferred habitat in high (up to elevations of 6,000 feet (1,829 m)) alpine pastures. In September or early October the groups descend to lower, drier, south-facing slopes. Their numbers may be greatly reduced by heavier than average snowfalls. Grasses and sedges are the main diet of Dall sheep. During the summer they feed on saxifrages, locoweed, licorice root, and horsetails. In winter they paw snow away to feed on woody plants such as willow; sage, cranberry, crowberry and mountain avens. Predation by wolves is most critical during the migration period, when bands may have to cross open tundra to reach winter range. Perhaps it was the relative lowness and lack of good cover that prevented mountain sheep from flourishing in the Old Crow Basin during the Pleistocene, while they evidently throve in the higher more rugged country near Dawson. Lynx, wolverines, coyotes and grizzly bears are other important predators. Golden Eagles occasionally prey on young lambs (Banfield 1974, p. 417).

Figure 92. Suggested chronological sequence of Pleistocene vertebrate faunas of Canada and Alaska. Yukon Pleistocene mammal faunas are marked with asterisks to show their relationships with the other faunas. Solid vertical lines indicate probable age, dashed ones indicate possible age. Details of each fauna are provided elsewhere (Harington 1976 MS.) according to its number: 1. Toronto, Ontario (Don Formation); 2. Toronto, Ontario (Scarborough Bluffs); 3. Hamilton, Ontario (Hamilton Bay); 4. Ottawa, Ontario (Greens Creek); 5. Oxbow Dam, Saskatchewan; 6. Fort Qu'Appelle, Saskatchewan (Echo Lake Gravels); 7. Saskatoon area, Saskatchewan (Floral Formation); 8. Wellsch Valley, Saskatchewan; 9. Empress, Alberta; 10. Bindloss area, Alberta; 11. to 19. Medicine Hat, Alberta faunas; 20. Hand Hills, Alberta (Hand Hills Conglomerate).


Postglacial
10,000 yrs BP to present
Wisconsin
Sangamon
Illinoian
Yarmouth
Kansan
Aftonian
Nebraskan
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23*
24*
25*
26*
27*
28
29
30
31

21. Cochrane, Alberta (Big Hill Creek Formation); 22. Acasta Lake, Northwest Territories; 23.* Gold Run Creek, Yukon Territory (Dawson Locality 32); 24.* Hunker Creek, Yukon Territory (Dawson Locality 16); 25.* Sixtymile River, Yukon Territory (Sixtymile Locality 3); 26.* Old Crow River, Yukon Territory (Old Crow Locality 14N); 27.* Old Crow River, Yukon Territory (Old Crow Locality 44);

28. Lost Chicken Creek, Alaska;

29. Fairbanks area, Alaska; 30. Sullivan Pit, Alaska (Tofty Placer District);

31. Cape Deceit, Alaska (Cape Deceit Formation).

CONCLUSIONS

1. From 1966 to 1975, approximately 14,000 Pleistocene vertebrate fossils were collected in the Yukon Territory for the National Museums of Canada. Most came from the Old Crow Basin, which I consider to be the richest area for Pleistocene mammal fossils in Canada. Many specimens have been collected in the Dawson Area also, and most of the conclusions reached here were based on an examination of this evidence, and an attempt to interpret it. Only several hundred of the most complete, or significant fossils are described in this study.

2. Ten orders (Insectivora, Primates, Edentata, Lagomorpha, Rodentia, Cetacea, Carnivora, Proboscidea, Perissodactyla, Artiodactyla), 19 families, 44 genera and 64 species of mammals have been identified from Yukon Pleistocene deposits. Among the families, the Cricetidae Mustelidae, Equidae and Bovidae are most strongly represented; and among the genera *Equus* and *Bison* seem to be represented by the greatest number of species. Two of the species, a large whale and a seal, are marine mammals, while the remainder are land mammals. The number of muskox genera (four or possibly five, if *Boötherium sargenti* and *Symbos cavifrons* are not female and male of the same species) is perhaps not surprising, considering the northern latitude

of the fossil localities. It is worth noting that all stages of North American mammoths are represented in the Yukon: the southern mammoth (Mammuthus meridionalis), the steppe mammoth (Mammuthus cf. armeniacus) and the woolly mammoth (Mammuthus primigenius).

3. Horse, mammoth, bison and caribou are the commonest species of large mammals represented in the Yukon fossil collections. Muskrat, ground squirrel, brown lemming and pika remains are very common among the small mammal specimens. Most of these species are adapted to cool grassland or tundra environments.

4. The discovery of a caribou tibia fleshing tool made by man at Old Crow Locality 14N is of great interest because radiocarbon analysis of a sample of bone from it yielded a date of $27{,}000 \; ^{+3000}_{-2000}$ years B.P. It suggests that people were present in Eastern Beringia at least as early as mid-Wisconsin time. Evidence suggests that they hunted caribou, mammoth, horse and bison. The find of a caribou antler punch or wedge with Pleistocene mammal remains at Dawson Locality 16 may indicate that these early hunters were present in that region also. A deeply permineralized mandible of a domestic dog from Herschel Island is tantalizing. It may imply that people lived near the northern coast of the Yukon before the late Wisconsin

maximum. Stone bifacial tools, including "knives" and a projectile point have been found in reworked deposits in the Old Crow Basin. Their age is uncertain.

5. Approximately 40% of the mammal species known as fossils from Yukon Pleistocene deposits are extinct, and about 60% no longer occur in the Yukon. Horses (all five species are considered to be extinct), bison, elephants, camels, muskoxen and large cats were particularly reduced by extinctions.

6. Mammal fossils which appear to be characteristic of the early, middle and late Pleistocene have been found in the Yukon Territory. The plains shrew *(?Planisorex* cf. *dixonensis)*, the giant pika *(Ochotona* cf. *whartoni)* and the southern mammoth *(Mammuthus meridionalis)* are considered to be good indicators of the early Pleistocene. Probably Soergel's muskox *(Soergelia* cf. *elisabethae)*, Staudinger's muskox *(Praeovibos priscus)*, giant moose *(Alces latifrons)*, steppe mammoth *(Mammuthus* cf. *armeniacus)*, large horses *(Equus*, cf. *(Plesippus) verae)*, and possibly the dhole *(Cuon* sp.) and Hensel's lemming *(Dicrostonyx* cf. *henseli)* are indicative of a middle Pleistocene element. Among mammals that typify the late Pleistocene in the Yukon are the woolly mammoth *(Mammuthus primigenius)*, moose *(Alces alces)*, Yukon wild ass *(Equus (Asinus) lambei)*, Dall sheep *(Ovis ?dalli)*,

helmeted muskox *(Symbos cavifrons)*, tundra muskox *(Ovibos moschatus)*, arctic fox *(Alopex lagopus)*, American lion *(Panthera leo atrox)*, American badger *(Taxidea taxus)*, large-horned bison *(Bison crassicornis)*, and the western bison *(Bison bison occidentalis)* which occurred near the close of the Wisconsin glaciation.

7. Radiocarbon dates pertaining to Yukon and Alaskan Pleistocene mammal fossils help to indicate the species that were present in Eastern Beringia during Wisconsin and postglacial time. Within the limits of the radiocarbon dating technique, chronological ranges for various species follow: ground squirrel *(Spermophilus parryi)* 14,760 ± 850 years B.P. to 14,510 ± 450 years B.P.; beaver (probably *Castor canadensis)* 9,330 ± 300 years B.P. to 3,700 ± 150 years B.P.; American lion *(Panthera leo atrox)* 22,680 ± 300 years B.P.; woolly mammoth *(Mammuthus primigenius)* 30,300 ± 2,000 years B.P. to 15,380 ± 300 years B.P.; large horse *(Equus* sp., probably *Equus* cf. *(Plesippus) [illegible])* >39,900 years B.P. to [illegible] ± 2,600 years B.P.; Yukon wild ass *(Equus (Asinus) lambei)* probably 26,760 ± 300 years B.P. to 14,870 ± 260 years B.P.; western camel *(Camelops* sp.*)* $24,900 \pm {}^{1100}_{1000}$ years B.P.; wapiti *(Cervus elaphus)* 4,570 ± 100 years B.P.; giant moose *(Alces latifrons)* 33,800 ± 2,000 years B.P.; caribou *(Rangifer tarandus)* $27,000 \pm {}^{3000}_{2000}$ years B.P. to 5,010 ± 100 years B.P.; Alaskan bison *(Bison*

alaskensis) >39,900 years B.P.; large-horned bison *(Bison crassicornis)* 30,300 ± 1,850 years B.P. to 11,910 ± 180 years B.P.; wood bison *(Bison bison athabascae)* 1,350 ± 95 years B.P.; Sargent's muskox *(Bootherium sargenti)* 25,540 ± 900 years B.P.; helmeted muskox *(Symbos cavifrons)* >40,000 years B.P. to 17,695 ± 445 years B.P.; tundra muskox *(Ovibos moschatus)* 2,830 ± 100 years B.P.; Dall sheep *(Ovis ?dalli)* 23,000 ± 600 years B.P. Except for the Alaskan bison, giant moose, large horse, and possibly the beaver, wapiti, wood bison and tundra muskox, on the basis of current radiocarbon dates, all of the preceding species can be considered to have occupied the Eastern Beringian refugium during the late Wisconsin glaciation.

8. An estimated 75% of the Yukon Pleistocene mammal species were derived from Eurasia or Beringia. Major influxes of Eurasian or western Beringian mammals entered Alaska and the Yukon via the Bering Isthmus - particularly during the Kansan and Illinoian glaciations. Many of them reached southern North America (e.g. *Bison, Alces, Panthera leo atrox, Mustela (Putorius) eversmanni)*, while some did not (e.g. *Praeovibos)*. The remaining 25% seem to have been derived from southern North America. Of these, I think the following species probably entered during an interglacial phase of the late Pleistocene - possibly mainly during the Sangamon: *Megalonyx* cf. *jeffersoni, Castoroides ohioensis, Ondatra zibethicus, Arctodus simus yukonensis, Taxidea taxus,*

Spilogale sp., *Mammut americanum*, *Equus* cf. *scotti* and *Camelops hesternus*. Their probable habitat requirements indicate that the route taken from southern North America to Eastern Beringia was dominated by dry scrub grassland, with occasional patches of spruce. Perhaps the muskrat and giant beaver moved northward along chains of lakes which formed as the Illinoian ice sheet melted back. Fossils of *Megalonyx* from central British Columbia and the Northwest Territories suggest that these ground sloths could have reached the Yukon through the central Cordillera or by the "western corridor" along the eastern flank of the Rocky Mountains. Remains of *Arctodus simus*, *Equus scotti*, *Camelops hesternus*, *Ondatra zibethicus*, and *Taxidea taxus* from deposits of probable Sangamon interglacial age at Fort Qu'Appelle and Saskatoon, Saskatchewan and Medicine Hat, Alberta, suggest that those species spread northward along the "western corridor". Discovery of one or two stratified Pleistocene mammal localities in the Peace River or Liard River regions would help to clarify this problem, and joint paleontological-archeological reconnaissances should be carried out there.

9. Based on evidence concerning habitat, albeit sparse in some cases, for 52 species of Yukon Pleistocene mammals described in this study, I estimate their ecological preferences as follows: grassland (30%), tundra (20%), forest (17%), water (11%), alpine terrain (3%). The dominance

of dry, cool grassland for long periods is clear, and is emphasized when the relative abundance of fossils representing bison, mammoth, horse and caribou are kept in mind. The number of species requiring moist, woodland habitat is surprisingly high considering the evidence for dryness throughout much of the late Pleistocene in central Alaska. This incidence is undoubtedly greatly influenced by the fact that most fossils were collected from the Old Crow Basin, which contained large glacial lakes during the latter half of the Pleistocene. Even during interglacials, such as the present one, there is much standing water in the basin.

10. Interesting glimpses of late Pleistocene paleo-environments in the Old Crow Area have been gained as a result of careful collecting at two localities, followed by detailed analyses of samples by specialists in several disciplines. Unit 2 at Old Crow Locality 44 contains thick spruce logs and remains of smaller plants, molluscs, ostracodes, bryozoans, insects, fishes, birds and mammals. Many of the species suggest the former presence of ephemeral shallow ponds and lakes in a river flood plain with sandy margins and patches of forest in places. Ostracode remains and abundant small pond snail shells indicate shallow or quiet water with nearby vegetation. Fish, goose, duck, muskrat, beaver and giant beaver fossils support this view of the

past environment. Analyses of pollen samples from Unit 2 show high values for spruce, birch, sedges and grasses. Remains of a plant, *Najas flexilis*, and a spotted skunk (*Spilogale* sp.) suggest that climate was warmer than at present during at least part of the depositional episode concerned. I think that the fossils are of Sangamon interglacial age. A radiocarbon date on a spruce log from the unit is >54,000 years B.P.

Mollusc shells from Unit 4 at Porcupine Locality 100 yielded a radiocarbon date of 32,400 ± 770 years B.P. - a mid-Wisconsin age. Remains of plants, molluscs, ostracodes, bryozoans, crustaceans, insects, fishes (grayling) and mammals (brown lemming) demonstrate the former presence of a large, cool, shallow lake with a mud bottom, and with *Potamogeton* and wet meadow habitat near its margin. Coniferous trees, sedges, buttercups and cinquefoils grew nearby. Fossils representing large numbers of tundra-adapted insects and plants from Unit 4 suggest that tundra was located near the site, that the elevation of the tree-line in mid-Wisconsin time was lower and that climate was colder than at present. Probably open areas in this parkland type of environment were richer in grasses than in contemporary forest-tundra areas.

It is interesting to speculate on the causes and repercussions of changing environments in Eastern Beringia toward the close of the late Wisconsin glaciation. The Bering Strait reopened then, and I postulate that easterly-moving storm tracks altered radically as a result, the new storms having their sources farther north in the Bering Strait, producing warmer, wetter conditions in Alaska and the Yukon. Consequently, cool, dry grasslands gave way to expanding spruce forests and boggy terrain there. Could such striking changes in vegetation have contributed substantially to the demise of large-horned bison (*Bison crassicornis* - apparently adapted to cool, dry grasslands), and the rise of western bison (*Bison bison occidentalis* - apparently adapted to moister, more heavily wooded habitat) about 12,000 years ago? Could other Pleistocene mammals that evidently flourished in Eastern Beringia during the late Wisconsin, such as woolly mammoths and Yukon wild asses, have succumbed because of the rapidity of such environmental changes at this critical period? Many problems like these await study.

REFERENCES *

Adams, A.L. 1881. Monograph on British fossil elephants. London. 265 pp.

Agadzhanyan, A.K. 1973. The arctic lemmings of the Pleistocene. In: Recent tectonics, recent deposits and man. Collection 5. Moscow. pp. 320-355.

Aguirre, E. 1969. Evolutionary history of the elephant. Science 164: 1366-1376.

Allen, J.A. 1913. Ontogenetic and other variations in muskoxen, with a systematic review of the muskox group, recent and extinct. Mem. Amer. Mus. Nat. Hist. N.S. No. 1, Pt. 4: 103-226.

American Kennel Club. 1975. The complete dog book. 15th Ed. Howell, New York. 672 pp.

Anderson, E. 1968. Fauna of the Little Box Elder Cave, Converse County, Wyoming. The Carnivora. Univ. Colorado Stud., Ser. Earth Sci. No. 6: 1-59.

______. 1970 Quaternary evolution of the genus *Martes* (Ca[illegible] Mustelidae). Acta Zool. Fennica 13[illegible]

______. 1973. Fer[illegible] om the Pleistocene of central Alaska. [illegible] 5[illegible] 3): 778-779.

---

* English trans[illegible] ny of the Russian papers listed are kept in the [illegible] Museums [illegible] Canada Library in Ottawa.

Anderson, E. and J.A. White. 1975. Caribou (Mammalia, Cervidae) in the Wisconsin of southern Idaho. Tebiwa 17(2): 59-65.

Andrée, J. 1933. Über diluviale Moschusochsen. Abhandl. Westfälischen Prov. Mus. f. Naturkunde 4: 5-34.

Anonymous. 1906. (Fossil bison from Yukon in Carnegie Museum). Science 24: 711.

Anonymous. 1975a. Racemization dating: further fine tuning. Science News 107: 349.

Anonymous. 1975b. Best friend. Sci. American 233(6): 50, 54.

Archaeological Team of the Provincial Museum of Liaoning. 1975. Discovery of Paleolithic artifacts in Gezidong Cave in Liaoning Province. Vertebrata Palasiatica 13(2): 129.

Armstrong, J.E., D.R. Crandell, D.J. Easterbrook and J.B. Noble. 1965. Late Pleistocene stratigraphy and chronology in southwestern British Columbia and northwestern Washington. Geol. Soc. Amer. Bull. 76: 321-330.

Atlas of Canada. 1974. Macmillan, Toronto. 4th Ed. Revised.

Augusta, J. and Z. Burian. 1963. A book of mammoths. Paul Hamlyn, London. 52 pp.

Azzaroli, A. 1953. The deer of the Weybourn Crag and Forest Bed of Norfolk. Bull. British Mus. (Nat. Hist.), Geology 2(1): 1-96.

Banfield, A.W.F. 1958. The mammals of Banff National Park, Alberta. Nat. Mus. Can. Bull. 159: 1-53.

_____. 1961. A revision of the reindeer and caribou, genus *Rangifer*. Nat. Mus. Can. Bull. No. 177: 1-137.

_____. 1974. The mammals of Canada. Univ. Toronto Press. Toronto and Buffalo. 438 pp.

Bannikov, A.G. 1971. The kulan - a maligned relative of the horse. Priroda 10: 90-95 (In Russian).

Barbour, E.H. 1931. The giant beaver, *Castoroides*, and the common beaver, *Castor*, in Nebraska. Nebraska State Mus. Bull. 20(1): 171-186.

Bazhanov, V.S. and N.N. Kostenko. 1962. Atlas of the index fossils of anthropogene mammals of Kazakhstan. Alma-Ata. Akad. Nauk Kaz. SSR Inst. Zool. 110 pp.

Bee, J.W. and E.R. Hall. 1956. Mammals of northern Alaska. Univ. Kansas Mus. Nat. Hist. Misc. Publ. No. 8: 1-309.

Benninghoff, W.S. and C.W. Hibbard. 1961. Fossil pollen associated with a late-glacial woodland musk ox in Michigan. Papers Michigan Acad. Sci., Arts, Letters 46: 155-159.

Bensley, B.A. 1913. A *Cervalces* antler from the Toronto interglacial. Univ. Toronto, Geol. Ser. No. 8: 1-3.

_____. 1923. A muskox skull from the Iroquois Beach deposits at Toronto: *Ovibos proximus* sp. nov. Univ. Toronto Stud., Biol. Ser. No. 23: 1-11.

Berger, R., A.G. Horney and W.F. Libby. 1964. Radiocarbon dating of bone and shell from their organic components. Science 144: 999-1001.

Bergerud, A.T. 1973. Movement and rutting behavior of caribou (*Rangifer tarandus*) at Mount Albert, Quebec. Can. Field Nat. 87: 357-369.

Berggren, W.A. and J.A. Van Couvering. 1974. The late Neogene. Biostratigraphy, geochronology and paleoclimatology of the last 15 million years in marine and continental sequences. Palaeogeogr. Palaeoclimatol. Palaeoecol. 16(1/2): 1-216.

Bishop, M.J. 1974. A preliminary report on the middle Pleistocene mammal bearing deposits of Westbury-Sub-Mendip, Somerset. Proc. Univ. Bristol Spelaeol. Soc. 13(3): 301-318.

Bjork, P.R. 1970. The Carnivora of the Hagerman local fauna (late Pliocene) of southwestern Idaho. Trans. Amer. Phil. Soc. N.S. 60, Pt. 7: 1-54.

Blake, W., Jr. 1970. Studies of glacial history in Arctic Canada. I. Pumice, radiocarbon dates, and differential postglacial uplift in the eastern Queen Elizabeth Islands. Can. J. Earth Sci. 7(2): 634-664.

Boorer, M. 1971. Wild cats. Bantam Books, Toronto, New York, London. 159 pp.

Bordes, F. 1968. The old stone age. McGraw-Hill, New York, Toronto. 255 pp.

Bostock, H.S. 1943. Ogilvie, Yukon Territory. Geol. Surv. Can. Map 711A.

_____. 1948. Physiography of the Canadian Cordillera, with special reference to the area north of the fifty-fifth parallel. Geol. Surv. Can. Mem. 247: 1-101.

_____. 1961. Physiography and resources of the northern Yukon. Can. Geogr. J. 63: 112-119.

Breyer, J. 1974. Examination of selected postcranial elements in Pleistocene camelids. Contrib. Geol. (Univ. Wyoming) 13(2): 75-85.

Broadbooks, H.E. 1965. Ecology and distribution of the pikas of Washington and Alaska. Amer. Midland Nat. 73(2): 299-335.

Brophy, J.A. 1965. A possible *Bison (Superbison) crassicornis* of mid-hypsithermal age from Mercer County, North Dakota. Proc. North Dakota Acad. Sci. 19: 214-223.

Brown, R.J.E. 1970. Permafrost in Canada; its influence on northern development. Univ. Toronto Press, Toronto. 234 pp.

_____ and W.O. Kupsch. 1974. Permafrost terminology. Nat. Res. Council Tech. Memorandum No. 111: 1-62.

Burton, M. 1965. Dictionary of the world's mammals. Sphere Books Ltd., London. 267 pp.

Cahn, A.R. 1932. Records and distribution of the fossil beaver, *Castoroides ohioensis*. J. Mamm. 13: 229-241.

Campbell, J.D. 1952. The paleobotany and stratigraphic sequence of the Pleistocene Klondike "muck deposits". Unpublished Ph.D. thesis, McGill Univ. Montreal. 131 pp.

Chaline, J. 1974. Esquisse de l'evolution morphologique, biométrique et chromosomique du genre *Microtus* (Arvicolidae, Rodentia) dans le Pléistocène de l'hémisphère nord. B.S.G.F. 7, 16(4): 440-450.

_____. 1975. Evolution et rapports phylétiques des Campagnols (Arvicolidae, Rodentia) apparentés à *Dolomys* et *Pliomys* dans l'hémisphère Nord. C.R. Acad. Sci. Paris 281 Ser. D: 33-36.

Choquette, L.P.E., C.R. Harington and J. Archibald. 1975. Paleopathology: exostoses of the third metacarpal in Pleistocene horses from the Yukon Territory. Can. J. Earth Sci. 12(6): 1053-1058.

Churcher, C.S. 1966. The affinities of Dinobastis serus Cope 1893. Quaternaria 8: 263-275.

_____. 1968a. Mammoth from the middle Wisconsin of Woodbridge, Ontario. Can. J. Zool. 46: 219-221.

_____. 1968b. Pleistocene ungulates from the Bow River gravels at Cochrane, Alberta. Can. J. Earth Sci. 5: 1467-1488.

_____ and P.F. Karrow. 1963. Mammals of Lake Iroquois age. Can. J. Zool. 41: 153-158.

_____ and A.V. Morgan. 1976. A grizzly bear from the middle Wisconsin of Woodbridge, Ontario. Can. J. Earth Sci. 13: 341-34

Clark, T.H. 1927. A fossil bison skull from Yukon Territory. Can. Field Nat. 41(3): 45-47.

Clutton-Brock, J. 1969. The origins of the dog. In: D. Brothwell and E. Higgs, Eds. Science in archaeology. Thames and Hudson, Bristol. pp. 303-309.

Colbert, E.H. 1968. Men and dinosaurs. E.P. Dutton & Co. New York. 283 pp.

Coleman, A.P. 1899. The Iroquois beach at Toronto and its fossils. Ottawa Nat. 12: 195.

Cook, H.J. 1931. A Pleistocene fauna from southern Nebraska. J. Mamm. 12: 273-280.

Corbet, G.B. 1966. The terrestrial mammals of Western Europe. Whitefriars Press, London. 264 pp.

Cornwall, I.W. 1964. Bones for the archaeologist. Phoenix House, London. 259 pp.

_____. 1968. Prehistoric animals and their hunters. Faber and Faber, London. 214 pp.

Cowan, I. McT. 1940. Distribution and variation in the native sheep of North America. Amer. Midland Nat. 24(3): 505-580.

_____. 1941. Fossil and subfossil mammals from the Quaternary of British Columbia. Trans. Roy. Soc. Can. 35, Sec. 4: 39-50.

_____. 1954. The occurrence of the Pleistocene wolf *Canis dirus* in the Rocky Mountains of central Alberta. Can. Field Nat. 168: 44.

_____ and G.J. Guiguet. 1965. The mammals of British Columbia. B.C. Prov. Mus. Handbook No. 11: 1-414. 3rd Ed. Revised.

Dawson, G.M. 1894. Notes on the occurrence of mammoth remains in the Yukon district of Canada and in Alaska. Quart. J. Geol. Soc. London 50: 1-9.

_____. 1901. (Skull of an extinct bison). Geol. Surv. Can. Summ. Rept. 1900: 185A.

Dawson, M.R. 1967. Lagomorph history and the stratigraphic record. Univ. Kansas Dept. Geol. Spec. Publ. 2: 287-316.

Dechaseaux, C. 1967. Un Castoridé du Pléistocène d'Europe *Trogontherium boisvilletti*; Etude du crane-type et du moulage endocranien. Annales de Paléontologie; Vertébrés 53(2): 121-160.

Degerbøl, M. 1961. On a find of a preboreal domestic dog (*Canis familiaris* L.) from Star Carr, Yorkshire, with remarks on other Mesolithic dogs. Proc. Prehistoric Soc. N.S. 27: 35-55.

Delorme, L.D. 1968. Pleistocene freshwater ostracoda from Yukon, Canada. Can. J. Zool. 46(5): 859-876.

Dietrich, W.O. 1938. Zur Kenntnis der oberpliozänen echten Hirsche. Zeitschr. Deutsch. geol. Ges. 90: 261-267.

_____. 1959. *Hemionus* Pallas im Pleistozän von Berlin. Vertebrata Palasiatica 3: 13-22.

Dodge, W.P. and S.A. Korff. 1953. Exploration expeditions contemplated and in the field. Explorer's J. 31(1-2): 11.

Dillon, L.S. 1956. Wisconsin climate and life zones in North America. Science 123(3188): 167-176.

Dreimanis, A. 1967. Mastodons, their geologic age and extinction in Ontario, Canada. Can. J. Earth Sci. 4: 663-675.

_____.1968. Extinction of mastodons in eastern North America: testing a new climatic-environmental hypothesis. Ohio J. Sci. 68(6): 257-272.

Dyck, W. 1967. The Geological Survey of Canada Radiocarbon Dating Laboratory. Geol. Surv. Can. Paper 66-45: 1-45.

Elton, C.S. 1954. Further evidence about the barren ground grizzly bear in northeast Labrador and Quebec. J. Mamm. 35: 345-357.

Erdbrink, D.P. 1953. A review of fossil and recent bears of the Old World. Jan De Lange, Deventer. 597 pp.

Erickson, B.R. 1962. A description of *Castoroides ohioensis* from Minnesota. Proc. Minnesota Acad. Sci. 30(1): 6-13.

_____.1967. Paleontological evidence concerning some post glacial features of the Mississippi Ri valley. Sci. Publ. Sci. Mus. (Saint Paul, Minnesota) 1(2): 1-4.

Evans, G.L. 1961. The Friesenhahn Cave. Bull. Texas Memorial Mus. No. 2: 7-22.

Ewer, R.F. 1965. Large carnivora of Bed II. In: L.S.B. Leakey, Ed. Olduvai Gorge 1951-61, 1. Cambridge Univ. Press, Cambridge. pp. 21-22.

Farrand, W.R. 1961. Frozen mammoths and modern geology. Science 133: 729-735.

Fedichuk, G. 1970. Recent archaeological investigations at Fisherman Lake: the Julian Site. In: R.A. Smith and J.W. Smith, Eds. Early man and environments in northwest North America. Univ. Calgary Students' Press, Calgary. pp. 105-112.

Fedyk, S. 1970. Chromosomes of *Microtus (Stenocranius) gregalis major* (Ognev, 1923) and phylogenetic connections between sub-arctic representatives of the genus *Microtus* Shrank, 1798. Acta Theriol. 15(9): 143-152.

Fejfar, O. 1966. Uber zwei neue Säugetiere aus dem Altpleistozän von Böhmen. N. Jahrb. Geol. u. Paläontol., Monatschr. 11: 680-691.

Fielden, H.W. and C.E. De Rance. 1878. Geology of the coasts of the arctic lands visited by the British Expedition under Capt. Sir George Nares. Quart. J. Geol. Soc. London 34: 556-567.

Flerov, K.K. 1972. The earliest forms and history of the genus *Bison*. Akad. Nauk SSR. Siberian Division. Amalgamated Sci. Council of Biol. Sci. Theriol. 1: 81-86. (In Russian).

Flerov, K.K. and M.A. Zablotski. 1961. The reasons for changes in the geographical range of bison. Bull. Moscow Nat. Soc. 66(6): 99-109.

Flint, R.F. 1971. Glacial and Quaternary geology. John Wiley and Sons, New York. 892 pp.

Forsten, A. 1973. Evolutionary changes in the metapodials of fossil horses. Soc. Sci. Fennica 69: 1-18.

Frenzel, B. 1968. The Pleistocene vegetation of northern Eurasia. Science 161: 637-649.

_____. 1973. Climatic fluctuations of the ice age. Case Western Reserve Univ. Press. Cleveland and London. 306 pp.

Freudenberg, W. 1910. Die Säugetierfauna des Pliocäns und Postpliocäns von Mexico. 1. Carnivoren. Geol. Paläontol. Abh. N.F. 9(3): 195-231.

Frick, C. 1930. Alaska's frozen fauna. Nat. Hist. 30: 71-80.

_____. 1933. New remains of trilophodont-tetrabelodont mastodons. Bull. Amer. Mus. Nat. Hist. 59(9): 505-652.

_____. 1937. Horned ruminants of North America. Bull. Amer. Mus. Nat. Hist. 69: 1-669.

Fuller, W.A. 1962. The biology and management of the bison of Wood Buffalo National Park. Can. Wildl. Serv., Wildl. Management Bull. Ser. 1, No. 16: 1-52.

Fuller, W.A. and L.A. Bayrock. 1965. Late Pleistocene mammals from central Alberta, Canada. In: C.R. Stelck, Ed. Vertebrate paleontology in Alberta. Dept. Geol., Univ. Alberta, Edmonton. pp. 53-63.

Gazin, C.L. 1933. The status of the extinct American "Eland". J. Mamm. 14(2): 162-164.

Geist, O.W. 1953. Collecting Pleistocene fossils in Alaska. Proc. Second Alaskan Sci. Conf.: 171-172.

______. 1955. Vertebrate paleontological reconnaissance of the Old Crow River area, Yukon Territory, Canada. Bull. Geol. Soc. Amer. 66: 1702.

______. 1956 MS. Scientific investigations in the Old Crow and Porcupine River regions of Alaska and Yukon Territory 1952-1953. 108 pp. (On file at the Univ. Alaska, College).

Geist, V. 1971a. The relation of social evolution and dispersal in ungulates during the Pleistocene, with emphasis on the Old World deer and the genus *Bison*. Quaternary Res. 1: 283-315.

______. 1971b. Mountain sheep: a study in behaviour and evolution. Univ. Chicago Press, Chicago. 384 pp.

Geological Survey of Canada. 1957. Geological map of the Yukon Territory. Geol. Surv. Can. Map 1048A.

Gidley, J.W. 1900. A new species of Pleistocene horse from the staked plains of Texas. Bull. Amer. Mus. Nat. Hist. 12: 111-116.

______.1913. Notice of the occurrence of a Pleistocene camel north of the Arctic Circle. Smithsonian Misc. Coll. 60(26): 1-2.

______ and C.L. Gazin. 1938. The Pleistocene vertebrate fauna from Cumberland Cave, Maryland. U.S. Nat. Mus. Bull. 171: 1-93.

Gilmore, C.W. 1908. Smithsonian exploration in Alaska in 1907 in search of Pleistocene fossil vertebrates. Smithsonian Misc. Coll. 51(3): 1-38.

______.1941. A history of the Division of Vertebrate Paleontology in the United States National Museum. Proc. U.S. Nat. Mus. 90(3109): 305-377.

Giterman, R. Ye. 1973. Vegetation of Pleistocene cold epochs of the Kolyma Lowland in connection with the problem of landscapes of polar Beringia. In: The Bering land bridge and its role for the history of Holarctic floras and faunas in the late Cenozoic. Acad. Sci. USSR, Far-Eastern Scientific Centre. Khabarovsk. pp. 65-68.

Green, M. and J.A. Lillegraven. 1965. Significance of *Rangifer* in the Herrick Formation of South Dakota. Proc. South Dakota Acad. Sci. 44: 48-51.

Gromov, V.I. 1935. The outward appearance of the cave lion in connection with some archaeological findings. Problemy istorii dokapitalisticheeskikh obshchestv. No. 1-2: 165-168. (In Russian).

______. 1948. Palaeontological and archaeological evidence on the stratigraphy of continental Quaternary deposits on the territory of the USSR. Trudy Inst. Geol. Nauk. 64, Geol. Ser. 17: 1-521. (In Russian).

Gromova, V.I. 1935. On the distribution of remains of the muskox *Ovibos moschatus* in eastern and northern Asia. Izvestiia Akad. Nauk SSSR No. 1: 101-114.

______. 1960. Determination of mammals of the USSR by bones of the skeleton. Acad. Sci. USSR, Trans. Commission in Study of the Quaternary Period 16: 1-116 (In Russian).

______. 1968. Fundamentals of paleontology. Vol. 13. Israel Program for Sci. Transl., Jerusalem. 585 pp.

Groves, C.P. 1974. Horses, asses, and zebras in the wild. David and Charles, Newton Abbot, London. 192 pp.

______ and V. Mazák. 1967. On some taxonomic problems of Asiatic wild asses; with the description of a new subspecies (Perissodactyla; Equidae). Zeitschr. f. Säugetierk. 32: 321-355.

Guilday, J.E. 1963. Pleistocene zoogeography of the lemming, *Dicrostonyx*. Evolution 17(2): 194-197.

______. 1965. *Rangifer* antler from an Ohio bog. J. Mamm. 47(2): 325-326.

______. 1968a. Grizzly bears from eastern North America. Amer. Midland Nat. 79(1): 247-250.

______. 1968b. Pleistocene zoogeography of the lemming *Dicrostonyx*. Univ. Colorado Ser. Earth Sci. No. 6: 65-71.

______. 1969. Small mammal remains from the Wasden Site (Owl Cave), Bonneville County, Idaho. Tebiwa 12(1): 47-62.

______. 1971. The Pleistocene history of the Appalachian mammal fauna. In: P.C. Holt, Ed., with the assistance of R.A. Paterson and J.P. Hubbard. The distributional history of the biota of the southern Appalachians. Part III: Vertebrates. Res. Div. Monogr. 4. Virginia Polytechnic Inst. and State Univ., Blacksburg, Virginia. pp. 233-262.

______ and E.K. Adam. 1967. Small mammal remains from Jaguar Cave, Lemhi County, Idaho. Tebiwa 10(1): 26-35.

______ and M.S. Bender. 1960. Late Pleistocene records of the yellow-cheeked vole, *Microtus xanthognathus* (Leach). Ann. Carnegie Mus. 35: 315-330.

Guilday, J.E., H.W. Hamilton and A.D. McCrady. 1969. The Pleistocene vertebrate fauna of Robinson Cave, Overton County, Tennessee. Palaeovertebrata 2: 25-75.

_____ and H.W. Hamilton. 1975. Caribou (*Rangifer tarandus* L.) from the Pleistocene of Tennessee. J. Tennessee Acad. Sci. 50(3): 109-112.

Guthrie, R.D. 1966a. The extinct wapiti of Ala Yukon Territory. Can. J. Zool. 44: 47-5

_____. 1966b. Pelage of fossil bison - a new osteo index. J. Mamm. 47: 725-727.

_____. 1968a. Paleoecology of a Late Pleistocene small mammal community from interior Alaska. Arctic 21(4): 223-244.

_____. 1968b. Paleoecology of the large-mammal community in interior Alaska during the late Pleistocene. Amer. Midland Nat. 79(2): 346-363.

_____. 1970. Bison evolution and zoogeography in North America during the Pleistocene. Quart. Rev. Biol. 45(1): 1-15.

_____. 1972. Re-creating a vanished world. Nat. Geogr. 141(3): 294-301. With a colored wall chart "Ice Age Mammals of the Alaskan Tundra".

Guthrie, R.D. 1973. Mummified pika (*Ochotona*) carcass and dung pellets from Pleistocene deposits in interior Alaska. J. Mamm. 54(4): 970-971.

_____ and J.V. Matthews, Jr. 1971. The Cape Deceit fauna - early Pleistocene mammalian assemblage from the Alaskan Arctic. Quaternary Res. 1: 474-510.

Hagmeier, E.M. 1959. A re-evalutaion of the subspecies of fisher. Can. Field Nat. 73(4): 185-197.

Hall, E.R. 1936. Mustelid mammals from the Pleistocene of North America, with systematic notes on some recent members of the genera *Mustela*, *Taxidea* and *Mephitis*. Carnegie Inst. Washington Publ. 473: 41-119.

Hall, S.A. 1972. Holocene *Bison occidentalis* from Iowa. J. Mamm. 53(3): 604-606.

Hallberg, G.R., H.A. Semken and L.C. Davis. 1974. Quaternary records of *Microtus xanthognathus* (Leach), the yellow-cheeked vole, from northwestern Arkansas and southwestern Iowa. J. Mamm. 55(3): 640-645.

Harington, C.R. 1961. History, distribution, and ecology of the muskoxen. Unpublished M.Sc. thesis, McGill Univ., Montreal. 489 pp.

Harington, C.R. 1964. Remarks on Devon Island muskoxen. Can. J. Zool. 42: 79-86.

______. 1968. A Pleistocene muskox *(Symbos)* from Dease Lake, British Columbia. Can. J. Earth Sci. 5(5): 1161-1165.

______. 1969. Pleistocene remains of the lion-like cat *(Panthera atrox)* from the Yukon Territory and northern Alaska. Can. J. Earth Sci. 6(5): 1277-1288.

______. 1970a. Ice age mammal research in the Yukon Territory and Alaska. In: R.A. Smith and J.W. Smith, Eds. Early man and environments in northwest North America. Univ. Calgary Students' Press, Calgary. pp. 35-51.

______. 1970b. A postglacial muskox *(Ovibos moschatus)* from Grandview, Manitoba, and comments on the zoogeography of *Ovibos*. Nat. Mus. Can. Publ. Palaeontol. No. 2: 1-13.

______. 1970c. A Pleistocene muskox *(Ovibos moschatus)* from gravels of Illinoian age near Nome, Alaska. Can. J. Earth Sci. 7(5): 1326-1331.

______. 1971a. Ice age mammals in Canada. Arctic Circular 22(2): 66-89.

Harington, C.R. 1971b. A Pleistocene mountain goat from British Columbia and comments on the dispersal history of *Oreamnos*. Can. J. Earth Sci. 8(9): 1081-1093.

______. 1971c. A Pleistocene lion-like cat *(Panthera atrox)* from Alberta. Can. J. Earth Sci. 8(1): 170-174.

______. 1972. The Champlain Sea and its vertebrate fauna. Pt. II. Vertebrates of the Champlain Sea. Trail & Landscape 6(1): 33-39.

______. 1973. A short-faced bear from ice age deposits at Lebret, Saskatchewan. Blue Jay 31(1): 11-14.

______. 1974. Animal life in the ice age. Can. Geogr. J. 88(4): 38-43.

______. 1975a. Evidence of early man in the Old Crow Basin, Yukon Territory. Arctic Circular 22(3): 118-128.

______. 1975b. A bone tool found with ice age mammal remains near Dawson City, Yukon Territory. Arctic Circular 23(1): 2-5.

______. 1975c. Pleistocene muskoxen *(Symbos)* from Alberta and British Columbia. Can. J. Earth Sci. 12(6): 903-919.

______. 1976 MS. Quaternary vertebrate faunas of Canada and Alaska and their suggested chronological sequence. 119 pp.

Harington, C.R., R. Bonnichsen and R.E. Morlan. 1975. Bones say man lived in Yukon 27,000 years ago. Can. Geogr. J. 91: 42-48.

______ and F.V. Clulow. 1973. Pleistocene mammals from Gold Run Creek, Yukon Territory. Can. J. Earth Sci. 10(5): 697-759.

______, Macpherson, A.H. and J.P. Kelsall. 1962. The barren ground grizzly bear in northern Canada. Arctic 15(4): 294-298.

______ and D.E. Sergeant. 1972. Pleistocene ringed seal skeleton from the Champlain Sea deposits near Hull, Quebec - a reidentification. Can. J. Earth Sci. 9(8): 1039-1051.

______, H.W. Tipper and R.J. Mott. 1974. Mammoth from Babine Lake, British Columbia. Can. J. Earth Sci. 11(2): 285-303.

Harper, F. 1961. Land and freshwater mammals of the Ungava Peninsula. Univ. Kansas Mus. Nat. Hist. Misc. Publ. No. 27: 1-178.

Harris, A.H. and P. Mundel. 1974. Size reduction in bighorn sheep (Ovis canadensis) at the close of the Pleistocene. J. Mamm. 55(3): 678-680.

Harrison, D.L. 1973. Some comparative features of the skulls of wolves (*Canis lupus* Linn.) and pariah dogs (*Canis familiaris* Linn.) from the Arabian Peninsula and neighbouring lands. Bonn. Zool. Beitr. 24: 185-191.

Hay, O.P. 1913a. The extinct bisons of North America; with description of one new species, *Bison regius*. Proc. U.S. Nat. Mus. 46: 161-200.

______.1913b. Notes on some fossil horses with descriptions of four new species. Proc. U.S. Nat. Mus. 44: 569-594.

______.1914. The Pleistocene mammals of Iowa. Geol. Surv. Iowa, Ann. Rept. 1912: 1-662.

______.1917. Description of a new species of extinct horse, *Equus lambei*, from the Pleistocene of Yukon Territory. Proc. U.S. Nat. Mus. 53: 435-443.

______.1923a. Characteristics of sundry fossil vertebrates. I. Additional specimens of *Equus lambei* from the Yukon. Pan-Amer. Geol. 39: 101-103.

______.1923b. The Pleistocene of North America and its vertebrated animals from the states east of the Mississippi River and from the Canadian provinces east of longitude 95°. Carnegie Inst. Washington Publ. 322: 1-499.

Hay, O.P. 1924. The Pleistocene of the middle region of North America and its vertebrated animals. Carnegie Inst. Washington Publ. 322A: 1-385.

Heck, H., D. Wurster and K. Benirschke. 1967. Chromosome study of members of the subfamilies Caprinae and Bovinae, family Bovidae; the musk ox, ibex, aoudad, Congo buffalo and gaur. Zeitschr. f. Säugetierk. 33(3): 172-179.

Heintz, A. 1955. The mammoth teeth from Norway. Norsk Geol. Tidsskrift 34(2-4): 73-104.

_____. 1962. Three new finds of mammoth in Norway. Norsk Geol. Tidsskrift 42(3): 207-222.

_____ and V.E. Garutt. 1965. Determination of the absolute age of the fossil remains of mammoth and woolly rhinoceros from the permafrost in Siberia by the help of radio carbon (C_{14}). Norsk Geol. Tidsskrift 45, Pt. 1: 1-79.

Hemmer, H. 1974. Untersuchungen zur Stammesgeschichte der Pantherkatzen (Pantherinae). Teil 3. Zur Artgeschichte des Löwen *Panthera (Panthera) leo* (Linnaeus 1758). Veröff. Zool. Staatssamml. München 17: [illegible]67-280.

Heptner, W.G. and A.A. Nasimowitsch. 1967. Der Elch (*Alces alces* L.). Die Neue Brehm-Bücherei. A. Ziemsen Verlag, Wittenberg Lutherstadt. 231 pp.

Hibbard, C.W. 1943. *Etadonomys*, a new Pleistocene heteromyid rodent, and notes on other Kansas mammals. Trans. Kansas Acad. Sci. 46: 185-191.

______. 1949. Techniques of collecting microvertebrate fossils. Contrib. Mus. Paleontol. Univ. Michigan. 8(2): 7-19.

______. 1951. Animal life in Michigan during the ice age. Michigan Alumnus Quart. Rev. 57: 200-208.

______. 1955a. Pleistocene vertebrate remains from the Upper Becerra (Becerra Superior) Formation, Valley of Tequixquiac, Mexico, with notes on other Pleistocene forms. Contrib. Mus. Paleontol. Univ. Michigan 12(5): 47-96.

______. 1955b. The Jinglebob interglacial (Sangamon?) fauna from Kansas and its climatic significance. Univ. Michigan Mus. Paleontol. Contrib. 12(10): 179-228.

______. 1956. Vertebrate fossils from the Meade Formation of southwestern Kansas. Papers Michigan Acad. Sci., Arts, Letters 41: 145-203.

______. 1958. Summary of North American Pleistocene mammalian local faunas. Papers Michigan Acad. Sci., Arts, Letters 43: 3-32.

______. 1963. A late Illinoian fauna from Kansas and its climatic significance. Papers Michigan Acad. Sci., Arts, Letters 48: 187-221.

Hibbard, C.W. 1970. Pleistocene mammalian local faunas from the Great Plains and Central Lowland Provinces of the United States. Dept. Geol., Univ. Kansas Spec. Publ. 3: 395-433.

_____ and F.J. Hinds. 1960. A radiocarbon date for a woodland musk ox in Michigan. Papers Michigan Acad. Sci., Arts, Letters 45: 103-111.

_____ and R.J. Zakrzewski. 1967. Phyletic trends in the late Cenozoic microtine *Ophiomys* gen. nov., from Idaho. Papers Michigan Acad. Sci. 21: 255-271.

Hill, J.E. 1942. *Citellus par* from the Pleistocene of Alaska. Geol. Soc. Amer. Bull. 53: 1842.

Hills, L.V. and R.T. Ogilvie. 1970. *Picea banksii* n. sp. Beaufort Formation (Tertiary) northwestern Banks Island, Arctic Canada. Can. J. Bot. 48(3): 457-464.

Hinton, M.A. 1926. Monograph of the voles and lemmings (Microtinae) living and extinct. Vol. 1. British Mus. Nat. Hist., London. 488 pp.

Hirschfeld, S.E. and S.D. Webb. 1968. Plio-Pleistocene megalonychid sloths of North America. Bull. Florida State Mus. 12(5): 213-296.

Holland, W.J. 1915. (On a Pleistocene bison skull from near Dawson, Y.T., deposited in the Carnegie Museum). Carnegie Mus. Annals 9: 225.

Hopkins, D.M. 1967. The Cenozoic history of Beringia - a synthesis. In: D.M. Hopkins, Ed. The Bering land bridge. Stanford Univ. Press, Stanford. pp. 451-481.

Howe, J.A. 1970. The range of variation in *Equus (Plesippus) simplicidens* Cope from the Broadwater quarries of Nebraska. J. Paleontol. 44(5): 958-968.

Hughes, O.L. 1969. Pleistocene stratigraphy, Porcupine and Old Crow River, Yukon Territory. Geol. Surv. Can. Paper 69-1 Pt. A.: 209-212.

______. 1972. Surficial geology of northern Yukon Territory and northwestern District of Mackenzie, Northwest Territories. Geol. Surv. Can. Paper 69-36: 1-11.

______ and V. Rampton. 1972. Geomorphology and auriferous deposits of the Klondike District. In: D.J. Glass, Ed. Quaternary geology and geomorphology, southern and central Yukon (Northern Canada). 24th Internat. Geol. Congr. Excursion A-11. pp. 30-36.

Hunter, H.A. and W. Langston, Jr. 1965. Odontoma in a northern mammoth. Palaeontology 7: 674-681.

Irving, W.N. and C.R. Harington. 1973. Upper Pleistocene radiocarbon-dated artefacts from the northern Yukon. Science 179(4071): 335-340.

nossy, D. 1954. Fossile Microtinen aus dem Karpatenbecken. I. Lemminge. Ann. Hist. Nat. Mus. Nation. Hungarici 5: 39-48.

Jeletzky, J.A. 1975. Jurassic and lower Cretaceous paleogeography and depositional tectonics of Porcupine Plateau, adjacent areas of northern Yukon and those of Mackenzie District. Geol. Surv. Can. 74-16: 1-52.

Johnson, N.M., N.D. Opdyke and E.H. Lindsay. 1975. Magnetic polarity stratigraphy of Pliocene-Pleistocene terrestrial deposits and vertebrate faunas, San Pedro Valley, Arizona. Geol. Soc. Amer. Bull. 86(1): 5-12.

Johnson, R. 1874. Notes of a new species of deer from the Norfolk Forest-Bed. Ann. Mag. Nat. Hist. Ser. 13(73): 1-4.

Kahlke, H.D. 1956a. Die Cervidenreste aus den altpleistozänen Ilmkiesen von Süssenborn bei Weimar. Vol. I. Akademie-Verlag, Berlin. 62 pp.

_____.1956b. Die Cervidentreste aus den altpleistozänen Ilmkiesen von Süssenborn bei Weimar. Vol. II. Akademie-Verlag, Berlin. 44 pp.

_____.1959. Die Cervidenreste aus den altpleistozänen Ilmkiesen von Süssenborn bei Weimar. Vol. III. Akademie-Verlag, Berlin. 44 pp.

Kahlke, H.D. 1964. Early middle Pleistocene (Mindel/ Elster) *Praeovibos* and *Ovibos*. Soc. Sci. Fennica, Commentat. Biol. 26(5): 1-17.

______. 1973. The macro-faunas of continental Europe during the middle Pleistocene: stratigraphic sequence and problems of inter-correlation. Wenner-Gren Foundation Anthropol. Res., Burg Wartenstein Symp. No. 58: 1-60.

Kelsall, J.P. 1968. The migratory barren-ground caribou of Canada. Can. Wild. Serv. Monogr. 3: 1-340.

Kennedy, G.E. 1975. Early man in the New World. Nature 255: 274-275.

Khan, E. 1970. Biostratigraphy and palaeontology of a Sangamon deposit at Fort Qu'Appelle, Saskatchewan. Nat. Mus. Can. Publ. Palaeontol. No. 5: 1-82.

Khaveson, Ya. I. 1954. Tertiary camels of the Eastern Hemisphere (Genus *Paracamelus*). Akad. Nauk SSSR. Paleontol. Inst. No. 47: 100-162. (In Russian).

Kind, N.V. 1967. Radiocarbon chronology in Siberia. In: D.M. Hopkins, Ed. The Bering land bridge. Stanford Univ. Press, Stanford. pp. 172-192.

Klein, R.G. 1973. Ice age hunters of the Ukraine. Univ. Chicago Press, Chicago. 140 pp.

Koby, F.E. 1941. Contribution à l'étude de *Felis spelaea* Goldf. Verh. Naturforsch. Ges. Basel 52: 168-188.

Korobitsyna, K.V., C.F. Nadler, N.N. Vorontsov and R.S. Hoffman. 1974. Chromosomes of the Siberian snow sheep, *Ovis nivicola*, and implications concerning the origin of amphiberingian wild sheep (subgenus *Pachyceros*). Quaternary Res. 4(3): 235-245.

Korotkevich, E.L. and Yu. A. Semenov. 1975. First finding of Neogene *Plesiogulo crassa* in the northern Black Sea area. Vestnik Zoologii No. 4: 33-38. (In Russian).

Kraft, J.C. and R.A. Thomas. 1976. Early man at Holly Oak, Delaware. Science 192: 756-761.

Kretzoi, M. 1942. A peszmatulok Magyarországon. Föld. Közlöny 72: 263-265.

Kurtén, B. 1960. A skull of the grizzly bear (*Ursus arctos* L.) from Pit 10, Rancho La Brea. Los Angeles County Mus. Contrib. Sci. No. 39: 1-7.

______. 1966. A late-glacial find of arctic fox (*Alopex lagopus* L.) from southwestern Finland. Soc. Sci. Fennica, Commentat. Biol. 29(6): 1-7.

______. 1967. Pleistocene bears of North America. 2. Genus *Arctodus*, short-faced bears. Acta Zool. Fennica 117: 1-60.

______. 1968. Pleistocene mammals of Europe. Weidenfeld and Nicolson, London. 317 pp.

______. 1971. The age of mammals. Weidenfeld and Nicolson, London. 250 pp.

______. 1973a. Geographic variation in size in the puma (*Felis concolor*). Soc. Sci. Fennica, Commentat. Biol. 63: 1-8.

Kurtén, B. 1973b. Fossil glutton (*Gulo gulo* (L.)) from Tornewton Cave, South Devon. Soc. Sci. Fennica, Commentat. Biol. 66: 1-8.

_____ and E. Anderson. 1972. The sediments and fauna of Jaguar Cave: II - The fauna. Tebiwa 15(1): 21-45.

_____ and _____. 1974. Association of *Ursus arctos* and *Arctodus simus* (Mammalia: Ursidae) in the late Pleistocene of Wyoming. Breviora No. 426: 1-6.

_____ and R. Rausch. 1959. A comparison between Alaskan and Fennoscandian wolverine (*Gulo gulo* Linnaeus). Biometric comparisons between North American and European mammals. Acta Arctica 11. Pt. I: 5-20.

La Baume, W. 1962. Zur Abstammung und Herkunst des Haushundes. Paideuma. Mitt. zur Kulturkunde 8: 166-174.

Lambe, L.M. 1898. On the remains of mammoth in the Geological Survey Department. Ottawa Nat. 12: 136-137.

_____. 1911a. Paleontological Division. Geol. Surv. Can. Summ. Rept. 1910: 269-273.

_____. 1911b. On *Arctotherium* from the Pleistocene of Yukon. Ottawa Nat. 25: 21-26.

_____. 1912. Paleontological Division. Geol. Surv. Can. Summ. Rept. 1911: 346-357.

Lambe, L.M. 1914. Report of the Vertebrate Paleontologist. Geol. Surv. Can. Summ. Rept. 1912: 397-403.

Laming, A. 1959. Lascaux: paintings and engravings. Penguin Books, Harmondsworth. 208 pp.

Larsen, H. 1968. Trail Creek. Acta Arctica 15: 1-80.

Lavrov, L.S. and V.N. Orlov. 1973. Karyotypes and taxonomy of modern beavers (*Castor*, Castoridae, Mammalia). Zool Zhurnal 52(5): 734-742.

Lawrence, B. 1967. Early domestic dogs. Zeitschr. f. Säugetierk. 32(1): 44-59.

______.1968. Antiquity of large dogs in North America. Tebiwa 11(2): 43-49.

Lawrence, J.R. 1973. Old Crow Basin. In: R.G. McC Ed. The future petroleum provinces of Canada. Can. Soc. Petrol. Geologists. Mem. 1. 307-314.

Leidy, J. 1853. Description of an extinct species of American lion: *Felis atrox*. Trans. Amer. Phil. Soc. N.S. 10: 319-321.

______.1855. A memoir on the extinct sloth tribe of North America. Smithsonian Contrib. Knowledge 7: 1-68.

Leith, E.I. 1949. Fossil elephants of Manitoba. Can. Field Nat. 63: 135-137.

Lemon, R.R.H. and C.S. Churcher. 1961. Pleistocene geology and paleontology of the Talara region, northwest Peru. Amer. J. Sci. 259: 410-429.

Lichti-Federovich, S. 1973. Palynology of six sections of late Quaternary sediments from the Old Crow River, Yukon Territory. Can. J. Earth Sci. 51(3): 553-564.

______.1974. Palynology of two sections of late Quaternary sediments from the Porcupine River, Yukon Territory. Geol. Surv. Can. Paper 74-23: 1-6.

Lucas, F.A. 1899. The fossil bison of North America. Proc. U.S. Nat. Mus. 21: 755-771.

Lundelius, E.L. 1972. Fossil vertebrates from the late Pleistocene Ingleside fauna, San Patricio County, Texas. Univ. Texas, Bur. Econ. Geol. Rept. Invest. 77: 1-74.

______ and M.S. Stevens. 1970. *Equus francisci* Hay, a small stilt-legged horse, middle Pleistocene of Texas. J. Paleontol. 44(1): 148-153.

Lydekker, R. 1885. Catalogue of the fossil Mammalia in the British Museum (Natural History). Pt. 2: 1-323.

______.1886. Catalogue of the fossil Mammalia in the British Museum (Natural History). Pt. 4: 1-233.

MacDonald, G.F. 1971. A review of research on Paleo-Indian in eastern North America, 1960-1970. Arctic Anthropol. 8(2): 32-41.

Mackay, J.R. 1958. The Anderson River map-area, N.W.T. Dept. Mines and Tech. Surv., Geogr. Br. Mem. 5: 1-137.

______, W.H. Mathews and R.S. MacNeish. 1961. Geology of the Engigstciak archaeological site, Yukon Territory. Arctic 14(1): 25-52.

Macpherson, A.H. 1964. A northward range extension of the red fox in the eastern Canadian Arctic. J. Mamm. 45: 138-140.

______. 1965. The origin of diversity in mammals of the Canadian Arctic tundra. Systematic Zool. 14(3): 153-173.

Maddren, A.G. 1907. Smithsonian exploration in Alaska in 1904 in search of mammoth and other fossil remains. Smithsonian Misc. Coll. 49: 1-117.

Maglio, V.J. 1973. Origin and evolution of the Elephantidae. Trans. Amer. Phil. Soc. N.S. 63, Pt. 3: 1-149.

Maher, W.J. 1968. Muskox bone of possible Wisconsin age from Banks Island, Northwest Territories. Arctic 21(4): 260-266.

Mansfield, A.W. 1967. Seals of arctic and eastern Canada. Fisheries Res. Bd. Can. Bull. No. 137: 1-35. 2nd Ed. Revised.

Martin, P.S. and J.E. Guilday. 1967. A bestiary for Pleistocene biologists. In: P.S. Martin and H.E. Wright, Jr., Eds. Pleistocene extinctions. Yale Univ. Press, New Haven and London. pp. 1-62.

Martin, R.A. 1969. Taxonomy of the giant Pleistocene beaver *Castoroides* from Florida. J. Paleontol. 43(4): 1033-1041.

_____ and R. Tedesco. 1974 MS. *Ondatra annectens* (Mammalia: Rodentia) from the Pleistocene Java local fauna of South Dakota. 14 pp.

Matthews, J.V., Jr. 1974. Wisconsin environment of interior Alaska: pollen and macrofossil analysis of a 27 meter core from the Isabella Basin (Fairbanks, Alaska). Can. J. Earth Sci. 11(6): 828-841.

_____. 1975. Insects and plant macrofossils from two Quaternary exposures in the Old Crow - Porcupine region, Yukon Territory, Canada. Arctic and Alpine Res. 7(3): 249-259.

Mawby, J.E. 1965. Machairodonts from the late Cenozoic of the Panhandle of Texas. J. Mamm. 46(4): 573-587.

Mazák, V. 1970. On a supposed prehistoric representation of the Pleistocene scimitar cat, *Homotherium* Fabrini, 1890 (Mammalia; Machairodontidae). Zeitschr. f. Säugetierk. 35(6): 359-362.

McAllister, D.E. and C.R. Harington. 1969. Pleistocene grayling, *Thymallus*, from Yukon, Canada. Can. J. Earth Sci. 6(5): 1185-1190.

McConnell, R.G. 1903. Report on the Klondike gold fields. Geol. Surv. Can. Ann. Rept. 13, 1900, Pt. A: 37-52.

_____. 1905. Report on the Klondike gold fields. Geol. Surv. Can. Ann. Rept. 14, 1901, Pt. B: 1-71.

_____. 1907. Report on gold values in the Klondike high-level gravels. Geol. Surv. Can. Publ. No. 979: 20-30.

_____ and J.B. Tyrrell. 1898. Preliminary note on the gold deposits and gold mining in the Klondike region. Geol. Surv. Can. Ann. Rept. 11, 1898, Pt. A: 36-62.

McCorquoda[illegible], B. 1957. Giant bison found. Blue Jay 15: 42.

McDonald, H.G. and E. Anderson. 1975. A late Pleistocene vertebrate fauna from southeastern Idaho. Tebiwa 18(1): 20-37.

McCulloch, D. and D. Hopkins. 1966. Evidence for an early recent warm interval in northwestern Alaska. Geol. Soc. Amer. Bull. 77: 1089-1108.

Meade, G.E. 1961. The saber-toothed cat *Dinobastis serus*. Bull. Texas Memorial Mus. No. 2: 23-60.

Meggers, B.J. 1972. Prehistoric America. Aldine Atherton, Chicago, New York. 200 pp.

Merriam, J.C. and C. Stock. 1925. Relationships and structure of the short-faced bear, *Arctotherium*, from the Pleistocene of California. Carnegie Inst. Washington Contrib. Palaeontol. Publl. 347(1): 1-35.

_____ and C. Stock. 1932. The Felidae of Rancho La Brea. Carnegie Inst. Washington Publ. No. 422: 1-231.

Miller, F.L. 1974. Biology of the Kaminuriak population of barren-ground caribou. Pt. 2: Dentition as an indicator of age and sex; composition and socialization of the population. Can. Wildl. Serv. Report Ser. No. 31: 1-88.

Miller, G.J. 1968. On the age distribution of *Smilodon californicus* Bovard from Rancho La Brea. Los Angeles County Mus. Contrib. Sci. No. 131: 1-17.

Monroe, R.L. 1974. Old Crow, Yukon Territory. Map of terrain classification and sensitivity (preliminary). Geol. Surv. Can. Open File 210.

Murie, O.J. 1957. The elk of North America. Stackpole, Harrisburg. 376 pp.

Nadler, C.F., K.V. Korobitsina, R.S. Hoffmann and N.N. Vorontsov. 1973. Cytogenetic differentiation, geographic distribution, and domestication of Palearctic sheep *(Ovis)*. Zeitschr. f. Säugetierk. 38(2): 109-125.

Nelson, R.S. and H.A. Semken. 1970. Paleoecological and stratigraphic significance of the muskrat in Pleistocene deposits. Geol. Soc. Amer. Bull. 81: 3733-3737.

Nero, R.W. and B.A. McCorquodale. 1958. Report of an excavation at the Oxbow Dam site. Blue Jay 16(2): 82-90.

Noble, W.C. 1971. Archaeological surveys and sequences in central District of Mackenzie, N.W.T. Arctic Anthropol. 8(1): 102-135.

Norford, B.S. 1964. Reconnaissance of Ordovician and Silurian rocks of northern Yukon Territory. Geol. Surv. Can. Paper 63-39: 119-122.

Novikov, G.A. 1962. Carnivorous mammals of the fauna of the USSR. Zool. Inst. Acad. Sci. USSR No. 62: 1-284. Israel Program for Sci. Transl., Jerusalem.

Obalski, T. 1904. Les grands mammifères fossiles dans le Yukon et l'Alaska. Bull. Mus. Hist. Nat., Paris 1904. No. 5: 214-217.

Olsen, S.J. 1974. Early domestic dogs in North America and their origins. J. Field Archaeol. 1(3/4): 343-345.

Osborn, H.F. 1936. Proboscidea. Vol. I.: 1-802. Amer. Mus. Press, New York.

______. 1942. Proboscidea. Vol. II.: 805-1675. Amer. Mus. Press, New York.

Osgood, W.H. 1905a. *Scaphoceros tyrrelli*, an extinct ruminant from the Klondike gravels. Smithsonian Misc. Coll. 48: 173-185.

______. 1905b. Mastodon remains in the Yukon valley. Proc. Biol. Soc. Washington 17: 254-255.

______. 1907. A specimen of *Bison occidentalis* from northwest Canada. Proc. Biol. Soc. Washington 20: 65.

Ovodov, N.D. 1970. The remains of the European brown bear (*Ursus arctos* L.) in the caves of Siberia and the far east. Bull. Moscow Soc. Nat. Stud. 75(4): 116-126. (In Russian).

Parry, W.E. 1821. Journal of a voyage for the discovery of a North-West Passage from the Atlantic to the Pacific; performed in the years 1819-1820, His Majesty's ships Hecla and Griper; under the orders of William Edward Parry. J. Murray, London. 310 pp.

Pei, W.C. 1934. On the Carnivora from Locality 1 of Choukoutien. Palaeontologia Sinica, Ser. C. 8(1): 1-216.

Peterson, R.L. 1955. North American moose. Univ. Toronto Press, Toronto. 280 pp.

_____. 1965. A well-preserved grizzly bear skull recovered from a late glacial deposit near Lake Simcoe, Ontario. Nature 208(5016): 1233-1234.

Pettipas, L. 1971. Roaring River relic. Zoolog. March: 8-10.

Péwé, T.L. 1975a. Quaternary geology of Alaska. U.S. Geol. Surv. Prof. Paper 835: 1-145.

_____. 1975b. Quaternary stratigraphic nomenclature in unglaciated central Alaska. U.S. Geol. Surv. Prof. Paper 862: 1-32.

_____ and D.M. Hopkins. 1967. Mammal remains of pre-Wisconsin age in Alaska. In: D.M. Hopkins, Ed. The Bering land bridge. Stanford Univ. Press, Stanford. pp. 266-270.

Pidoplichko, I.G. 1969. Late Paleolithic dwellings of mammoth bones in the Ukraine. Naukova Dumka, Kiev. 161 pp.

Porsild, A.E., C.R. Harington and G.A. Mulligan. 1967. *Lupinus arcticus* Wats. grown from seeds of Pleistocene age. Science 158(3797): 113-114.

Prest, V.K. 1969. Retreat of Wisconsin and Recent ice in North America. Geol. Surv. Can. Map 1257A.

Quackenbush, L.S. 1909. Notes on Alaskan mammoth expeditions of 1907 and 1908. Bull. Amer. Mus. Nat. Hist. 26: 87-130.

Quinn, J.H. 1955. Miocene Equidae of the Texas Gulf Coastal Plain. Univ. Texas, Bur. Econ. Geol. Publ. No. 5516: 1-102.

______.1957. Pleistocene Equidae of Texas. Univ. Texas, Bur. Econ. Geol. Rept. Invest. No. 33: 1-51.

Rainey, F. 1940. Archaeological investigation in central Alaska. Amer. Antiquity 5(4): 299-308.

Rasmussen, D.L. 1974. *Bison occidentalis* from northeastern Montana. Northwest Geol. 3: 56-61.

Rausch, R. 1953. On the status of some arctic mammals. Arctic 6: 91-148.

______.1964. The specific status of the narrow-skulled vole (Subgenus *Stenocranius* Kashchenko) in North America. Zeitschr. f. Säugetierk 29(6): 343-358.

______ and V.R. Rausch. 1974. Taxonomy and zoogeography of *Lemmus* spp. (Rodentia: Arvicolinae) with notes on laboratory-reared lemmings. Zeitschr. f. Säugetierk. 40(1): 8-34.

Rausch, R. and V.R. Rausch. 1975. Relationships of the redbacked vole, *Clethrionomys rutilus* (Pallas), in North America; karyotypes of the subspecies *dawsoni* and *albiventer*. Systematic Zool. 24(2): 163-170.

Ray, C.E., B.N. Cooper and W.S. Benninghoff. 1967. Fossil mammals and pollen in a late Pleistocene deposit at Saltville, Virginia. J. Paleontol. 41(3): 608-622.

Reimchen, T.H.F. 1968. Pleistocene mammals from the Saskatchewan gravels in Alberta, Canada. Unpublished M.Sc. thesis. Univ. Alberta, Edmonton. 92 pp.

Repenning, C.A. 1967. Subfamilies and genera of the Soricidae. U.S. Geol. Surv. Prof. Paper 565: 1-73.

_____, D.M. Hopkins and M. Rubin. 1964. Tundra rodents in a late Pleistocene fauna from Tofty Placer District, central Alaska. Arctic 17(3): 176-197.

_____, Ray, C.E. and D. Grigorescu. 1976 MS. Pinniped biogeography. 47 pp.

Reynolds, S.H. 1934. A monograph on British Pleistocene Mammalia. *Ovibos* (supplement). Palaeontographical Soc. London. 21 pp.

Rhoads, S.N. 1897. Notes on living and extinct species of North American Bovidae. Proc. Acad. Nat. Sci. Philadelphia 49: 483-502.

Richardson, J. 1854. Vertebrals, including fossil mammals. In: The zoology of the voyage of H.M.S. Herald under the command of Captain Henry Kellett, R.N. C.B., during the years 1845-1851. Lovell Reeve, London. pp. 1-172.

Romer, A.S. 1928. A "fossil" camel/recently living in Utah. Science N.S. 68(1749): 19-20.

______.1951. *Bison crassicornis* in the late Pleistocene of New England. J. Mamm. 32: 230-231.

______.1966. Vertebrate paleontolocy. 3rd Ed., Univ. Chicago Press, Chicago and London. 468 pp.

Rusanov, B.S. 1968. Biostratigraphy of the Cenozoic deposits of southern Yakutia. Izd-vo Nauka, Moscow. 459 pp. (In Russian).

Rutter, N.W., V. Geist and D.M. Shackleton. 1972. A bighorn sheep skull 9280 years old from British Columbia. J. Mamm. 53(3): 641-644.

Ryder, M.L. 1974. Hair of the mammoth. Nature 249: 190-192.

Ryziewicz, Z. 1933. *Ovibos recticornis* n. sp. Ein Beitrag zur Systematik der Unterfamilie Ovibovinae. Bull. Acad. Polonaise Sci., Lettres (Classe Sci., Math., Nat., Ser. B: Sci. Nat. (II)): 71-87.

Sahni, M.R. and E. Khan. 1968. *Probison dehmi* n. g. n. sp. a recent find of an Upper Sivalik bovid. Mitt. Bayer. Staatssamml. Paläontol. hist. Geol. 8: 247-251.

Sanderson, I.T. 1955. Living mammals of the world. Hanover House, New York. 303 pp.

Savage, D.E. 1951. Late Cenozoic vertebrates of the San Francisco Bay region. Univ. California Publ. Bull. Dept. Geol. Sci. 28(10): 215-314.

Schaub, S. 1951. *Soergelia* n. gen., ein Caprine aus dem thuringischen Altpleistocaen. Eclogae geol. Helvetiae 44(2): 375-381.

Schultz, G.E. and C.H. Lansdown. 1972. A skull of *Bison latifrons* from Lipscomb County, Texas. Texas J. Sci. 23(3): 393-401.

Schütt, G. 1969. Untersuchungen am Gebiss von *Panthera leo fossilis* (v. Reichenau 1906) und *Panthera leo spelaea* (Goldfuss 1810). N.Jb. Paläontol. Abh. Stuttgart 134(2): 192-220.

Scott, W.B. 1885. *Cervalces americanus*, a fossil moose, or elk, from the Quaternary of New Jersey. Proc. Acad. Nat. Sci. Philadelphia 37: 181-202.

______. 1962. A history of land mammals in the Western Hemisphere. Revised Ed., Hafner Publishing Co., New York. 786 pp.

Semken, H.A. 1966. Stratigraphy and paleontology of the McPherson *Equus* Beds (Sandahl local fauna), McPherson County, Kansas. Univ. Michigan Mus. Paleontol. Contrib. 20: 121-178.

______, B.B. Miller and J.B. Stevens. 1964. Late Wisconsin woodland musk oxen in association with pollen and invertebrates from Michigan. J. Paleontol. 38(5): 823-835.

Shackleton, D.M. 1973. Population quality and bighorn sheep (*Ovis canadensis canadensis* Shaw). Unpublished Ph.D. thesis, Univ. Calgary, Calgary. 227 pp.

Sher, A.V. 1971. Pleistocene mammals and stratigraphy of the far northeast USSR and North America. Nauka, Moscow. 310 pp. (English translation published in the Internat. Geol. Rev. 16: 1-284. 1974. Page references in the text are to those of the English translation).

Shotwell, J.A. 1956. Hemphillian mammalian assemblage from northeastern Orego Geol. Soc. Amer. Bull. 67: 717-738.

______. 1970. Pliocene mammals of southeast Oregon and adjacent Idaho. Mus. Nat. Hist. Univ. Oregon Bull. No. 17; 1-103.

Silver, I.A. 1969. The ageing of domestic animals. In: D. Brothwell and E. Higgs, Eds. Science and archaeology. Thames and Hudson, Bristol. pp. 283-303.

Simpson, G.G. 1930. Tertiary land mammals of Florida. Bull. Amer. Mus. Nat. Hist. 59(3): 149-211.

_____. 1941. Large Pleistocene felines of North America. Amer. Mus. Novitates No. 1136: 1-27.

_____. 1945. The principles of classification and a classification of mammals. Bull. Amer. Mus. Nat. Hist. 85: 1-350.

Skeels, M.A. 1962. The mastodons and mammoths of Michigan. Papers Michigan Acad. Sci., Arts, Letters 47: 101-133.

Skinner, M.F. and C.W. Hibbard, with the collaboration of E.D. Gutentag, G.R. Smith, J.G. Lundberg, J.A. Holman, J.A. Feduccia and P.V. Rich. 1972. Early Pleistocene preglacial and glacial rocks and faunas of north-central Nebraska. Bull. Amer. Mus. Nat. Hist. 141(1): 1-148.

_____ and O.C. Kaisen. 1947. The fossil *Bison* of Alaska and preliminary revision of the genus. Bull. Amer. Mus. Nat. Hist. 89: 123-256.

Soergel, W. 1939. Unter welchen klimatischen Verhältnissen lebten zur Bildungszeit der altdiluvialen Kiese von Süssenborn *Rangifer*, *Ovibos* und *Elephas trogontherii* in Mittel-und Norddeutschland? Zeitschr. deutsch. geol. Ges. 91(11): 828-835.

Soergel, W. 1942. Die Verbreitung des diluvialen Moschusochsen in Mitteleuropa. Beitr. Geol. Thuringen 7(1/2): 75-95.

Solomatin, A.O. 1973. The kulan. Nauka, Moscow. 144 pp. (In Russian).

Soper, J.D. 1941. History, range and home life of the northern bison. Ecol. Monogr. 11: 347-412.

______. 1964. The mammals of Alberta. Hamly Press, Edmonton. 402 pp.

Stalker, A. MacS. 1971. Quaternary studies in the southwestern prairies. Geol. Surv. Can. Paper 71-1. Pt. A: 180-181.

______ and C.S. Churcher. 1970. Deposits near Medicine Hat, Alberta, Canada. Chart published by Surveys and Mapping Br., Dept. Energy, Mines, and Resources, Ottawa.

______ and ______. 1972. Glacial stratigraphy of the southwestern Canadian prairies; the Laurentide record. 24th Int. Geol. Congress Sec. 12: 110-119.

Stirton, R.A. 1942. Comments on the origin and generic status of *Equus*. J. Paleontol. 16: 627-637.

______. 1965. Cranial morphology of *Castoroides*. Mining & Metallurg. Inst. India. Dr. D.N. Wadia Commemorative Vol.: 273-285.

Stock, C. 1942. A ground sloth in Alaska. Science 95(2474): 552-553.

______.1965. Rancho La Brea, a record of Pleistocene life in California. Los Angeles County Mus. Sci. Ser. No. 20: 1-83. 6th Ed.

______ and H.G[illegible]s. 1949. A *Megalonyx* tooth from the No[illegible] Territories, Canada. Science 110: 709-[illegible]

Stock, A.D. and W.L. Stokes. 1969. A re-evaluation of Pleistocene bighorn sheep from the Great Basin and their relationship to living members of the genus *Ovis*. J. Mamm. 50: 805-807.

Stokes, W.L. and K.C. Condie. 1961. Pleistocene bighorn sheep from the Great Basin. J. Paleontol. 35: 598-609.

______ and G.H. Hansen. 1937. Two Pleistocene musk-oxen from Utah. Proc. Utah Acad. Sci., Arts, Letters 14: 63-65.

Stovall, J.W. 1936. A recent grizzly bear skull found fossil in Oklahoma. Amer. Midland Nat. 17: 781-783.

______ and C.S. Johnston. 1935. Two fossil grizzly bears from the Pleistocene of Oklahoma. J. Geol. 43: 208-213.

Stroganov, S.U. 1969. Carnivorous mammals of Siberia. Israel Program for Sci. Transl., Jerusalem. 522 pp.

Swain, F.M. 1963. Pleistocene Ostracoda from the Gubik Formation, Arctic Coastal Plain, Alaska. J. Paleontol. 37(4): 798-834.

Teilhard de Chardin, P. and C.C. Young. 1931. Fossil mammals from the late Cenozoic of northern China. Palaeontologia Sinica Ser. C. 9(1): 1-67.

Tener, J.S. 1965. Muskoxen in Canada, a biological and taxonomic review. Can. Wildl. Serv. Monogr. 2: 1-166.

Terasmae, J. 1967. Notes on Quaternary palaeoecological problems in the Yukon Territory, and adjacent regions. Geol. Surv. Can. Paper 67-46: 1-12.

Thenius, E. 1967. Zur Phylogenie der Feliden (Carnivora, Mamm.). Z. zool. Syst. Evolutionsforsch. 5(2): 129-143.

______.1972. Grundzüge der Verbreitungsgeschichte der Säugetiere. Gustav Fischer, Stuttgart. 345 pp.

______ and H. Hofer. 1960. Stammesgeschichte der Säugetiere. Springer, Berlin, Göttingen, Heidelberg. 322 pp.

Tietz, W.J., Jr. and J.J. Teal, Jr. 1967. Chromosome number of the musk-ox *(Ovibos moschatus)*. Can. J. Zool. 45: 235-236.

Tobien, H. 1973. Migrations of proboscideans and lagomorphs (Mammalia) via Bering Strait land bridge in the late Cenozoic. In: The Bering land bridge and its role for the history of Holarctic floras and faunas in the late Cenozoic. Acad. Sci. USSR. Far-eastern Sci. Centre. Khabarovsk. pp. 56-61.

Toepfer, V. 1963. Tierwelt des Eiszeitalters. Akademische Verlag Ges., Geest & Portig K.-G., Leipzig. 198 pp.

Troxell, E.L. 1915a. The vertebrate fossils of Rock Creek, Texas. Amer. J. Sci. 39: 613-638.

______. 1915b. A fossil ruminant from Rock Creek, Texas, *Preptoceras mayfieldi* sp. nov. Amer. J. Sci. 40: 479-482.

Tyrrell, J.B. 1912. The gold of the Klondike. Trans. Roy. Soc. Can. 4., Ser. 3, Sec. 4: 29-59.

Ucko, P.J. and A. Rosenfeld. 1967. Palaeolithic cave art. McGraw-Hill, New York, Toronto. 256 pp.

Vangengeim, E.A. 1961. Palaeontological basis of the stratigraphy of the Quaternary deposits of the northern part of eastern Siberia. Akad. Nauk. SSSR, Trudy Geol. Inst. 48: 1-182.

______. 1967. The effect of the Bering land bridge on the Quaternary mammalian faunas of Siberia and North America. In: D.M. Hopkins, Ed. The Bering land bridge. Stanford Univ. Press, Stanford. pp. 281-287.

Vangengeim, E.A. and K.K. Flerov. 1965. The broad-browed elk (*Alces latifrons*) in Siberia. Biull. Komiss. po izuch. chetvertichn. perioda. No. 30: 166-170.

______ and V.S. Zazhigin. 1965. Some results of a study of the Anthropogene mammalian fauna of West Siberia. In: V.N. Saks, Ed. Fundamental problems of studying the Quaternary period. Izd-vo Nauka, Moscow. pp. 301-310.

van Zyll de Jong, C.G. 1972. A systematic review of the Nearctic and Neotropical river otters (Genus *Lutra*, Mustelidae, Carnivora). Life Sci. Contrib. Roy. Ontario Mus. 80: 1-104.

Vereshchagin, N.K. 1959. The mammals of the Caucasus. A history of the evolution of the fauna. Israel Program for Sci. Transl., Jerusalem. 816 pp.

______. 1967a. Primitive hunters and Pleistocene extinction in the Soviet Union. In: P.S. Martin and H.E. Wright, Jr., Eds. Pleistocene extinctions. Yale Univ. Press, New Haven. pp. 365-398.

______. 1967b. The geological history of the elk and its utilization by primitive man. Biology and Hunting of the Elk, Symp. 3: 1-36. (In Russian).

______. 1971. The cave lion and its history in the Holarct and on the territory of the USSR. Akad. Nauk SSSR, Zool. Inst. Trudy 49: 123-199. (In Russian).

Vereshchagin, N.K. 1974. The mammoth "cemeteries" of north-east Siberia. Polar Record 17(106): 3-12.

Vorontsov, N.N. and E. Yu. Ivanitskaya. 1973. Comparative karyology of north Palaearctic pikas (*Ochotona*, Lagomorpha, Ochotonidae). Zool. Zhurnal 52(4): 584-588.

______ and E.A. Liapunova. 1973. Genetics and the problems of transberingian connections of Holarctic mammals. In: The Bering land bridge and its role for the history of Holarctic floras and faunas in the late Cenozoic. Acad. Sci. USSR, Far-Eastern Sci. Centre. Khabarovsk. pp. 146-149.

Warren, J.C. 1852. The Mastodon Giganteus of North America. 2nd Ed., J. Wilson and Son, Boston. 219 pp.

Webb, S.D. 1965. The osteology of *Camelops*. Bull. Los Angeles County Mus. Sci. No. 1: 1-54.

______. 1974a. Chronology of Florida Pleistocene mammals. In: S.D. Webb, Ed. Pleistocene mammals of Florida. Univ. Presses of Florida, Gainesville. pp. 5-31.

______. 1974b. Pleistocene llamas of Florida, with a brief review of the Lamini. In: S.D. Webb, Ed. Pleistocene mammals of Florida. Univ. Presses of Florida, Gainesville. pp. 170-213.

Weber, F.R. 1975. Vertebrate fossil discovery. In: Geological Survey Research 1975. U.S. Geol. Surv. Prof. Paper 975: 67.

West, R.G. 1968. Pleistocene geology and biology with especial reference to the British Isles. Longmans, London and Harlow. 377 pp.

Weston, M.L. 1975 MS. Evaluation of the stratigraphic significance of the muskrat (*Ondatra zibethicus* L.). 48 pp.

Wetmore, A. 1958. Miscellaneous notes on fossil birds. Sec. V. Pleistocene bird records from Ontario. Smithsonian Misc. Coll. 135(8): 9-10.

Whiteaves, J.F. 1903. Crania of extinct bisons from the Klondike creek gravels. Ottawa Nat. 16: 240-241.

Whitmore, F.C. Jr. and H.L. Foster. 1967. *Panthera atrox* (Mammalia: Felidae) from central Alaska. J. Paleontol. 41(1): 247-251.

______, K.O. Emery, H.B.S. Cooke and D.J.P. Swift. 1967. Elephant teeth from the Atlantic continental shelf. Science 156: 1477-1481.

Williams, M.Y. 1937. Three skulls of *Bison crassicornis* Richardson from the Yukon. Trans. Roy. Soc. Can. Ser. 3, Sec. 4, 31: 105-110.

Williamson, C.W. 1912. History of Ohio and Auglaize County. Geol. Surv. Ohio Bull. 16: 39.

Willoughby, D.P. 1948. A statistical study of the metapodials of *Equus occidentalis* Leidy. Bull. Southern California Acad. Sci. 47, Pt. 3: 84-94.

Wilson, M. 1974a. The Casper local fauna and its fossil bison. In: G.C. Frison, Ed. The Casper Site, a Hell Gap bison kill on the High Plains. Academic Press, New York. pp. 125-171.

______.1974b. History of the bison in Wyoming, with particular reference to early Holocene forms. In: M. Wilson, Ed. Applied geology and archaeology: the Holocene history of Wyoming. Geol. Surv. Wyoming Rept. Invest. No. 10: 91-99.

Winans, W. 1913. Deer breeding for fine heads. Rowland Ward Ltd., London. 128 pp.

Woodburne, M.O. 1961. Upper Pliocene geology and vertebrate paleontology of part of the Meade Basin, Kansas. Michigan Acad. Sci., Arts, Letters 46: 61-101.

Wright, B.S. 1962. Wildlife sketches near and far. Brunswick Press, Fredericton. 288 pp.

Yakhimovich, N.N. 1965. Remains of mammals from the Anthropogene deposits of the South Urals: Anthropogene of the South Urals. Izd-vo Nauka, Moscow. (In Russian).

Young, H.R. 1966. Proboscidean molars from Manitoba. Can. Field Nat. 80: 95-98.

Youngman, P.M. 1975. Mammals of the Yukon Territory. Nat. Mus. Can. Publ. Zool. No. 10; 1-192.

Zakrzewski, R.J. 1969. The rodents from the Hagerman local fauna, Upper Pliocene of Idaho. Univ. Michigan Mus. Paleontol. 23(1): 1-36.

Zdansky, O. 1926. *Paracamelus gigas*, Schlosser. Palaeontologia Sinica, Ser. C. 2(4): 1-44.

Zeuner, F.E. 1963. A history of domesticated animals. Hutchinson, London. 560 pp.

APPENDIX I Staining of Quaternary bones from the northern Yukon Territory in relation to geological age.

In 1974, in co-operation with R. Bonnichsen, 22 samples of dated mammal bone from the Old Crow Area were submitted to P. Tymchuk (Division of Chemistry, National Research Council) for bone mineral analysis using the emission spectroscopy technique.* The first group of three samples included moose *(Alces alces)*, and caribou *(Rangifer tarandus)* bones that dated from approximately 80 years B.P. to 2,000 years B.P. This sample was whitish to pale tan in surface staining. The second group of 11 samples included wapiti *(Cervus elaphus)*, and large-horned bison *(Bison crassicornis)* bones that had been radiocarbon dated between 4,570 ± 100 years B.P. and 12,460 ± 220 years B.P. by Teledyne Isotopes. This sample was manila to dark tan in surface staining. The third group of eight samples included mammoth *(Mammuthus sp.)*, large-horned bison *(Bison crassicornis)*, giant moose *(Alces latifrons)* and large horse *(Equus sp.)* that had been radiocarbon dated between 33,800 ± 200 years B.P. and >39,900 years B.P. These bones were chocolate brown to black in their surface staining.

As expected, iron and manganese were important in

---

* Readings indicate the per cent concentration of each element in the sample.

differentiating geologically younger from older bone. Obviously these two elements in the groundwater had been largely responsible for the brown to black staining of the older bones. However, among the suite of 23 elements recorded in this instance by the emission spectroscopy method (Sr, Co, Ni, Na, Zn, Ag, Cu, Zr, Ti, Al, Ca, V, Fe, Si, Pb, Mn, Mg, B, Ba, Yb, Y, and Au), two rarer elements, barium and strontium, appeared to have some value in differentiating younger from older bone.

In the first group, dating between approximately 80 years B.P. and 2,000 years B.P., iron readings ranged from 0.1 to 0.3, whereas the second group, dating between approximately 4,500 years B.P. and 12,500 years B.P., and the third group dating more than 33,800 years B.P., yielded readings between 3.0 and 5.0 (except for one reading of 0.1 from the centre of Sample 2), and 5.0 to 6.0, respectively.

Manganese from bone of the first group yielded readings of 0.005 to 0.1, whereas the second and third groups gave readings between 0.05 and 0.3 (except for one reading of 0.001 from the centre of Sample 2), and 0.1 to 0.25, respectively.

Barium from bone of the first group gave readings of 0.03 to 0.04, whereas the second and third groups yielded readings between 0.03 and 0.3 (except for one reading of 0.01 from the centre of Sample 2), and 0.1 to 0.3, respectively.

Strontium from bone of the first group gave readings of 0.01, whereas the second and third groups yielded readings between 0.01 and 0.03, and 0.02 and 0.05, respectively.

These limited data indicate that whitish to tan bone of postglacial and late Wisconsin age can usually be separated from the chocolate brown to black bone of pre-late Wisconsin age (i.e >33,800 years B.P.). The analysis also indicates that such elements as iron and manganese are particularly important in bringing about the darker staining of older bone, a point that I became aware of in 1968 after I had received the first radiocarbon date of 12,460 ± 220 years B.P. on fresh-looking bison bone from Old Crow Locality 11(1). The concentration of iron, manganese, barium and strontium seems to increase in direct proportion to the increase in age of the bones. Furthermore, the analysis suggests that iron, manganese, barium and probably many other elements, decrease in concentration from the outer surface of the bone to a point near the centre (e.g. Sample 2). This is apparent when looking at sections through many Pleistocene bones - generally they are darker near the surface and lighter near the centre. Presumably the elements are concentrated at varying rates during periods of active groundwater. In 1968, I hypothesized that the darkest bones had undergone penetration by iron and manganese during the mid-Wisconsin interstadial or Sangamon interglacial, because groundwater carrying the minerals was probably most active during these phases. Presumably, also, most of the bones of mammals that had died in the Dawson and Old Crow areas between approximately 30,000 years B.P. and 12,000 years B.P. had been preserved in permafrost for most of the time until they were exposed and collected. Thus, there would have been little opportunity for penetration of the bones by minerals in the groundwater, and this would explain their relatively fresh appearance.

It should be kept in mind that these are only preliminary results, and that the subject requires much more detailed investigation.

An apparent exception to this bone-staining hypothesis is a horncore of an Alaskan bison (*Bison alaskensis*, NMC 13506 from Dawson Locality 33; Figure 76) that yielded a radiocarbon date of >39,900 years B.P. It is not much darker than most *Bison crassicornis* horncores from the Yukon dating between approximately 30,000 years B.P. and 20,000 years B.P., except for a black area on the dorsal surface.

A few specimens display an unusual combination of darkly-stained cranial bone and unusually white, fresh-looking teeth (e.g. a wolverine *(Gulo gulo)* cranium (NMC 14582 from the bar opposite Old Crow Locality 22; Figure 41) and a red fox *(Vulpes vulpes)* cranium (NMC 14353 from Old Crow Locality 115; Figure 31)). They are tentatively considered to be of Pleistocene or postglacial age.

APPENDIX II Criteria used for suggesting the geological age of Yukon Pleistocene mammal fossils.

		Criteria			
Species	Suggested Age	Radiocarbon Dating (years B.P.)	Stratigraphic Position	Staining of Bone	Evolutionary Stage
Planisorex cf. *dixonensis*	early Pleistocene (?Nebraskan)	—	Nebraskan, in southern N. America	pre-late Wisconsin	—
Homo sp.	late Pleistocene	27,000 $^{+3000}_{-2000}$ date on bone artifact	—	pre-late Wisconsin and ?late Wisconsin	—
Megalonyx cf. *jeffersoni*	pre-late Wisconsin (?Sangamon)	—	—	pre-late Wisconsin	?pre-Wisconsin
Ochotona cf. *whartoni*	early Pleistocene (?Nebraskan)	—	?Nebraskan, in Alaska	pre-late Wisconsin	—
Ochotona princeps	pre-late Wisconsin (?Sangamon)	>54,000, indirect date on wood	?Sangamon	pre-late Wisconsin	—
Lepus americanus	pre-late Wisconsin	—	—	pre-late Wisconsin	—
Lepus arcticus	pre-late Wisconsin (?Sangamon)	>54,000, indirect date on wood	?Sangamon	pre-late Wisconsin	—
Marmota cf. *monax*	pre-late Wisconsin	—	—	pre-late Wisconsin	—
Spermophilus parryi	?Sangamon to late Wisconsin	>54,000, indirect date on wood	?Sangamon, late Wisconsin	pre-late Wisconsin, late Wisconsin	—
Castor canadensis	?Sangamon to late Wisconsin	>54,000, indirect date on wood	?Sangamon	pre-late Wisconsin, late Wisconsin	—
Castoroides ohioensis	?Sangamon	>54,000, indirect date on wood	?Sangamon	pre-late Wisconsin	—
Dicrostonyx cf. *henseli*	pre-late Wisconsin	—	—	pre-late Wisconsin	—
Dicrostonyx torquatus	?Sangamon to late Wisconsin	>54,000, indirect date on wood	?Sangamon, late Wisconsin	pre-late Wisconsin, late Wisconsin	—
Lemmus sibiricus	?Sangamon to mid-Wisconsin	32,400 ± 770, >54,000, indirect date on wood	?Sangamon, mid-Wisconsin	pre-late Wisconsin	—
Clethrionomys cf. *rutilus*	?Sangamon	>54,000, indirect date on wood	?Sangamon	pre-late Wisconsin	—
Ondatra zibethicus	?Sangamon	>54,000, indirect date on wood	?Sangamon	pre-late Wisconsin	small size of M_1s suggests Sangamon
Microtus (Stenocranius) miurus	?Sangamon	—	?Sangamon	pre-late Wisconsin	—
Microtus xanthognathus	?Sangamon	>54,000, indirect date on wood	?Sangamon	pre-late Wisconsin	—
Order Cetacea, genus and species indeterminate	Sangamon or earlier	—	pre-early Wisconsin	pre-late Wisconsin	—
Canis lupus	?Sangamon to late Wisconsin	>54,000, indirect date on wood	?Sangamon, late Wisconsin	pre-late Wisconsin, late Wisconsin	—
Canis familiaris	pre-late Wisconsin to postglacial	—	probably late Wisconsin	pre-late Wisconsin, late Wisconsin or postglacial	—

APPENDIX II...(cont'd.)

Species	Suggested Age	Criteria Radiocarbon Dating (years B.P.)	 Stratigraphic Position	 Staining of Bone	 Evolutionary Stage
Alopex lagopus	?Sangamon to late Wisconsin	>54,000, indirect date on wood	?Sangamon, late Wisconsin	pre-late Wisconsin, late Wisconsin	—
Vulpes vulpes	pre-late Wisconsin to postglacial	—	—	pre-late Wisconsin (cranial bone) to postglacial (teeth)	—
Cuon sp.	pre-late Wisconsin	—	—	pre-late Wisconsin	—
Arctodus simus yukonensis	pre-late Wisconsin (?Sangamon) to ?late Wisconsin	—	—	pre-late Wisconsin, ?late Wisconsin	—
Ursus cf. *americanus*	pre-late Wisconsin	—	—	pre-late Wisconsin	—
Ursus arctos	pre-late Wisconsin to late Wisconsin	—	—	pre-late Wisconsin, late Wisconsin	—
Mustela erminea	pre-late Wisconsin to late Wisconsin	—	—	pre-late Wisconsin, late Wisconsin	—
Mustela (Putorius) eversmanni	pre-late Wisconsin	—	—	pre-late Wisconsin	—
Martes nobilis	pre-late Wisconsin	—	—	pre-late Wisconsin	—
Martes pennanti	pre-late Wisconsin (?Sangamon)	—	—	pre-late Wisconsin	—
Gulo gulo	?Sangamon to postglacial	>54,000, indirect date on wood	?Sangamon	pre-late Wisconsin (cranial bone) to postglacial (teeth)	small size of teeth may indicate an interglacial (?Sangamon)
Taxidea taxus	late Wisconsin	—	—	late Wisconsin	—
Spilogale sp.	?Sangamon	>54,000, indirect date on wood	?Sangamon	pre-late Wisconsin	—
Lontra canadensis	pre-late Wisconsin	—	—	pre-late Wisconsin	—
Felis (Lynx) canadensis	pre-late Wisconsin	—	—	pre-late Wisconsin	—
Felis (Puma) cf. *concolor*	pre-late Wisconsin	—	—	pre-late Wisconsin	—
Panthera leo atrox	pre-late Wisconsin to late Wisconsin	—	—	pre-late Wisconsin, late Wisconsin	—
Homotherium serum	pre-late Wisconsin to late Wisconsin	—	—	pre-late Wisconsin, late Wisconsin	—
Phoca cf. *(Pusa) hispida*	?Sangamon	—	?Sangamon	pre-late Wisconsin	—
Mammut americanum	pre-late Wisconsin (possibly Sangamon)	?>54,000, indirect date on wood	possibly Sangamon, but not definitely in place	pre-late Wisconsin	—

APPENDIX II...(cont'd.)

Species	Suggested Age	Criteria			
		Radiocarbon Dating (years B.P.)	Stratigraphic Position	Staining of Bone	Evolutionary Stage
Mammuthus meridionalis	early Pleistocene	———	———	pre-late Wisconsin	early Pleistocene in Eurasia
Mammuthus cf. *armeniacus*	middle to late Pleistocene	———	———	pre-late Wisconsin, late Wisconsin	middle to late Pleistocene
Mammuthus primigenius	late Pleistocene (Wisconsin)	probably from >39,900 to 16,000 ± 130; Whitestone mammoth is 30,300 ± 2000	———	pre-late Wisconsin, late Wisconsin	Wisconsin
Equus cf. *(Plesippus) verae*	middle to late Pleistocene (late Wisconsin)	dates of >39,900 and 34,000 ± 2600 probably apply to this species	?Illinoian, ?Sangamon	pre-late Wisconsin, late Wisconsin	middle Pleistocene in Eurasia
Equus sp.	?middle Pleistocene	———	———	pre-late Wisconsin	?middle Pleistocene
Equus cf. *scotti*	pre-late Wisconsin to late Wisconsin	———	———	pre-late Wisconsin, late Wisconsin	———
Equus (Asinus) lambei	pre-late Wisconsin to late Wisconsin	14,870 ± 260	late Wisconsin	pre-late Wisconsin, late Wisconsin	———
Equus (Asinus) cf. *kiang*	late Wisconsin	———	late Wisconsin	late Wisconsin	———
Camelini (genus and species indeterminate)	?middle to late Pleistocene	>54,000, indirect date on wood	late ?Illinoian or early ?Sangamon	pre-late Wisconsin	———
Camelops hesternus	late Wisconsin	———	———	late Wisconsin	———
Cervus elaphus	late Wisconsin to postglacial	4,570 ± 100	———	late Wisconsin, postglacial	———
Alces latifrons	?middle to late Pleistocene (mid-Wisconsin)	33,800 ± 2000	———	pre-late Wisconsin	middle Pleistocene in Eurasia
Alces alces	late Pleistocene (Wisconsin)	———	———	pre-late Wisconsin, late Wisconsin	late Pleistocene
Rangifer tarandus	?Illinoian to postglacial	27,000 $^{+3000}_{-2000}$ to 5,810 ± 100	?Illinoian to postglacial	pre-late Wisconsin, late Wisconsin, postglacial	———
Cervidae (genera and species undetermined)					
"First" group	pre-late Wisconsin	———	———	pre-late Wisconsin	———
Second group	pre-late Wisconsin to late Wisconsin	———	———	pre-late Wisconsin, late Wisconsin	———
Bison alaskensis	?middle Pleistocene (pre-late Wisconsin)	>39,900	?pre-late Wisconsin	looks like late Wisconsin, except for dark stain on dorsal surface of horncore	middle Pleistocene in Eurasia
Bison crassicornis	mid-Wisconsin to late Wisconsin	33,800 ± 2000 to 11,910 ± 180	late Wisconsin	late Wisconsin	?late Pleistocene
Bison bison occidentalis	late Wisconsin	———	———	late Wisconsin	late Wisconsin to early postglacial

APPENDIX II...(cont'd.)

				-ria	
Species	Suggested Age	Radiocarbon Dating (years B.P.)	Stratigraphic Position	Staining of Bone	Evolutionary Stage
Bison bison athabascae	late postglacial	1,350 ± 95	postglacial	postglacial	late postglacial
Soergelia cf. *elisabethae*	middle Pleistocene (Kansan)	————	————	pre-late Wisconsin	middle Pleistocene (Kansan)
Bootherium sargenti	pre-late Wisconsin	————	————	pre-late Wisconsin	————
Symbos cavifrons	pre-late Wisconsin to late Wisconsin	————	————	pre-late Wisconsin, late Wisconsin	————
Praeovibos priscus	?middle Pleistocene; possibly Illinoian	————	————	pre-late Wisconsin	middle Pleistocene in Eurasia; Illinoian in Alaska
Ovibos moschatus	?late Pleistocene (pre-late Wisconsin to late Wisconsin) to postglacial	2,830 ± 600	postglacial	pre-late Wisconsin, ?late Wisconsin, postglacial	mainly late Pleistocene
Ovis dalli	late Wisconsin	23,000 ± 600	late Wisconsin	late Wisconsin	————