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C.R. HARINGTON

QUATERNARY VERTEBRATE FAUNAS OF CANADA AND ALASKA AND THEIR SUGGESTED CHRONOLOGICAL SEQUENCE

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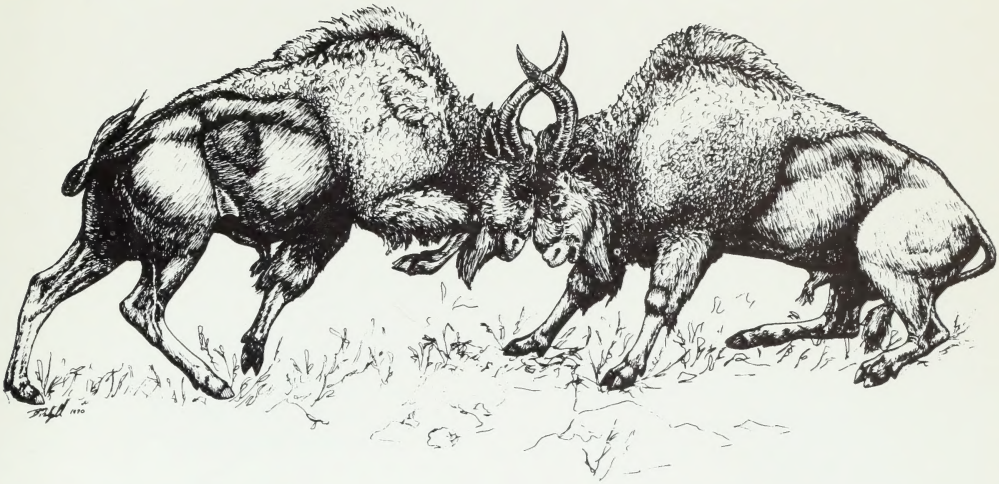

FIGURE 1. *A restoration of* Bison crassicornis *bulls fighting. Based on skeletal material from a late-Wisconsin site in the Dawson area, Yukon Territory. Ink sketch by Bonnie Dalzell.*

QUATERNARY VERTEBRATE FAUNAS OF CANADA AND ALASKA AND THEIR SUGGESTED CHRONOLOGICAL SEQUENCE

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National Museum of Natural Sciences
Ottawa

Syllogeus No. 15

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CONTENTS

TABLE OF CONTENTS ...cont'd

ABSTRACT

Thirty-one Canadian and Alaskan Quaternary vertebrate faunas, ranging in age from about 1,800,000 to 5,000 years, are reviewed against a background of some of the major characteristics of the ice age in northern North America, and an attempt is made to outline their chronological sequence. For each fauna a list of species is given, and the following points are dealt with where possible: suggested geological age, stratigraphy at the site, palaeoenvironmental implications, and pertinent references. Where interest seems to warrant it, single species or specimens are discussed. Radiocarbon dates on bone from Pleistocene vertebrates or from associated organic material are included.

In conclusion, significant features of the faunas are reviewed from oldest to youngest and in relation to several faunas of similar age from northeastern Siberia and the Great Plains of the United States. Early man is mentioned briefly. Evidence suggests that people were present in the northern Yukon about 27,000 years ago, and perhaps even earlier than 32,000 years ago in southern Alberta.

Corrections

Page 44 - lines 34-36. Because the 7,670 ± 170 B.P. (I-2244) date was based on a carbonate sample, it is considered to be unreliable (see Hassan, A.A., J.D. Termine, and C.V. Haynes, Jr. 1977. Mineralogical studies on bone apatite and their implications for radiocarbon dating. Radiocarbon 19(3):364-374). Radiocarbon analysis of a very small organic residue from the first sample indicates that the tusk is older (>11,600 B.P. (I-2244A)) (W. Blake, Jr., personal communication 1978).

Page 85 - lines 11-14. The date of about 7,000 B.P. now appears to be unreliable, and the mammoth evidently died earlier than 11,600 B.P. (I-2244A). See above.

ACKNOWLEDGEMENTS

I am grateful to Drs. R.E. Morlan (Archaeological Survey of Canada), D.M. Hopkins (United States Geological Survey), T.L. Péwé (Arizona State University), and C.A. Repenning (United States Geological Survey) for their helpful comments on parts of the manuscript. A great deal of the information presented here has resulted from the hard and perceptive work of the late Otto Geist and of Dr. R.D. Guthrie (University of Alaska) on the Quaternary vertebrate faunas of Alaska, as well as that of Drs. A. MacS. Stalker (Geological Survey of Canada) and C.S. Churcher (University of Toronto) on Quaternary vertebrate faunas of the southwestern Canadian prairies, although they are in no way responsible for my interpretation of their data.

Ink restorations of the Quaternary mammals were made, under my supervision, by Miss Bonnie Dalzell and by Mr. C.H. Douglas, of the National Museum of Natural Sciences. I wish to thank Mr. G. Anderson and his staff at the National Museums of Canada for the photographs, and my fellow staff member Mrs. Gail Rice for typing the manuscript.

This paper is dedicated to my colleagues at the Academy of Sciences of the U.S.S.R.: Drs. A.V. Sher (Palaeontological Institute), E.A. Vangengeim (Geological Institute) and N.K. Vereshchagin (Zoological Institute).

INTRODUCTION

The Quaternary has lasted for about two million years and has been characterized in the northern regions by four main glaciations separated by warmer phases, or interglacials, during which northern North America appeared very much as it does today. In North America, the commonly recognized glaciations, from earliest to latest, are known as: Nebraskan, Kansan, Illinoian, and Wisconsin. The interglacials are: Aftonian, Yarmouth, Sangamon and the present interglacial (postglacial), which began some 10,000 years ago.

Glacials and interglacials evidently occurred at about the same times in both Eurasia and North America, but correlations between their fossil-bearing deposits are still doubtful in many cases. In Canada, evidence for a series of glacials and interglacials is clearly visible at Medicine Hat in southern Alberta, where the sequence of ice-age deposits extends back to possibly Kansan time. A sequence of glacial and interglacial deposits covering a similar time span (pre-Yarmouth? to postglacial) at Eva Creek near Fairbanks, Alaska, is of key importance in interpreting the Pleistocene history of northwestern North America.

Much of man's evolution has taken place during the Quaternary, and he is an important member of the ice-age fauna. Probably he first entered North America from Siberia in small hunting groups following abundant game, such as the woolly mammoth herds that were exploiting new and rich pastures to the east of their Siberian ranges. However, it is possible that man could have arrived in America by sea, on either rafts or boats.

Conditions for migration between Eurasia and North America were most favourable during glaciations, when worldwide depressions in sea level exposed land in the shallow Bering Strait region. The Bering Isthmus connecting the two continents emerged at least four times during the Quaternary, and was of greatest north--south breadth during the last two glaciations. It was flooded by rising seas as the continental ice melted during the interglacials, restoring Bering Strait much as it exists today.

Many vertebrate species that are often considered to be native to North America actually entered from Eurasia during the Pleistocene. Bison, muskox (*Ovibos*), moose (*Alces*), wapiti (*Cervus*), mountain sheep and brown bear are typical examples. A few mammals that still survive in Asia, such as the yak and the saiga antelope, penetrated no farther east than northwestern North America, where they died out toward the close of the last glaciation. *Praeovibos*, a muskox, exemplifies a species, now extinct, that penetrated no

farther than northwestern North America. Some mammals that originated in North America, such as camels and horses, migrated west into Eurasia from North America. Others, like the woolly rhinoceros of Eurasia and the prongbuck (*Antilocapra americana*) of North America, remained in the continents where they originated.

It is worth noting that some animals originating in southern North America or in South America — for example, short-faced bear (*Arctodus*), camel (*Camelops*), ground sloth (*Megalonyx*), giant beaver (*Castoroides*), badger (*Taxidea*) — reached the Alaska–Yukon region, probably during an interglacial, but were not able to cross into Eurasia. Obviously, natural barriers of various kinds were effective in restricting the dispersal of some vertebrates between Eurasia and America during the Quaternary.

Expanding continental and alpine glaciers of northern North America not only acted as occasional barriers to the movement of land and freshwater vertebrates, but forced animals occupying central Canada and parts of Alaska to move away from their original ranges. Ice spread out from the lowlands of Keewatin and central Ungava, from the mountainous country of the Cordillera (including the Brooks Range) in the west, and from the eastern Canadian Arctic Islands. As a result, at glacial maxima, vertebrates occupied three or four main survival areas, or refugia: the southern refugium, comprising unglaciated parts of the northern United States; the Beringian refugium in unglaciated areas of the Yukon and Alaska and extending across the Bering Isthmus into eastern Siberia; the Banks Island refugium in the western Canadian Arctic Islands; and the Pearyland refugium in northern Greenland. Of lesser importance as refugia for vertebrates were nunataks, higher areas of land not covered by ice, such as the Cypress Hills of southern Alberta and Saskatchewan; Pacific offshore islands sometimes connected with the mainland; and parts of the exposed Atlantic continental shelf.

Thus, fossils of tundra-adapted mammals such as the collared lemming (*Dicrostonyx torquatus*) and muskox (*Ovibos moschatus*) have been found in the northern United States, whereas their natural habitat is at present in the Canadian Arctic and Greenland. In addition to the southern refugium, the muskox also occupied the Beringian and Banks Island refugia.

On the other hand, some species that seem to have been adapted originally to warmer climates moved far to the north during interglacial phases, as shown by ground-sloth and camel fossils in the Yukon Territory and Alaska, and beaver-cut sticks on Banks Island in the Northwest Territories.

Perhaps the most important migration route between Beringia and southern North America was the "western corridor", which runs along the eastern flanks of the Rocky Mountains. This corridor appears to have been open to land and freshwater vertebrates for relatively long periods of time. Although the problem is still being investigated, Cordilleran ice from the west and Keewatin ice from the east evidently joined for short periods at only a few places in western Alberta. Probably the lack of suitable habitats for many species along the length of the route was a more significant barrier than temporary, local ice-blockades.

An interesting question arises concerning the migration of birds. As glacial ice spread over their former nesting grounds during glacial maxima, did most migratory species shift their flyways eastwards toward exposed tracts of Atlantic continental shelf off Nova Scotia and Newfoundland, and westwards toward Beringia and its broad freshly exposed arctic coastal plain? Or did some shorten their flights and nest in the narrow tundra-like zone along the southern margin of the continental ice? Presumably a forceable shift from their extensive and apparently traditional nesting grounds in the Canadian Arctic Islands to more marginal areas would have significantly reduced the populations of some species.

Many dispersal routes appear to have been used by North American freshwater fishes to reoccupy formerly glaciated regions during the postglacial. Routes most commonly used were to the southeast via the Yukon and the Mackenzie systems and east into the central Arctic from the Beringian refugium; to the north from the Pacific refuge (unglaciated northern Washington and Oregon region); and northwestward from the Mississippi refuge (unglaciated parts of the Mississippi drainage system).

Although much more work on Quaternary vertebrates in Canada and Alaska remains to be done, a map of faunal localities (Figure 2) clearly shows the relative barrenness of central Canada in this respect. A combination of extensive Precambrian rock, severe climate, and heavy multiple glaciation militated against occupation of that region by a great variety of vertebrates and against adequate preservation of faunal remains that might have been present. Similarly, heavy Cordilleran glaciation has undoubtedly resulted in the destruction of many potential ice age vertebrate localities, although the interior of British Columbia offers possibilities. The interglacial grassland that occupied that region may have provided another favourable route for migration of vertebrates between Beringia and southern North America.

Wisconsin glacial ice began melting back about 17,000 years ago, and most of it had disappeared by 7,000 years ago. During periods when the ice paused

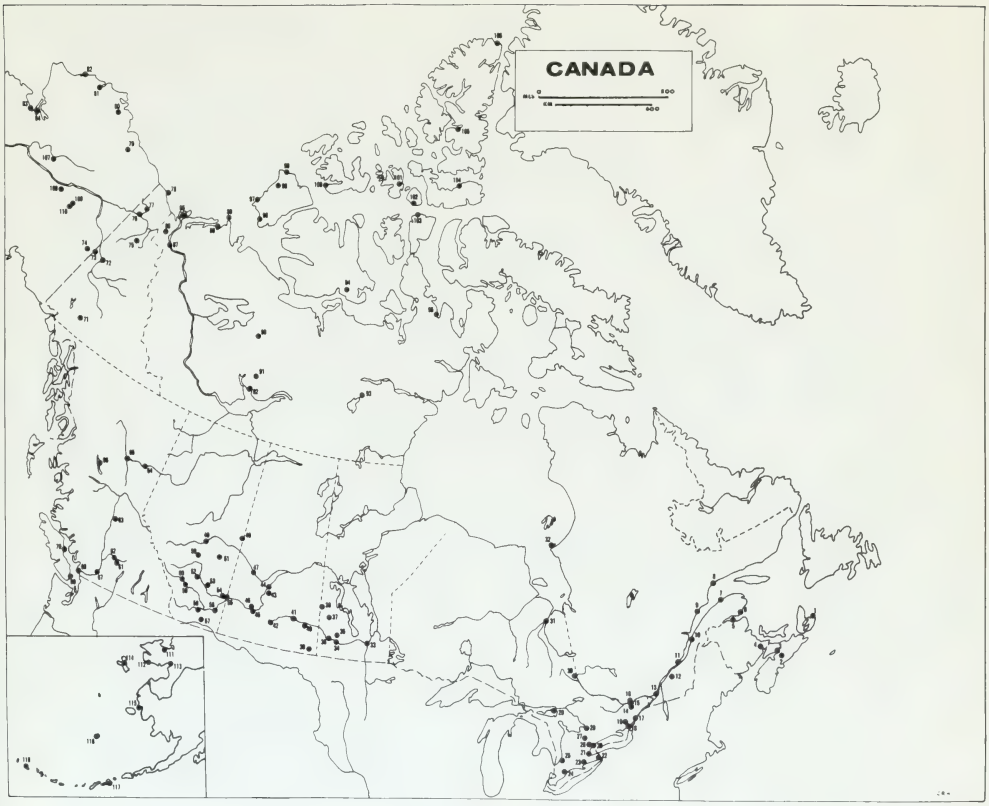

FIGURE 2. *Maps showing localities of Quaternary vertebrates of Canada and Alaska that are described in the text. Inset map in lower corner shows localities in western Alaska.*

Key (with the names of Quaternary vertebrate faunal localities capitalized): 1. Donkin, Cape Breton Island, Nova Scotia. 2. Milford Station, Nova Scotia. 3. Debert, Nova Scotia. 4. Hillsborough, New Brunswick. 5. Jacquet River, New Brunswick. 6. Saint-Jogues, Québec. 7. Sainte-Anne-des-Monts, Québec. 8. Sept-Îles, Québec. 9. Rivière aux Outardes, Québec. 10. Rivière-du-Loup, Québec. 11. Québec, Québec. 12. Daveluyville, Québec. 13. Montréal, Québec. 14. Moose Creek, Ontario. 15. OTTAWA, Ontario. 16. Hull, Québec. 17. Brockville, Ontario. 18. Kingston, Ontario. 19. Sydenham, Ontario. 20. TORONTO, Ontario. 21. HAMILTON, Ontario. 22. Welland, Ontario. 23. Waterford, Ontario. 24. Muirkirk, Ontario. 25. Parkhill, Ontario. 26. Woodbridge, Ontario.

27. Alliston, Ontario. 28. Orillia, Ontario. 29. Sheguiandah, Manitoulin Island, Ontario. 30. New Liskeard, Ontario. 31. Moose River, Ontario. 32. Long Island, Northwest Territories. 33. Winnipeg, Manitoba. 34. Brandon, Manitoba. 35. Minnedosa, Manitoba. 36. Rivers, Manitoba. 37. Grandview, Manitoba. 38. Benito, Manitoba. 39. OXBOW DAM, Saskatchewan. 40. Grenfell, Saskatchewan. 41. FORT QU'APPELLE, Saskatchewan. 42. Lillestrom, Saskatchewan. 43. Dundurn, Saskatchewan. 44. SASKATOON, Saskatchewan. 45. WELLSCH VALLEY, Saskatchewan. 46. Kyle, Saskatchewan. 47. North Battleford, Saskatchewan. 48. Cold Lake, Alberta. 49. Edmonton, Alberta. 50. Ponoka, Alberta. 51. Killam, Alberta. 52. Three Hills, Alberta. 53. HAND HILLS, near Delia, Alberta. 54. Site near BINDLOSS, Alberta. 55. EMPRESS, Alberta. 56. MEDICINE HAT, Alberta. 57. Fletcher Site, Alberta. 58. Taber, Alberta. 59. Calgary, Alberta. 60. COCHRANE, Alberta. 61. Westwold, British Columbia. 62. Kamloops, British Columbia. 63. Quesnel Forks, British Columbia. 64. Portage Pass, British Columbia. 65. Finlay Forks, British Columbia. 66. Babine Lake, British Columbia. 67. Yale, British Columbia. 68. Vancouver, British Columbia. 69. Saanich Peninsula, Vancouver Island, British Columbia. 70. Courtenay, British Columbia. 71. Canyon Site, Yukon Territory. 72. DAWSON AREA, Yukon Territory. 73. SIXTYMILE RIVER and Miller Creek, Yukon Territory. 74. LOST CHICKEN CREEK, Alaska. 75. Whitestone River, Yukon Territory. 76. Old Crow settlement, Yukon Territory. 77. OLD CROW BASIN, Yukon Territory. 78. Herschel Island, Yukon Territory. 79. Sagavanirktok River, Alaska. 80. Ikpikpuk River, Alaska. 81. Kuk River, Alaska. 82. Point Lay, Alaska. 83. CAPE DECEIT, Alaska. 84. Eschscholtz Bay, Alaska. 85. Richards Island, Northwest Territories. 86. Rat River, Northwest Territories. 87. Arctic Red River, Northwest Territories. 88. Nicholson Peninsula, Northwest Territories. 89. Baillie Islands, Northwest Territories. 90. ACASTA LAKE, Northwest Territories. 91. Lower Carp Lake, Northwest Territories. 92. Yellowknife, Northwest Territories. 93. Grant Lake, Northwest Territories. 94. Ferguson Lake, Victoria Island, Northwest Territories. 95. Pelly Bay, Northwest Territories. 96. Masik River, Banks Island, Northwest Territories. 97. Worth Point, Banks Island, Northwest Territories. 98. Bernard River, Banks Island, Northwest Territories. 99. Ballast Brook, Banks Island, Northwest Territories. 100. Cape James Ross, Melville Island, Northwest Territories. 101. Goodsir River, Bathurst Island, Northwest Territories. 102. Resolute Bay, Cornwallis Island, Northwest Territories. 103. Cunningham River, Somerset Island, Northwest Territories. 104. Truelove Inlet, Devon Island, Northwest Territories. 105. Strathcona Fiord, Ellesmere Island, Northwest Territories. 106. Alert, Ellesmere Island, Northwest Territories. 107. Batza Tena, Alaska. 108. TOFTY, Alaska. 109. Chatanika, Alaska. 110. FAIRBANKS AREA, Alaska. 111. Trail Creek, Alaska. 112. Nome, Alaska. 113. Inglutalik River, Alaska. 114. St. Lawrence Island, Alaska. 115. Nelson Island, Alaska. 116. St. Paul Island, Pribilof Islands, Alaska. 117. Unalaska, Aleutian Islands, Alaska. 118. Amchitka, Aleutian Islands, Alaska.

or occasionally re-advanced during its overall retreat, extensive moraines were laid down on its margins. Another feature of the Quaternary in northern North America is the sequence of vast glacial lakes that ringed the Precambrian shield in postglacial time (for example, Lakes Barlow-Ojibway, Agassiz, and McConnell). At times these lakes probably acted as barriers to the northerly movement of land mammals while promoting the rapid northwesterly distribution of some freshwater fishes.

Against this background of some major characteristics of the ice age in northern North America, I wish to review Canadian and Alaskan Quaternary vertebrate faunas. To make the review more complete, I have attempted to outline the chronological sequence of the faunas (Figure 3). Because northwestern North America and northeastern Siberia have been connected for long periods in the Quaternary, I will discuss some of the relationships between faunas. Several of the most important Quaternary vertebrate faunas of northeastern Siberia are described in the Appendix.

The emphasis is on listing vertebrate species identified from bones in fossil-bearing beds at each locality. In most cases, species from a single sedimentary layer or unit are treated collectively as a "fauna", but it is difficult to tell whether all species identified from each unit actually lived in the same area at the same time. This is especially true when the remains consist of bone fragments from stream deposits in which reworking and mixing of fossils of various ages is possible.

The faunas considered range in age from about 1,800,000 years to 5,000 years. For each fauna the following points are dealt with, where possible: suggested geological age, stratigraphy at the site, palaeoenvironmental implications, and pertinent references.

Where interest seems to warrant it, single species or specimens are discussed. Radiocarbon dates on bone from Pleistocene vertebrates or from associated organic material are included where relevant. Early man is mentioned briefly. Recent evidence suggests that he was present in northern North America about 27,000 years ago, and perhaps even earlier than 32,000 years ago.

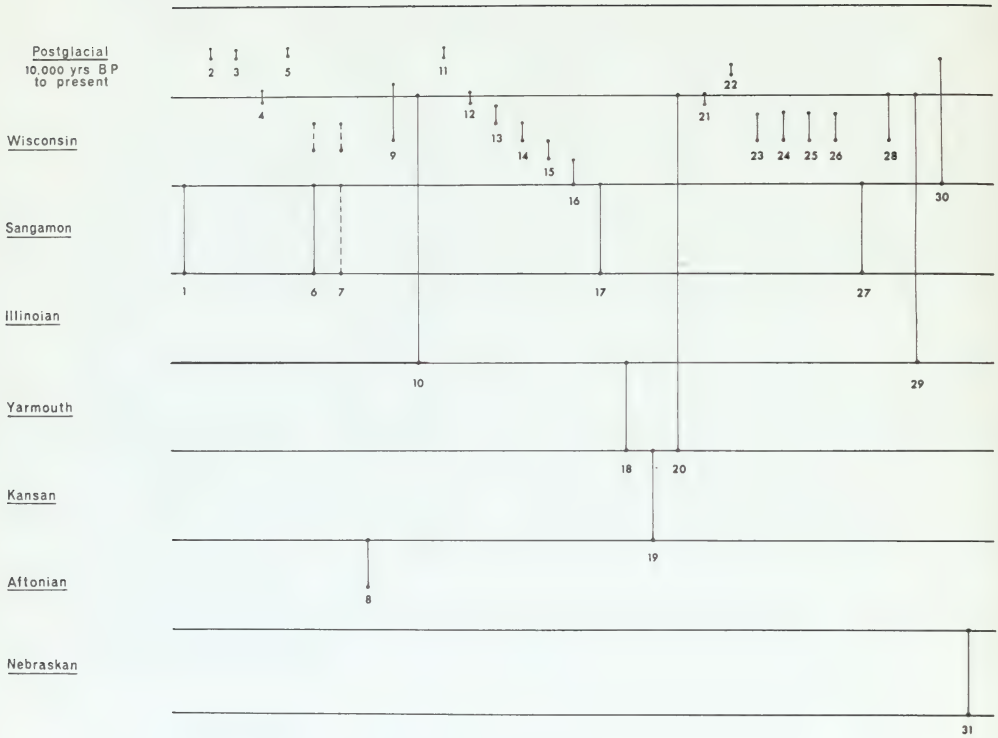

FIGURE 3. *Suggested chronological sequence of Quaternary vertebrate faunas of Canada and Alaska. Solid vertical lines indicate probable age; broken lines indicate possible age. Numbers are those used in the text to identify the faunas:*

1. Toronto, Ontario (Don Formation); 2. Hamilton, Ontario (Hamilton Bay); 4. Ottawa, Ontario (Green 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); 21. Cochrane, Alberta (Big Hill Creek Formation); 22. Acasta Lake, Northwest Territories; 23. Gold Run Creek, Yukon Territory (Dawson area); 24. Upper Hunker Creek, Yukon Territory (Dawson area); 25. Sixtymile River (Dawson area); 26. Old Crow River, Yukon Territory (Locality 14N); 27. Old Crow River, Yukon Territory (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).

QUATERNARY VERTEBRATE FAUNAS IN CANADA

Atlantic Provinces

No important Quaternary vertebrate faunas are known from the Atlantic Provinces. Heavy multiple glaciation of the region and the highly acidic soils are partly responsible for this lack of faunal preservation. Although beaver-cut sticks and unspecified mammal remains probably more than 33,800 years old (GSC-33) have been reported from a sinkhole in gypsum near Milford Station, Nova Scotia (Prest 1970), the material has not been thoroughly studied and its significance has yet to be assessed.

Scattered mastodon (*Mammut americanum*) teeth have been excavated or ploughed up on mainland Nova Scotia and on Cape Breton Island (Piers 1912). In 1936 a virtually complete mastodon skeleton was excavated by members of the New Brunswick Provincial Museum from blue clay near Hillsborough, New Brunswick (Squires 1966) (Figure 4). A bone from the skeleton has yielded a radiocarbon date of 13,600 ± 200 B.P. (GSC-1222).

Several mastodon and mammoth (*Mammuthus* sp.) teeth have been brought up in fishermen's nets from Georges Bank and the continental shelf of the northeastern United States, where submerged shorelines, peat deposits, lagoonal shells and relict sands are present. Evidently Quaternary elephants and other large mammals lived there during the low sea-level stage 25,000 to 6,000 years ago, when the Wisconsin ice sheet was near its maximum extent (Whitmore et al. 1967).

Beaver-cut wood from organic silt and peat overlying glacial till near Donkin, Cape Breton Island, indicates that beavers occupied that area a few thousand years after the Wisconsin ice had vanished. The gnawed wood yielded a radiocarbon date of 9,590 ± 160 B.P. (I-2477).

One of the most important sites of early man in eastern North America is at Debert, Nova Scotia (MacDonald 1968). Evidently a fairly large population of Palaeo-Indians lived there about 10,600 years ago. Cooperative hunting at the site may have concentrated on the woodland caribou (*Rangifer tarandus*). Unfortunately, high soil acidity destroyed all traces of faunal remains at the site.

Québec

Marine mammal remains of early postglacial age are relatively common in raised beach deposits along the shores of the St. Lawrence River. Fossils of

FIGURE 4. *Restoration of an American mastodon* (Mammut americanum) *in an open spruce forest. Ink sketch by Charles Douglas.*

white whales (*Delphinapterus leucas*) and harp seals (*Phoca (Pagophilus) groenlandica*) have been found in clays of Champlain Sea age at Montréal. A ringed seal (*Phoca (Pusa) hispida*) deposited in place in Champlain Sea clay near Hull probably lived during an early cold phase of the sea about 11,000 to 12,000 years ago. It indicates the presence of fast ice near the sea's western margin during winter and spring. The restored skeleton is mounted and on display at the National Museum of Natural Sciences (Harington and Sergeant 1972) (Figure 5). Postglacial walrus (*Odobenus rosmarus*) specimens have been found at nine localities along the St. Lawrence River and the north shore of the Gulf of St. Lawrence (Harington 1975b).

In 1916 an almost complete skeleton of an adult white whale was excavated from marine clay in eastern Montréal. Another exciting find was a nearly complete skeleton of a common finback whale (*Balaenoptera physalus*), which came from clay deposits about 275 feet (84 m) above sea level at Daveluyville (Laverdière 1950). Part of a bowhead whale (*Balaena mysticetus*) was excavated at Sainte-Anne-des-Monts in 1949 (Cameron 1951). Remains of a humpback whale (*Megaptera novaeangliae*) were found at Métis. Only two narwhal (*Monodon monoceras*) fossils have been reported from deposits of probable Champlain Sea age. They are from the north and south shores of the Baie des Chaleurs at Saint-Jogues, Québec and Jacquet River, New Brunswick (Perkins 1910).

Postglacial fish remains from Québec are uncommon. A well-preserved skull of a cod (*Gadus* sp.) was found in a clay nodule at "Goose River" (probably near the mouth of the Rivière aux Outardes) (Gruchy 1971), and a cod mandible was collected from gray marine silts in the Sept-Îles region. Unidentified fish vertebrae have been reported from Rivière-du-Loup (Dawson 1893).

Ontario

The most important Quaternary vertebrate faunas known from Ontario are located near Toronto, Hamilton and Ottawa.

The history of the Champlain Sea (Elson 1968, Prest 1970) and its vertebrate fauna (Harington 1971d, 1972, 1977; see Wagner 1967 for additional references) merit a brief description. This sea was an important late-Quaternary event that affected both Ontario and Québec. As the Wisconsin ice sheet retreated north of the St. Lawrence valley, the Atlantic Ocean flooded this depressed lowland. When the sea reached its maximum extent about 12,000 years ago, it covered at least 20,500 square miles (53,100 sq. km), including the area between Québec City and Brockville as well as the lower Ottawa River and Lake Champlain valleys.

FIGURE 5. *Restored skeleton of a ringed seal* (Phoca (Pusa) hispida) *from Champlain Sea deposits near Hull, Québec.*

Whales, particularly those adapted to cool inshore conditions, such as the white (*Delphinapterus leucas*), humpback (*Megaptera novaengliae*), bowhead (*Balaena mysticetus*), and common finback (*Balaenoptera physalus*), and the harbour porpoise (*Phocoena phocoena*) penetrated the Champlain Sea and exploited its food organisms, as did seals adapted to breeding on fast ice and pack ice, such as the harp (*Phoca (Pagophilus) groenlandica*), the ringed (*Phoca (Pusa) hispida*), the bearded (*Erignathus barbatus*), and possibly the bladdernose (*Cystophora cristata*).

Bone from a well-preserved white whale skeleton excavated at a sand pit in southern Ottawa yielded a date of 10,420 ± 150 B.P. (GSC-454). This whale was probably washed up on a beach of the Champlain Sea during an early formative stage of the Ottawa Delta. It has been fully restored and is displayed as a composite specimen in the National Museum of Natural Sciences. Radiocarbon analysis of bone from several vertebrae of a white whale from Pakenham, Ontario gave a date of 10,300 ± 80 B.P. (GSC-2418). Bone cored from the centre of the humerus of a bowhead whale from a high (575 feet (175 m) above sea level) beach of the Champlain Sea near White Lake, Ontario yielded a radiocarbon date of 11,400 ± 90 B.P. (GSC-2269).

Remains of land vertebrates — such as hare, presumably the snowshoe hare (*Lepus americanus*), from clay deposits at Montréal, eastern chipmunk (*Tamias striatus*) from marine gravels and sands near Moose Creek, Ontario, and American marten (*Martes americana*) from near Ottawa — suggest the presence of boreal and hardwood forest along the edges of the receding sea. The skull and part of the vertebral column and forelimbs of the marten are well preserved in both halves of a split nodule from Green Creek (Figure 6) (Harington 1972).

Birds, possibly shore birds, fed along the sea beaches. They are represented by imprints of feathers in Green Creek nodules, most of a vertebra from sands in southern Ottawa, and unspecified bones from the Leda Clay at Montréal.

Fish specimens such as capelin (*Mallotus villosus*), sculpin (*Artediellus uncinatus*), three-spined stickleback (*Gasterosteus aculeatus*), lake trout (*Salvelinus (Cristivomer) namaycush*), and possibly smelt (*Osmerus mordax*) and lumpfish (*Cyclopterus lumpus*) are preserved in clay nodules from Green Creek, indicating that a cool marine coastal habitat fed by streams from nearby deep lakes existed near Ottawa about 10,000 years ago.

Based largely on evidence from the shells of marine molluscs (Elson 1969, Wagner 1970), the early Champlain Sea environment was probably similar to that of the Gulf of St. Lawrence today, where most vertebrate species that occupied

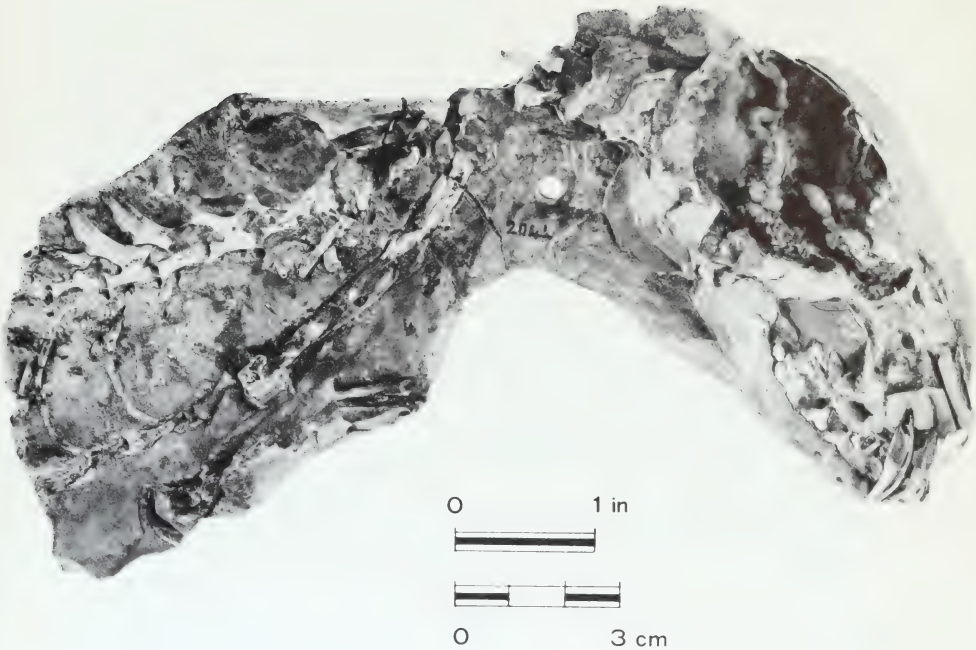

FIGURE 6. *Right side of the skull of an American marten* (Martes americana) *preserved in a calcareous clay nodule of Champlain Sea age from Green Creek near Ottawa, Ontario.*

the inland sea are still found. During its later phases, the Champlain Sea became warmer and less saline until it reached the freshwater phase (Lampsilis Lake), which may have occurred between about 10,000 and 8,000 years ago. Finally, the Lampsilis Lake drained and the landscape assumed its present character.

Of the mammoth (*Mammuthus* sp.) and mastodon (*Mammut americanum*) remains found in Ontario, those of the mastodons are by far the most abundant, and present an interesting problem. At least 62 occurrences of mastodons are known from the province; they are mainly from southern Ontario and are of postglacial age, between 12,900 and 9,000 years old according to some radiocarbon dates. Dreimanis (1967, 1968) has produced evidence to show that mastodons were especially adapted to open spruce woodlands or spruce forests, and has suggested that their extinction in southern Ontario was initiated by rapidly increasing dryness 10,000 to 11,000 years ago, which caused the spruce forests to retreat to moister lowlands and finally led to their disappearance. He believes that growth of an intervening belt of pine and hardwood forest on the better-drained morainic areas in central Ontario tended to prevent the mastodons from migrating to the more northerly spruce forests, and left them to die out among the ever-decreasing southern spruce "islands". However, King's discovery (1973) that mastodons occupied pine-parkland in the Ozarks of western Missouri and were capable of surviving away from spruce forests argues against Dreimanis's hypothesis. Probably the best American mastodon specimen from Ontario is a partial skeleton collected near Welland in 1912. It has been restored and mounted and is displayed in the Royal Ontario Museum (Russell 1965).

Most of the skeleton of a woolly mammoth (*Mammuthus primigenius*) was excavated from clay beneath a 2- to 3-foot (0.6 to 0.9 m) layer of peat near Muirkirk (Lambe 1898). The specimen is in the National Museums of Canada collections. Organic material with a woolly-mammoth tooth buried deeply in gravels near Woodbridge yielded a radiocarbon date of 45,000 ± 900 B.P. (GSC-1181), which indicates a mid-Wisconsin age for the mammoth (Churcher 1968b).

Scattered remains of wapiti (*Cervus elaphus*) have been found in postglacial deposits at such places as Sydenham, Kingston, Toronto, and Waterford. Grizzly bears (*Ursus arctos*) were present in early postglacial time too, for a well preserved skull 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 B.P. (Peterson 1965). Fossils from Toronto and Woodbridge indicate that grizzly bears lived in Ontario even earlier — in the Sangamon interglacial (or early Wisconsin) and mid-Wisconsin time respectively (Churcher

and Morgan 1976).

When they are more thoroughly explored, the Sangamon interglacial deposits in the Moose River Basin of northern Ontario may provide an insight into Quaternary vertebrate faunas of that region. Skinner (1973) collected a cyprinid-fish skeletal fragment and beaver-gnawed sticks from these deposits near Moose River Crossing. A mastodon tooth with jaw has been reported from the bed of the Moose River in the same area (Bell 1898).

A freshwater-drum specimen (*Aplodinotus grunniens*) was ploughed up from the former lake bed of Glacial Lake Barlow-Ojibway near New Liskeard. These fishes may have entered Glacial Lake Barlow-Ojibway from the west during the Gimli phase of Glacial Lake Agassiz about 8,000 years ago (Harington 1971e).

Soon after 12,500 years ago, as the continental ice sheet melted back, small bands of Palaeo-Indians, probably caribou hunters, moved into the tundra and boreal-forest landscape of southern Ontario. Approximately 50 of their fluted spear-points have been reported as isolated surface finds in that part of the province. However, few early Palaeo-Indian campsites have been detected in southern Ontario. One site, probably dating between 10,570 B.P. (GSC-1006, 1028) and 9,750 ± 135 B.P. (I-5786), which has produced major portions of more than 80 fluted points and knives and many scrapers and gravers, was excavated near Parkhill (Roosa 1977). Storck (1974) also mentions a possible site near Alliston. Several late Palaeo-Indian quarry campsites are known from the northern margins of the Great Lakes (MacDonald 1971). The Sheguiandah site on Manitoulin Island has been used by various peoples for over 10,000 years. Wright (1972) has summarized much of this information.

Faunas

1. Toronto, Ontario (Don Valley Brickyard — Don Formation)

Fishes - *Ictalurus punctatus* (channel catfish), *Esox* sp. (pike or muskellunge).

Mammals - *Marmota monax* (woodchuck), *Castoroides ohioensis* (giant beaver), Ursidae* (*?Ursus arctos*) (bear, possibly a brown bear), Proboscidea* (mammoth or mastodon), *Odocoileus virginianus* (white-tailed deer), *Cervalces borealis** (moose-like animal, *Bison* sp.* (bison).

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*From beds tentatively correlated with the Don Formation. However, Karrow believes that they may be of early-Wisconsin age (Churcher and Morgan 1976).

Suggested Age - Sangamon interglacial. Organic material from the Don Formation has yielded a radiocarbon date of more than 46,000 B.P. (L-409).

Remarks - Fossils are from a 25-foot-thick layer (7.6 m) of stratified, cross-bedded clay and sand underlain by the York Till of Illinoian age and overlain by the Scarborough Formation of early-Wisconsin age. Basal parts of the Don Formation contain pollen of a warm flora, which may have required for growth an average temperature as much as 5°F (2.8°C) warmer than at present (Terasmae 1960). Study of mollusc shells, wood, leaves, pollen and diatoms from the deposits indicates that the Don Formation was deposited in a freshwater estuary at the edge of a large lake that was at least 60 feet (18 m) higher than the present Lake Ontario. The kinds of fishes represented suggest a turbid freshwater environment, whereas the mammals indicate a partly forested area with patches of grassland and lakes or ponds.

References - Bensley 1913; Coleman 1913, 1933; Crossman and Harington 1970; Karrow 1969; Terasmae 1960; Terasmae, Karrow and Dreimanis 1972.

2. Toronto, Ontario (Scarborough Bluffs)

Mammals - *Tamias striatus* (eastern chipmunk), *Microtus pennsylvanicus* (meadow vole), *Urocyon cinereoargenteus* (grey fox).

Suggested Age - Postglacial. Associated charcoal fragments yielded radiocarbon dates of 5,240 ± 100 B.P. (S-115B) and 5,550 ± 70 B.P. (S-115A).

Remarks - Fossils are from a band of dark organic soil 4 feet (1.2 m) beneath turf covering an outwash fan that overlies a wave-cut bench of probable Lake Iroquois age. Undisturbed sands, silts and fine gravels overlie the fossiliferous soil, which seems to be alluvial in origin. The mammals represented suggest a moist, partly forested area with grassy patches (like that proposed for Hamilton; see Fauna 3). Mixed forest was prevalent according to species identified from charcoal, with fossils of *Pinus strobus* (white pine), *Acer saccharum* or *A. nigrum* (maple), and probably *Fagus grandifolia* (beech). Shells of gastropods in and below the organic soil support the presence of a mixed deciduous–conifer woodland, and are consistent with the warm climate ("climatic optimum") known to have existed about 5,000 years ago.

Reference - Churcher and Karrow 1963.

3. Hamilton, Ontario (Hamilton Bay site near Coote's Paradise)

Fishes - *Esox* sp. ("pickerel")

Amphibians - *Rana* sp. (frog)

Birds - *Aix sponsa* (wood duck), *Strix varia* (barred owl), *Agelaius phoeniceus* (red-winged blackbird), *Quiscalus quiscula* (common grackle).

Mammals - *Blarina brevicauda* (short-tailed shrew), *Sciurus carolinensis* (grey squirrel), *Tamiasciurus hudsonicus* (red squirrel), *Tamias striatus* (eastern chipmunk), *Glaucomys sabrinus* (flying squirrel), *Peromyscus* sp. (white-footed mouse), *Ondatra zibethicus* (muskrat), *Microtus pennsylvanicus* (meadow vole), *Microtus pinetorum* (pine vole), *Vulpes vulpes* (red fox).

Suggested Age - Possibly 5,000 to 6,000 B.P.

Remarks - Fossils are from a medium sand to fine gravel layer underlying deposits 3 to 4 feet (0.9 to 1.2 m) thick of the former shoreline of Lake Iroquois. The fossil layer has been interpreted as an inshore lake-bottom deposit that became covered with beach material as the lake level dropped. Fish and amphibian remains suggest a lake-margin habitat, bird fossils a moist mixed-woodland, and mammals a moist mixed-forest habitat with some grassy patches.

References - Churcher and Karrow 1963; Wetmore 1958.

4. Ottawa, Ontario (near the mouth of Green Creek)

Fishes - *Mallotus villosus* (capelin), *Artediellus uncinatus* (sculpin), *Cyclopterus lumpus** (lumpfish), *Osmerus mordax** (smelt) *Gasterosteus aculeatus* (three-spined stickleback), *Salvelinus (Cristivomer) namaycush* (lake trout).

Birds - Unidentified species. Possibly a shore bird is represented.

Mammals - *Martes americana* (American marten), *Phoca (Pagophilus) groenlandica* (harp seal), *Phoca* sp. (seal).

Suggested Age - Postglacial. Probably about 10,000 B.P., when the shoreline of the Champlain Sea was in the Ottawa area, and during the formation of the Ottawa Delta.

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*Reported by Dawson (1893). Better fossil evidence of this species is required.

Remarks - Fossils are from calcareous clay nodules weathering out of Leda Clay of Champlain Sea age. Two distinct bodies of clay exist at Green Creek; the older is undoubtedly marine and was deposited in the Champlain Sea, but the nature and age of the younger is controversial. Gadd (1961) favours a freshwater origin for the younger clay. The nodules contain many shells indicating a subarctic marine environment. The vertebrate fauna preserved in the nodules is indicative of a cool marine coastal environment with patches of coniferous forest nearby. More research is required on plant and insect remains in the nodules to obtain a clearer idea of the palaeoenvironment.

References - Dawson 1893; Gadd 1961; Gruchy 1968; Harington 1971d, 1972, 1977; Harington and Sergeant 1972; Sternberg 1951; Wagner 1967.

Manitoba

No Quaternary vertebrate faunas are known from this province, although many scattered finds have been made, particularly of the extinct western bison (*Bison bison occidentalis*) in postglacial deposits of southern Manitoba (Pettipas 1971). These bison, the long-horned ancestors of the modern plains bison (*B. b. bison*), ranged over southwestern Manitoba about 9,000 years ago and evidently were hunted by Palaeo-Indians.

Leith (1949) and Young (1966) have reviewed ice-age elephant finds in Manitoba. Most specimens represent the woolly mammoth (*Mammuthus primigenius*), but an upper third molar from Rivers is best referred to the Columbian mammoth (*M. columbi*). These fossils are concentrated in the south-central (Brandon–Winnipeg) and western (Benito) parts of the province.

A skull fragment of a tundra muskox (*Ovibos moschatus*) was collected from gravels near Grandview in 1963 (Figure 7). Bone from the specimen yielded a radiocarbon date of 8,620 ± 190 B.P. (I-1623). The fossil may represent muskox herds that moved north from a refugium south of the Wisconsin ice sheet, feeding in the tundra-like zone bordering the retreating ice until they reached their present range on the Northwest Territories mainland (Harington 1970a).

An interesting sequence of Quaternary deposits is exposed near Minnedosa. There, bones of ground squirrel (*Spermophilus* sp.) were recovered from an ancient burrow in a silt bed 5 feet (1.5 m) thick that was overlain by 61 feet (18.6 m) of sediment, including three glacial tills, and underlain by 16 feet (4.9 m) of till. Plant fragments associated with the bones yielded a

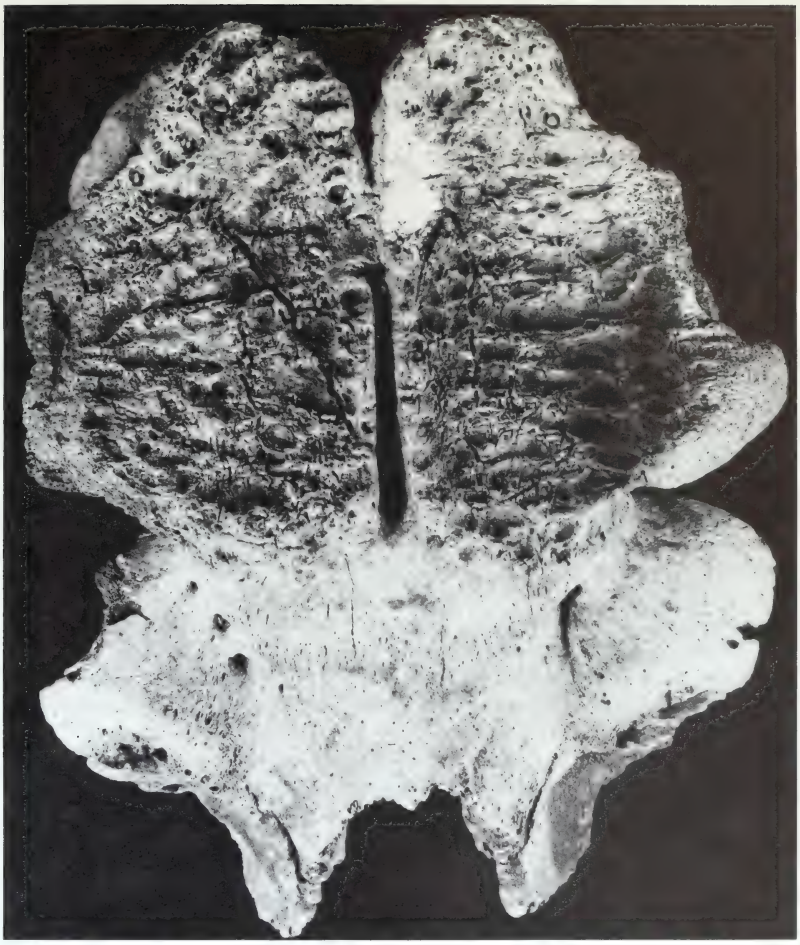

FIGURE 7. *Upper surface of a tundra muskox* (Ovibos moschatus) *cranial fragment from postglacial deposits near Grandview, Manitoba.*

radiocarbon date of more than 31,300 B.P. (GSC-297). The fossil-bearing silt is probably of early-Wisconsin interstadial or Sangamon interglacial age (Klassen, Delorme and Mott 1967).

Evidence for early man in Manitoba has been discussed by Mayer-Oakes (1967) and Pettipas (1970).

Saskatchewan

A few productive vertebrate localities have been discovered in southern Saskatchewan. The Wellsch Valley fauna is the oldest, Fort Qu'Appelle and Saskatoon may be of similar age (probably Sangamon interglacial, but possibly Wisconsin interstadial), and Oxbow Dam is the youngest.

Many scattered remains of mammoths and a few of mastodons have been reported from Saskatchewan (Sternberg 1963). The Kyle mammoth, one of the most interesting specimens, was collected from contorted lake sediments near Kyle in 1964, and was relatively complete but poorly preserved. Radiocarbon dates suggest that active ice had left the Kyle area more than 14,000 years ago. Radiocarbon analysis of bone indicates that the mammoth died toward the close of the Wisconsin glaciation (12,000 ± 200 B.P. (S-246)).

A rich site deserving further investigation is located near Dundurn. In 1924 many chert tools and flakes and some shell and bone artifacts were excavated from a 6-foot-thick (1.8 m) layer of sand containing freshwater gastropod shells, which was overlain by 4 feet (1.2 m) of sticky clay and underlain by tough yellowish clay (Parks 1925). All the fragments of bone broken by man were stained black. Vertebrate remains from the site include: Pisces (undetermined fish vertebrae), Rodentia (undetermined rodent mandibles), *Canis lupus* (wolf), *Taxidea taxus* (badger), *?Rangifer* sp. (caribou), *Antilocapra americana* (prongbuck), *Bison* sp. (bison). The basal yellowish clay may be a till of late-Wisconsin age, in which case the specimens would be postglacial. The new genus *"Neomeryx finni"* reported from this site is now considered to be synonymous with *Antilocapra americana*, the prongbuck (Simpson 1945).

An interesting, but problematical, specimen of a sciaenid fish with similarities to *Pogonias* (a drum adapted to warm marine conditions in the Gulf of Mexico) was collected from gravels over 35,000 years old that are exposed near North Battleford (Harington 1971e). Uyeno and Miller (1963) record remains of cyprinid fishes (Cyprinidae) from deposits near Lillestrom estimated to be 10,000 years old.

The discovery of a bone projectile point or foreshaft at Grenfell suggests that Palaeo-Indians hunted big game near the margin of the retreating Wisconsin ice sheet in southeastern Saskatchewan. The implement, carved from mammoth or mastodon bone, was excavated from postglacial deposits probably less than 10,000 years old (Wilmeth 1968).

Faunas

5. Oxbow Dam, Saskatchewan (one mile [1.6 km] south of Oxbow)

Amphibians - *?Rana* sp. (frog)

Mammals - *Homo* sp. (man — indirect evidence from artifacts), *Canis latrans* (coyote), *Canis lupus* (wolf), *Vulpes velox* (kit fox), *?Cervus elaphus* (?wapiti), *Bison* sp. (bison).

Suggested Age - Postglacial. Charcoal from an ash bed directly below the zone where most of the vertebrates were found yielded radiocarbon dates of 5,100 ± 250 B.P.

Remarks - Most bones and artifacts are from a thin layer of ash at the base of a dark silty unit that also contained pelecypod shells. This unit is overlain by about 1 foot (30.5 cm) of bluff silt capped by 8 inches (20.3 cm) of soil, and underlain by an unknown thickness of buff silt. Vertebrate species, particularly the bison and kit fox, suggest a grassland environment, while the mollusc and frog remains indicate the presence of wet areas, perhaps ponds or streams nearby.

Reference - Nero and McCorquodale 1958.

6. Fort Qu'Appelle, Saskatchewan (Bliss Gravel Pit — Echo Lake Gravels)

Mammals - Rodentia (rodent), *Canis* sp. (?wolf), *Arctodus simus** (short-faced bear), *Taxidea taxus* (badger), *Mammuthus columbi* (Columbian mammoth), *Equus scotti* (Scott's horse), *Camelops* cf. *hesternus* (camel), *Cervalces roosevelti (= Alces latifrons?)* (moose-like animal), *Bison latifrons* (giant bison), *Symbos cavifrons* (extinct muskox).

*From deposits near Lebret, across the valley from Fort Qu'Appelle, that I tentatively correlate with the Echo Lake Gravels.

Suggested Age - Probably of Sangamon interglacial or, at the latest, Wisconsin interstadial age. Mollusc shells from sand overlying the fossiliferous gravels have yielded a radiocarbon date of >30,000 B.P. (GSC-987).

Remarks - Vertebrate fossils are from a series of gravel beds (Echo Lake Gravels) overlain by sand and thick till, presumably of Wisconsin age, and underlain by another thick till. The gravels may be outwash material laid down at the close of an interglacial or interstadial by an advancing ice sheet that deposited the Floral Formation. Most of the mammals represented suggest a grassland habitat. The badger is a particularly good grassland indicator. The moose-like animal may indicate occasional pockets of moist woodland, but wood remains in the Echo Lake Gravels are generally not large and suggest a shrubby grassland rather than a parkland environment with many trees. Aquatic molluscs found with the extinct-muskox skull (Figure 8) probably occupied a mesotrophic to eutrophic body of water at a depth of 10 to 20 feet (3.1 to 6.1 m). Terrestrial molluscs indicate the presence of some trees and a moister climate than now, in addition to some muddy lake or river banks. Therefore the evidence points toward a grassland environment with scattered shrubs, a few trees, and persistent ponds and streams.

References - Christiansen 1960, 1972; Harington 1973a; Khan 1970; McCorquodale 1957; Russell 1956.

7. Saskatoon area, Saskatchewan (Saskatoon, Riddell and other sites — Floral Formation)

Mammals - Rodentia (rodent), *Taxidea taxus** (badger), *Mammuthus columbi* (Columbian mammoth), *Equus scotti* (Scott's horse), *Camelops* sp. (camel), *Cervus elaphus* (wapiti), *Bison* sp. (bison).

Suggested Age - Probably of Sangamon interglacial age or possibly of Wisconsin interstadial age. Stratigraphic studies and radiocarbon dates indicate that the Floral Formation is more than 34,000 years old (S-426). The similarity of the Fort Qu'Appelle and Saskatoon faunas is remarkable, and could indicate a general similarity in age.

*The specimen on which this identification is based cannot now be located in collections of the Royal Ontario Museum.

FIGURE 8. *Cranium with horncores of the extinct muskox* (Symbos cavifrons) *from gravels of probable Sangamon interglacial age at Fort Qu'Appelle, Saskatchewan.*

Remarks - At the Saskatoon Site, sands containing the vertebrate fossils are 20 to 30 feet (6.1 to 9.1 m) thick and are enclosed by two tills of the Floral Formation. This formation is overlain by till of the Battleford Formation (late Wisconsin) and surficial stratified drift (silts and clays), and underlain by sand and till of the Sutherland Group. Fold and wedge structures in the fossil-bearing sand indicate that it was probably laid down during the retreat of the glacier that deposited the Floral Formation. The vertebrates are similar to those from Fort Qu'Appelle, and suggest a basic grassland environment. Shells of a pelecypod and of six species of gastropod molluscs from the Floral Formation sands indicate a fluvial environment. The mollusc faunas of both Fort Qu'Appelle and Saskatoon localities may tell more about the environments of deposition than about the environments occupied by the vertebrate faunas.

References - Christiansen 1968; Harington 1973b; Lammers 1968; Pohorecky and Wilson 1968; Russell 1943.

8. Wellsch Valley, Saskatchewan (50°39'50"N, 107°52'30"W)

Mammals - Xenarthra (ground sloth), *?Hypolagus limnetus* (marsh rabbit), *Cynomys ?meadensis** (prairie dog), *Spermophilus* sp.* (ground squirrel), *?Oryzomys* sp.* (rice rat), *Thomomys* sp. near *T. umbrinus** (pocket gopher), *T. talpoides* * (northern pocket gopher), *Synaptomys (Mictomys) kansasensis** (Kansas bog lemming), *Pliomys* cf. *deeringensis** (Deering meadow mouse), *Microtus deceitensis** (Cape Deceit vole), *Borophagus diversidens* (bone-eating dog), *Lynx* cf. *rufus* (bobcat-like carnivore), *Mammuthus* cf. *meridionalis* (southern mammoth), *Equus pacificus* (Pacific horse), *E. complicatus* (horse), *Platygonus* sp. (flat-headed peccary), *Camelops* sp. (camel), Antilocapridae (prongbuck), Ovibovini* (muskox).

Suggested Age - Late Aftonian interglacial, according to the known chronological range of the mammals. It is certainly older than the fauna considered to be of Kansan age at Medicine Hat, Alberta. Recent palaeomagnetic evidence indicates that the fossiliferous unit was deposited about the time of the Olduvai Event, approximately 1.7 million years ago (A. MacS. Stalker, personal communication, 1976).

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*C.S. Churcher, personal communication, 1975.

Remarks - Fossils are from a 53-foot-thick (16.2 m) layer of stony silt, clay, sand and gravel that was probably deposited during intermittent flash floods. It contains stones from the Canadian Shield. This unit is overlain by four or more tills with beds of sand, gravel, silt and clay between them that so far have not yielded fossils. The top till is probably of late-Wisconsin age. The fossiliferous unit is underlain unconformably by Upper Cretaceous bedrock. Current bedding indicates that most of the unit was deposited by streams flowing from the south or southeast. Rodent, horse, camel and prongbuck fossils suggest a grassland environment. The fauna may have lived in an interglacial environment at least as warm as the present one. The presence of *Microtus deceitensis* and *Pliomys* cf. *deeringensis* are the first reports of these taxa in North America except for those from Cape Deceit, Alaska. They suggest a southward migration from the Beringian region during interglacial time and a roughly similar age for the Cape Deceit and Wellsch Valley faunas. A single molar tooth of *Merychippus insignis* found with these faunal remains is considered to be intrusive because of its different state of fossilization.

References - Stalker 1971; Stalker and Churcher 1972.

Alberta

A number of ice-age vertebrate faunal localities have been found in Alberta. The Medicine Hat area is most important, for fossils from various stratigraphic levels enable us to reconstruct a picture of successive faunas extending from Kansan to postglacial time. Approximately 2 types of birds and 29 kinds of mammals are represented from deposits of probable Sangamon age at Medicine Hat. It is one of the richest Pleistocene vertebrate faunas in Canada. Faunas from Empress and Cochrane are probably late Wisconsin in age.

Pleistocene mammal remains have been collected for many years near Calgary. Bison and mammoth are occasionally reported from excavations in or near the city, and remains of Mexican wild ass (*Equus (Asinus) conversidens*), camel (*Camelops* sp.), and bison (*Bison bison antiquus*) have been derived from postglacial gravels there (Wilson 1974:39; M. Wilson, personal communication, 1975). Radiocarbon analysis of bison bone yielded dates of 8,080 ± 150 B.P. (GSC-1209) and 8,145 ± 320 B.P. (GX-2104). At the Milan Site near Three Hills, abundant remains of a herd of *Bison bison occidentalis* and part of the skeleton of a wapiti (*Cervus elaphus*) (Figure 9) have been excavated from clay and sand underlying till-like material (Shackleton and Hills 1973).

FIGURE 9. *Front view of a postglacial wapiti* (Cervus elaphus) *skull with antlers from the Milan Site near Three Hills, Alberta. Whitish areas have been restored. Photograph by D.M. Shackleton.*

Radiocarbon analyses of bison bones have yielded dates of 9,630 ± 300 B.P. (GSC-1894) and 9,670 ± 160 B.P. (I-8579). What appears to be a glacial till overlying bones of postglacial age presents a problem that requires careful investigation by Pleistocene geologists.

The Edmonton area has also produced many Pleistocene mammal fossils. Part of the skull of a tundra muskox (*Ovibos moschatus*) was collected there in 1898. Other Alberta *Ovibos* fossils have been reported from surface gravel deposits at Ponoka and Cold Lake. Gravel pits in eastern Edmonton (Beverly) have yielded remains of the following mammals: *Mammuthus* sp. (mammoth), *Equus* sp. (horse), *?Camelus* sp. (camel), and three species of bison (*Bison latifrons*, *B. crassicornis* and *B. bison occidentalis*). Fuller and Bayrock (1965) suggest that these species existed in the vicinity of Edmonton some 8,000 years ago. However, there are difficulties in identifying and dating these specimens. Churcher (1968a) has referred six horse metacarpals from the Beverly Gravel Pits to *Equus (Asinus) conversidens*, and I would refer the *?Camelus* phalanx to *Camelops hesternus*. Further, it seems unlikely that three different species of bison occupied the same area at the same time. Perhaps the *Bison crassicornis* and *B. latifrons* specimens were somehow derived from older gravels. The *B. bison occidentalis* cranial fragment, which has two important characters suggesting a closer affinity to *B. b. antiquus*, is probably of postglacial age. The horncore referred to *B. latifrons* (certainly atypical of that species in its relative shortness and high degree of curvature) and the *B. crassicornis* cranial fragment are probably Illinoian to Wisconsin in age.

In 1974, J.A. Westgate sent me a number of interesting specimens from the Apex Gravel Pit near Edmonton. They shed additional light on this problem. Biostratigraphic evidence from this pit indicates that bison with very robust horns (*Bison* cf. *alleni*) and medium-sized horses like *Equus scotti* lived in the region before it was glaciated, and were succeeded by smaller-horned bison (*B. crassicornis*) and ass-like horses (*Equus (Asinus)* cf. *conversidens*) after the area had been first affected by continental glaciation. A specimen of the extinct muskox *Symbos cavifrons* from a correlative stratum at a nearby gravel pit (Harington 1975a) indicates that this species lived about the same time as *B. crassicornis* and *E. (Asinus)* cf. *conversidens*.

Remains of amphibians are rarely found in Pleistocene or early postglacial deposits in Canada. Therefore, it is interesting to note that large numbers of toad skeletons (approximately 50 were collected in an hour) came from fine to medium-grained impure sand of postglacial age near Killam. Both the spadefoot toad (*Scaphiopus hammondi bombifrons*) and the great plains toad (*Bufo cognatus*) from the site are about 100 miles (160 km) north of their

present ranges. They probably lived near Killam during the postglacial warm period that existed about 7,000 to 4,000 years ago, when the prairie (to which these species are adapted) extended farther northwards than it does at present (Bayrock 1964). I speculate that these toads became concentrated in a decreasing area of moistness before finally succumbing to extreme drought.

In 1961, important human skeletal remains were discovered by a field party under A. MacS. Stalker, of the Geological Survey of Canada (Langston and Oschinsky 1963, Stalker 1969a). Cranial fragments, part of a lower jaw containing two unerupted deciduous molars, and a free second-molar cap came from a cliff on the east side of the Oldman River about 3 miles (4.8 km) north of Taber (Figures 10a, b). Some postcranial material was also collected. Evidently the bones are those of a child about four months old (Irving 1971). Although the bones have not been dated directly, evidently they were found about 60 feet (18.3 m) below the prairie surface, and were derived from a layer of sand beneath a glacial till. As the till was laid down by an ice sheet that spread over the area some 22,000 years ago, it seems that the bones are at least that old. Correlation with other bluffs along the Oldman River suggests that the human remains are more than 32,000 years old (Stalker 1969a, 1977).

Palaeo-Indians evidently killed and butchered bison (*Bison* sp.) at the Fletcher Site in southern Alberta. Alberta and Scottsbluff projectile points were derived from the bone layer, which was deposited between 11,000 and 7,000 years ago according to stratigraphic evidence (Forbis 1968).

A cobble chopper imbedded in the braincase of an extinct bison (*Bison bison occidentalis*) was found at the Bayrock Site near Taber in alluvium approximately 250 feet (76 m) above the Oldman River. Wood from this deposit yielded a radiocarbon date of 11,000 ± 250 B.P. (S-68). This artifact and bison braincase are displayed in the Drumheller Museum. Other stone artifacts, including an Alberta point, were scattered among fragments of bison bone derived from a blue-stained occupation layer near the top of the section. Wormington and Forbis (1965) have summarized other information on Palaeo-Indians in Alberta. Reeves (1969) provides a summary of the palaeoenvironments and palaeocultures of southern Alberta.

Faunas

9. Empress, Alberta (50°57'50"N, 110°00'50"W)

Mammals - *Mammuthus imperator* (imperial mammoth), *Mammuthus primigenius* (woolly mammoth), *Equus (Asinus) conversidens*

FIGURE 10a. *Right-side view of the cranial bones (dark) of a human* (Homo *sp.*) *child about four months old. Setting the bones into a plaster cast (white) of an older child's skull was done to show the relative position of the fossil bone. These remains from near Taber, Alberta, may be more than 32,000 years old.*

FIGURE 10b. *Left-side view of the fossilized cranial bones (dark) of the "Taber child".*

(Mexican wild ass), *Equus scotti* (Scott's horse), *Rangifer* sp. (caribou), *Camelops* cf. *hesternus* (camel), *Bison bison* cf. *occidentalis* (western bison).

Suggested Age - Late Wisconsin. Radiocarbon analyses of unspecified bone fragments from the site yielded dates of 14,200 ± 1,120 B.P. (GSC-1199) and 20,400 ± 320 B.P. (GSC-1387).

Remarks - Fossils are from a sand and gravel terrace approximately 49 feet (15 m) above river level on the south bank of the Red Deer River. They were deposited in the bed of a fast-flowing stream. The presence of caribou and woolly mammoth suggests that the fauna occupied a cool grassland or tundra-like environment. The presence of the imperial mammoth in this fauna appears to be anomalous.

References - Lowden and Blake 1975; Stalker 1971.

10. Bindloss area, Alberta (50°57'N, 110°08'W)

Mammals - *Panthera leo atrox* (American lion), *Mammuthus imperator* (imperial mammoth), *Equus (Asinus) conversidens* (Mexican wild ass).

Suggested Age - Late Pleistocene. As the region was covered by ice during the maximum Wisconsin advance, the fossils are probably of interstadial or interglacial age.

Remarks - Fossils are from sandy gravel in a terrace about 100 feet (30.5 m) above the present level of the Red Deer River. Boulders in the sandy gravel appear to be a lag deposit from a moraine. The presence of imperial mammoth suggests that the fauna occupied a relatively warm grassland environment.

References - Churcher 1972; Harington 1971a.

11–19. Medicine Hat area, Alberta (main localities are Surprise, Mitchell and Island bluffs)

11. Fauna 1

Mammals - *Homo* sp. (indirect evidence of man), *Antilocapra* cf. *americana* (prongbuck), *Bison bison* cf. *bison* (plains bison).

Suggested Age - Postglacial, 5,000 B.P.

Remarks - Fossils are from a sand unit 50 feet (15.2 m) thick at the top of the section. The presence of bison and prongbuck remains suggests a prairie grassland like that at present covering the Medicine Hat region.

It should be noted that stratigraphic data presented here have been drawn from a chart (Stalker and Churcher 1970) showing a composite portrayal of deposits exposed at 12 bluffs along the South Saskatchewan River from 7 miles (11.3 km) west to 8 miles 12.9 km) north of Medicine Hat. As no single bluff exhibited a complete section, the thickest exposure of each unit in the area was used in the chart. Units whose correct positions in the composite section were uncertain were generally omitted.

References - See No. 19 Fauna 9.

12. Fauna 2

Mammals - *Homo* sp. (indirect evidence of man), *Canis lupus* (wolf), *Mammuthus primigenius* (woolly mammoth), *Equus (Asinus) conversidens* (Mexican wild ass), ?Camelidae (camel), *Bison* sp. (large bison).

Suggested Age - Late Wisconsin, 11,000 B.P.

Remarks - Fossils are from the upper 40 feet (12 m) of a 60-foot-thick (18.3 m) sand and gravel unit that underlies the uppermost postglacial sand unit. A grassland environment is indicated by the number of grazers in the fauna. Cool grassland or tundra-like conditions are suggested by the woolly-mammoth remains.

References - See No. 19 Fauna 9.

13. Fauna 3

Mammals - *Canis lupus* (wolf), *Mammuthus imperator* (imperial mammoth), *Equus (Asinus) conversidens* (Mexican wild ass), *Camelops* sp. (camel).

Suggested Age - Late Wisconsin. The dating of 15,000 B.P. estimated by Stalker and Churcher (1970) seems too old or too recent if the ice-frontal positions near Medicine Hat indicated by Prest (1969) are correct.

Remarks - Fossils are from near the base of the lower 20 feet (6.1 m) of a 60-foot-thick (18.3 m) unit of sand and gravel that is underlain by a yellowish-buff till of Wisconsin age. The fauna suggests a grassland environment, perhaps warmer than that indicated by Fauna 2. The imperial mammoth evidently occupied a warmer environment than the woolly mammoth.

References - See No. 19 Fauna 9.

14. Fauna 4

Amphibians - *Bufo hemiophrys* (toad)

Mammals - *Nothrotherium ?shastense* (Shasta ground sloth), *Canis* cf. *dirus* (dire wolf), *Smilodon floridanus* (sabretooth cat), *Mammuthus* sp. (mammoth), *Equus (Asinus) conversidens* (Mexican wild ass), *Camelops hesternus* (western camel), *Odocoileus* sp. (deer), *?Antilocapra* cf. *americana* (prongbuck).

Suggested Age - Late mid-Wisconsin.

Remarks - Fossils are from an 80-foot-thick (24.4 m) sand and gravel unit overlain by yellowish-buff till and underlain by a gravel bed 15 feet (4.6 m) thick. There is an erosional break between fossiliferous and till deposits. Most of the mammals, such as the mammoth, wild ass, camel and possibly the prongbuck, suggest that the fauna occupied a basically grassland environment. Probably moist areas and patches of trees and shrubs were present too, as indicated by the toad and deer fossils respectively.

References - See No. 19 Fauna 9.

15. Fauna 5

Mammals - *Lepus* cf. *townsendi* (hare), *Cynomys* cf. *ludovicianus* (prairie dog), *Spermophilus richardsoni* (ground squirrel), *Thomomys* cf. *talpoides* (pocket gopher), *Microtus* sp. (vole), *Canis* cf. *latrans* (coyote), *Spilogale* cf. *putorius* (spotted skunk), *Smilodon floridanus* (sabretooth cat), *Mammuthus* sp. (mammoth), *Equus (Asinus) conversidens* (Mexican wild ass), *Equus* cf. *giganteus* (large horse), *Hemiauchenia ?stevensi* (long-legged llama), *Camelops hesternus* (western camel), *Odocoileus* sp. (deer), *?Antilocapra* cf. *americana* (prongbuck), *Bison* sp. (large bison).

Suggested Age - Early mid-Wisconsin. Radiocarbon analyses of wood approximately 3 to 7 feet (1 to 2 m) above the faunal remains yielded dates of 37,900 ± 1,100 B.P. (GSC-1442) and 38,700 ± 1,100 B.P. (GSC-1442-2).

Remarks - Fossils are from a 105-foot-thick (32 m) unit of silt containing sand and minor clay, overlain and underlain by gravel. Most mammal fossils suggest a prairie grassland habitat for this fauna.

References - See No. 19 Fauna 9.

16. Fauna 6

Mammals - *Mammuthus primigenius* (woolly mammoth), *Equus (Asinus) conversidens* (Mexican wild ass), *Camelops* cf. *hesternus* (western camel).

Suggested Age - Early Wisconsin.

Remarks - Fossils are from a 2-foot-thick (0.6 m) gravel unit overlain by sand and clay and underlain by dark-grey contorted till. The mammal fossils suggest a cool grassland or tundra-like environment.

References - See No. 19 Fauna 9.

17. Fauna 7

Birds - *?Buteo* sp. (hawk), *Canachites* sp. (grouse).

Mammals - *Megalonyx* sp. (ground sloth), *Sylvilagus floridanus* (rabbit), *Lepus* cf. *townsendi* (hare), *Thomomys* cf. *talpoides* (pocket gopher), *Cynomys* cf. *ludovicianus* (prairie dog), *Spermophilus richardsoni* (ground squirrel), *Microtus* sp. (vole), *Ondatra zibethicus* (muskrat), *Erethizon dorsatum* (porcupine), *Canis lupus* (wolf), *Vulpes vulpes* (red fox), *Procyon lotor* (raccoon), *Mustela (Putorius)* cf. *nigripes* (large ferret), *Lynx canadensis* (lynx), *Panthera leo atrox* (American lion), *Mammuthus columbi jeffersoni* (Jefferson's mammoth), *Equus (Asinus) conversidens* (Mexican wild ass), *Equus scotti* (Scott's horse), *Amerhippus* sp. (neotropical horse), *Hemiauchenia* sp. (long-legged llama), *Camelops hesternus* (western camel), *Odocoileus* sp. (deer), *Cervus* cf. *elaphus* (wapiti), *Rangifer tarandus* (caribou), *Rangifer* sp. (small caribou) *?Alces* sp. (moose-like deer), *?Antilocapra* cf. *americana* (prongbuck), *Ovis canadensis* (mountain sheep), *Bison* cf. *latifrons* (giant bison).

Suggested Age - Sangamon interglacial.

Remarks - Fossils are from a 95-foot-thick (29 m) sand and gravel unit containing stones from the Canadian Shield near its base. The unit is overlain by a dark-grey contorted till and underlain by black till. The environment of deposition was mainly fluvial. Some conclusions can be reached concerning the past environment of the vertebrate fauna by considering habitats commonly occupied by the various species represented. The hawk suggests woodland or open country, while the grouse probably

indicates the proximity of coniferous or mixed forest. Of the 29 mammal species possibly represented, 12 are commonly found in open grassland habitats, 5 in parkland, 4 in woodland, 2 in tundra or coniferous forest, and one commonly in alpine grassland; another is associated with water; and the remaining 3 are variable in their choice of habitat. Therefore, large tracts of open grassland with patches of trees and some ponds or lakes probably were present in this region of southern Alberta during the Sangamon interglacial. Of the species listed, approximately one third are extinct.

References - See No. 19 Fauna 9.

18. Fauna 8

Mammals - *Megalonyx jeffersoni* (Jefferson's ground sloth), *Cynomys* cf. *ludovicianus* (prairie dog), *Mammuthus columbi* (Columbian mammoth), *Equus (Asinus)* sp. (wild ass), *E. scotti* (Scott's horse), *Camelops* sp. (camel), *Rangifer* sp. (small caribou), *Bison* cf. *latifrons* (giant bison).

Suggested Age - Yarmouth interglacial.

Remarks - Fossils are from an 80-foot-thick (24.4 m) sand unit underlying a thin black till containing stones from the Canadian Shield, and overlying a thin organic layer containing spruce, poplar and willow wood. The environment of deposition was fluvial. Mammal remains suggest a predominantly open-grassland environment, which evidently followed a moister period when woodlands were more common in the region than they are now. The elements of this mammal fauna seem to be the same as that of the Sangamon fauna. The early appearance of bison in a fauna considered to be of Yarmouth age would seem remarkable if a probably earlier bison had not been recorded from Alaska (Table 1).

D.M. Hopkins (personal communication, 1976) suggests that this fauna could be of pre-Sangamon interglacial age and still not be Yarmouthian. In Alaska, the Kotzebuan and Einahnuhtan interglacials (which could be a single event) are clearly within the Brunhes normal polarity interval, and seem to be younger than lavas dated about 0.3 million years old, but are clearly pre-Sangamon. Hopkins states that the Yarmouth interglacial of mid-continental North America, on the other hand, seems to be near the Brunhes-Matuyama boundary and to be approximately 0.6 to 1.0 million years old. He suspects that this fauna

"is younger than the mid-continent Yarmouth, inasmuch as the fauna seems to be quite modern."

19. Fauna 9

Mammals - *?Nothrotherium* sp. (small ground sloth), Mylodontidae (large ground sloth), *Castor* cf. *canadensis* (beaver), *Canis* cf. *etruscus* (Etruscan wolf), Felidae (extinct large cat), *Mammuthus meridionalis* (southern mammoth), *Equus ?calobatus* (stilt-legged ass), *Equus scotti* (Scott's horse), *?Hemiauchenia blancoensis* (Blancan long-legged llama), *Camelops minidokae* (Irvington camel), Antilocapridae (prongbuck).

Suggested Age - Kansan. The mammal fauna apparently straddles the boundary of the Blancan–Irvingtonian land-mammal ages.

Remarks - Except for the beaver specimen, the fossils are from a unit 25 feet (7.6 m) thick of coarse, heavily oxidized gravels. This unit, grading upwards into an organic deposit consisting of blue clay, sand and peat, is underlain by bedrock of Upper Cretaceous age. The fossiliferous unit was deposited in a floodplain. Mammal remains suggest a warm grassland environment with some trees and permanent bodies of water. This appears to be the first record in North America of the Etruscan wolf, which characterized the Villafranchian (?pre-Nebraskan) faunas of Europe. *Canis etruscus* may be ancestral to the wolf (*C. lupus*) (Kurtén 1968).

Analysis of pollen and wood from the organic layer that intergrades with the upper surface of the Kansan gravels indicates open grassland on upland areas, with trees and shrubs along the streams and possibly pine and spruce forests in the nearby Cypress Hills. *Artemisia* is represented in quantity in the best pollen samples. The climate during this phase may have been slightly cooler and moister than at present. This organic layer, with its abundance of wood, is the only one near Medicine Hat from which beaver has been reported.

References - Churcher 1970; Lowden and Blake 1975; Mott and Stalker 1972; Russell and Churcher 1972; Stalker 1969b, 1971, 1972a, b; Stalker and Churcher 1970, 1972; Szabo, Stalker and Churcher 1973.

20. Hand Hills, Alberta (near Delia — Hand Hills Conglomerate)

Mammals - Leporidae (hare or rabbit), *Cynomys ludovicianus* (prairie dog), *Spermophilus richardsoni* (ground squirrel), *Geomys* sp. (pocket gopher), *Microtus* cf. *pennsylvanicus* (meadow vole), Elephantidae (extinct elephant), *Equus (Asinus)* cf. *conversidens* (Mexican wild ass).

Suggested Age - Middle-to-late Pleistocene. Probably of Irvingtonian faunal age or later.

Remarks - Fossils are from the Hand Hills Conglomerate, which lies at the summit of the Hand Hills some 700 feet (213 m) above the level of the prairie. Russell reported horse (probably *Equus*) from this formation in 1958. Storer indicates that two mammalian faunal elements are present, one of uppermost Miocene or lowermost Pliocene age and the other of middle-to-late Pleistocene age. The Hand Hills Conglomerate formed as a result of deposition by fast-moving streams. The Pleistocene mammals evidently occupied a plains grassland with well-developed soil. The climate may have been warmer and drier than now, for the Hand Hills lie approximately 225 miles (362 km) northwest of the nearest modern occurrence of the prairie dog (*Cynomys ludovicianus*).

References - Russell 1958; Storer 1972, 1975.

21. Cochrane, Alberta (Griffin South Pit, Griffin North Pit, Clarke Pit — Bighill Creek Formation)

Mammals - *Equus (Asinus) conversidens* (Mexican wild ass), *Rangifer tarandus* (caribou), *Bison bison occidentalis* (western bison), *Ovis canadensis* (mountain sheep).

Suggested Age - Late Wisconsin. Radiocarbon analyses of *Bison* bones yielded dates of 11,000 ± 160 B.P. (GSC-989), 10,760 ± 160 B.P. (GSC-612), and 11,370 ± 170 B.P. (GSC-613).

Remarks - Fossils are from deposits of sand to coarse gravel on Terrace 5 of the lower set of terraces on the north bank of the Bow River. These deposits constitute the Clarke Pit Member of the Bighill Creek Formation. The bones were deposited in a floodplain environment. The mammal remains indicate a cool open grassland. The presence of mountain sheep and caribou in the fauna may be accounted for by their having moved onto the western plains toward the end of the Wisconsin glaciation and in

postglacial time. On the other hand, the heavy erosion of these fossils may indicate that they were transported from the eastern flanks of the Rocky Mountains.

References - Churcher 1968a, 1975; Stalker 1968.

British Columbia

Cowan (1941) provided the first valuable review of Quaternary and postglacial mammals from British Columbia. Ice-age vertebrate fossils in this mountainous province are rare because of periodic intense glaciation by Cordilleran ice. Many concentrations of fossils must have been crushed and ground beneath great masses of ice. Even during interglacial phases, remains of alpine species undergo particularly heavy erosion in fast-running mountain streams, and consequently are seldom preserved.

The earliest known mountain-goat record (*Oreamnos* sp.) is of a partial skull from Sangamon, or earlier, interglacial deposits near Quesnel Forks (Harington 1971b). Fossils of mountain sheep are uncommon in Canadian ice-age deposits. A well-preserved cranium of a bighorn ram (*Ovis canadensis*) was recovered from a gravel pit near Finlay Forks (Rutter, Geist and Shackleton 1972). Radiocarbon analysis of bone from the specimen yielded a date of 9,280 ± 200 B.P. (GSC-1497). The evidence suggests that bighorn sheep reached this northerly part of their range near the close of the Wisconsin, and that they had not come in contact with thinhorn sheep at the time. However, the presence of relatively large mountain-sheep bones from late-Pleistocene deposits in the Yukon make this picture more complex.

In addition to the mountain goat from Quesnel Forks, other species have been reported from gold-bearing gravels of the Cariboo District: ground sloth (*Megalonyx* sp.), Columbian mammoth (*Mammuthus columbi*), woolly mammoth (*M. primigenius*), wild ass (*Equus (Asinus)* sp.), mule deer (*Odocoileus hemionus*), deer (*Odocoileus* sp.), moose (*Alces* sp.), caribou (*Rangifer* sp.), and bison (*Bison* sp.).

Radiocarbon analysis of the molar of a woolly mammoth (*Mammuthus primigenius*) from terrace gravels near Taylor yielded a date of 27,400 ± 580 B.P. (GSC-2034). This evidence implies that these tundra-adapted mammoths lived in the Peace River region before the ice of the last glaciation covered the area. They appear to have reoccupied the region after the Wisconsin ice retreated, if a radiocarbon date of 7,670 ± 170 B.P. (I-2244) on tusk from moraine deposits at Portage Pass is correct.

In 1971 the partly articulated skeleton of a Columbian mammoth (*Mammuthus* cf. *columbi*) was excavated from silty pond deposits overlain by a thick layer of glacial till at Babine Lake. Two radiocarbon dates of 42,900 ± 1,860 B.P. (GSC-1657) and 43,800 ± 1,830 B.P. (GSC-1687) on wood from the silty fossiliferous layer and another of 34,000 ± 690 B.P. (GSC-1754) on the mammoth bone suggest that the animal sank in sticky pond deposits and died there. Palaeobotanical evidence indicates that during this part of the Olympia Interglaciation, the vegetation near Babine Lake was similar to present shrub tundra just beyond the treeline in northern Canada (Harington, Tipper and Mott 1974) (Figure 11).

Only traces have been found of the vertebrate faunas that occupied the southern interior of British Columbia during nonglacial phases of the ice age. None of the species identified would be out of place in a late-Pleistocene (i.e. Illinoian to Wisconsin) fauna. Remains of unidentified fish, rodents, wild asses (*Equus (Asinus)* sp.) and bison (*Bison* sp.) from deposits covered by two tills near Westwold indicate that those vertebrates, at least, occupied the region during Sangamon, or earlier, interglacial time.

Fossils of Pacific salmon (*Oncorhynchus* sp.) are known from ?late Wisconsin deposits on the Thompson River (Miller 1965). *Oncorhynchus* remains have also been identified from calcareous nodules near Kamloops, but they are probably of Tertiary rather than Quaternary age.

Remains of Pleistocene mammals have been reported from Vancouver Island and vicinity since 1895. At least 18 specimens of large land mammals are known from Vancouver Island, and over 14 have been collected from islands between the mainland and Vancouver Island. The fact that the extinct muskox (*Symbos cavifrons*), American mastodon (*Mammut americanum*), imperial mammoth (*Mammuthus imperator*), and possibly the Columbian mammoth (*M. columbi*), horse (*Equus* sp.) and bison (*Bison* sp.) once lived on what is now Vancouver Island suggests that land connections with the mainland could have existed during glacial maxima of the late Pleistocene. This is substantiated by what is known about Pleistocene worldwide sea-level depression and the present bathymetry of the waters between the mainland and southeastern Vancouver Island (Harington 1975a). Also, some of the "warmer-adapted" species, such as the imperial mammoth and American mastodon, could have crossed large floodplains that filled the Strait of Georgia during the Olympia Interglaciation. The most northerly ice-age land-mammal records for Vancouver Island concern molar teeth of the American mastodon and the imperial mammoth (*Mammuthus* cf. *imperator*) from near Courtenay. Stratigraphic evidence suggests that the fossils, most of them from the gravel pits on the Saanich Peninsula, are more than 20,000 years old.

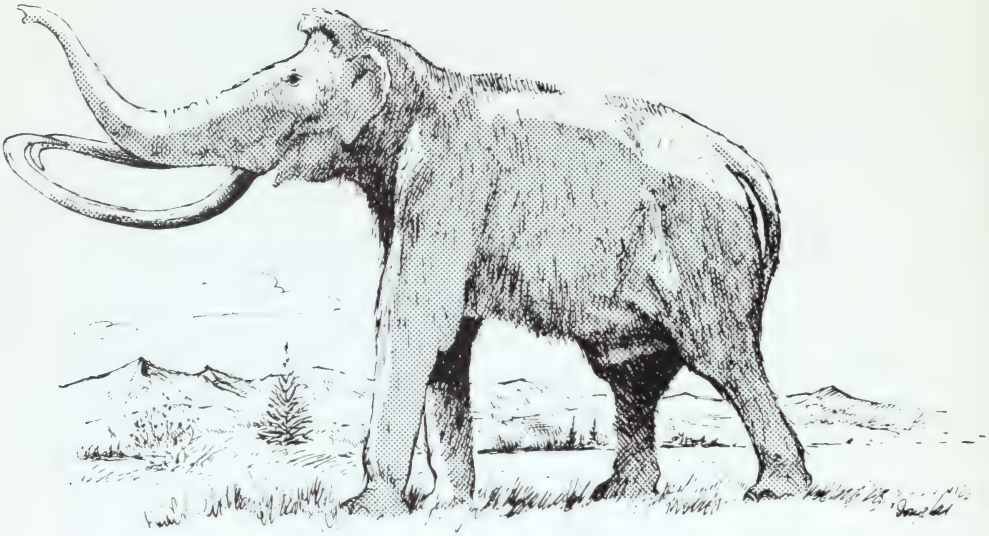

FIGURE 11. *A restoration of the Babine Lake Mammoth* (Mammuthus *cf.* columbi) *as it may have appeared in its natural shrub-tundra environment in central British Columbia about 30,000 to 40,000 years ago. Ink sketch by Charles Douglas.*

A few vertebrates have been collected from Pleistocene and postglacial marine or coastal deposits at Vancouver or on southern Vancouver Island. They include the northern sea lion (*Eumetopias* cf. *jubata*), baleen whale (Mysticeti), and killer whale (*Orcinus* sp.) (Cowan 1941). An operculum of the Pacific sardine (*Sardinops sagax*) was recovered from a marine bottom core taken at Saanich Inlet, Vancouver Island (Casteel 1975). Radiocarbon dates from above and below the specimen are 9,850 ± 100 B.P. (UW-678) and 10,890 ± 95 B.P. (UW-688).

Palaeo-Indians, presumably adapted to life along rivers, particularly to salmon fishing, occupied a site near Yale on the Fraser River in early postglacial time (Borden 1960). At the nearby Milliken Site, the earliest level was radiocarbon dated at 9,000 ± 150 B.P. (S-113) (Borden 1965).

Northwest Territories

An early postglacial fauna from Acasta Lake is the only one recognized from this vast area. The remaining specimens are mostly isolated finds seldom found in stratigraphic context. Repeated heavy glaciation, the preponderance of barren Precambrian rock on the mainland, the rather formidable climate, and a consequently impoverished flora and fauna have militated against occupation of the region by a large variety of vertebrates and the preservation of Pleistocene vertebrate faunas.

Remains of large ice-age land mammals, such as mammoth and bison, are occasionally found in the Mackenzie Delta region (Mackay 1958, 1963), but are nearly absent in the more heavily glaciated areas of the Canadian Shield. In the early 1970s, fossils of the Yukon wild ass (*Equus (Asinus) lambei*) were identified from Pleistocene deposits near Tununuk on the Mackenzie River in association with bones of the woolly mammoth (*Mammuthus* cf. *primigenius*) which yielded a radiocarbon date of 19,440 ± 290 B.P. (I-8578); on Richard's Island; and on the sea floor near a man-made island called Immerk. The latter find deserves further comment. In 1973, a perfect deeply stained humerus of the Yukon wild ass was excavated from beneath 11 feet (3.4 m) of water and 42 feet (12.8 m) of sea-bottom sediment in the course of dredging for the construction of an oil-drilling platform in Mackenzie Bay.

Vertebrate specimens from beaches on the Baillie Islands just east of the Mackenzie Delta suggest two successive types of environment (Harington 1971c): a cool loess-steppe environment as indicated by remains of woolly mammoth (*Mammuthus primigenius*), horse (*Equus* sp.), caribou (*Rangifer tarandus*), bison (*Bison* sp.), saiga antelope (*Saiga tatarica*), and muskox (*Ovibos moschatus*); and a marine coastal environment as indicated by remains of

bowhead whale (*Balaena mysticetus*), ringed seal (*Phoca (Pusa) hispida*) and polar bear (*Ursus maritimus*). The latter group of specimens could range in age from Quaternary to Recent.

The saiga fossil from Baillie Islands is the first recorded for Canada (Figure 12). Other specimens have been collected near Fairbanks and near the north coast of Alaska. Because saiga antelopes are particularly adapted to dry steppe-grasslands, they probably crossed the wide steppe-like plains of the northern Bering Isthmus and spread along the broadened Arctic Coastal Plain of North America as far east as the Baillie Islands during Illinoian and Wisconsin glacial phases. The species became extinct in North America toward the close of the Wisconsin glacial, but survives in central Eurasia.

An interesting exception to the rule that ice-age vertebrate remains are generally absent in the heavily glaciated areas of the Canadian Shield was the discovery of the cheek tooth of a ground sloth (*Megalonyx* cf. *jeffersoni*) and fragments of the tooth of a mastodon (*Mammut americanum*) at Lower Carp Lake north of Yellowknife (Stock and Richards 1949). The occurrence of the former specimen, when considered with a *Megalonyx* toe-bone from near Fairbanks, Alaska (Stock 1942), and more than a dozen *Megalonyx* specimens from the Old Crow Basin, Yukon Territory, suggests that these large ground sloths occupied a fairly broad east–west range in northwestern North America during a warmer phase of the late Quaternary (Harington 1970b).

During the Wisconsin glaciation, muskoxen (*Ovibos moschatus*) and caribou (*Rangifer tarandus*) may have survived in a Banks Island refugium. This is suggested, but not proved, by a radiocarbon date of more than 34,000 B.P. (S-288) on a muskox bone from the Bernard River (Maher 1968); a radiocarbon date of 10,660 ± 170 B.P. (GSC-240) on plant debris enclosing a muskox pelvic fragment from a locality north of Masik River; and a fragment of caribou mandible of possibly late-Quaternary age from sands containing plant remains on the south side of Masik River.

Sticks gnawed by beavers have been collected from Tertiary and Quaternary deposits in many localities throughout the Northwest Territories. L.V. Hills (personal communication, 1973) has collected them from well-preserved organic beds of late-Miocene or Pliocene age near Ballast Brook on northwestern Banks Island. At that time, environmental conditions on northern Banks Island resembled those in the southern part of Ontario's boreal forest today. Beaver-cut sticks, probably of similar age, have also been found in organic sediments on west-central Ellesmere Island, for example Strathcona Fiord (J.G. Fyles, personal communication, 1971). They have been reported from Quaternary interglacial deposits on Rat River and at Worth Point on Banks

FIGURE 12. *Fragment of the left side of a saiga-antelope* (Saiga tatarica) *cranium with horncore, from Quaternary deposits on Baillie Islands, Northwest Territories.*

Island. At Rat River a beaver-gnawed stick from the base of a 40-foot (12.2 m) layer of organic silt overlying an older till yielded a radiocarbon date of more than 38,600 B.P. (GSC-120). At Worth Point, beaver-gnawed wood was collected from uncompressed peat that yielded a radiocarbon date of >49,000 B.P. (GSC-367) (Prest 1970). Beaver-cut sticks from organic sediments near Arctic Red River were radiocarbon dated at 9,500 ± 90 B.P. (GSC-1814). These reports indicate the great latitudinal fluctuations in the range of beavers and their moist woodland habitat since the late Tertiary, and provide some evidence of the cooling climate throughout this period. Thus, beavers are known to have reached their most northerly limit of approximately 79°N in the late Tertiary, retreated to about 73°N by Sangamon interglacial time, and reoccupied habitat 2° south of their present interglacial limit of 69°N by the close of the Wisconsin glaciation.

In addition to those from the Baillie Islands, mammoth remains have been collected from two islands in the Northwest Territories. Members of Stefansson's Canadian Arctic Expedition (1913–18) collected most of the tusk of an elephant (Proboscidea cf. *Mammuthus*), yielding a radiocarbon date of 21,900 ± 320 B.P. (GSC-1760), from a site near Cape James Ross on Melville Island (Kindle 1924; Blake 1974). This is the most northerly record of a mammoth in North America. 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. A heavily worn molar of a Columbian mammoth (*Mammuthus columbi*) was collected from the rocky surface of Long Island in southeastern Hudson Bay in 1878 (Bell 1898). Presumably Columbian mammoths occupied grasslands in that region during an earlier interglacial. Sternberg's report (1963) of a mammoth tusk from Pond Inlet on northern Baffin Island must be regarded as doubtful.

A radiocarbon date of 7,320 ± 120 B.P. (I-7796) on walrus bone from raised beach deposits near the Goodsir River on central Bathurst Island shows that walruses were able to occupy this part of the Queen Elizabeth Islands about 2,000 years after the last ice sheet had vanished from the region. Large whales, probably bowheads (*Balaena mysticetus*), entered the area about the same time according to a date of 7,830 ± 140 B.P. (GSC-1193) on whale bone from a raised beach near Resolute Bay on Cornwallis Island (Harington 1975b). Evidently bowhead whales were widespread along the southern and eastern coasts of the Canadian Arctic Islands 8,000 to 9,000 years ago, as indicated by radiocarbon dates on bone from raised beaches at the mouth of the Cunningham River on Somerset Island (8,990 ± 140 B.P. [GSC-266]), and at Truelove Inlet on Devon Island (8,270 ± 150 B.P. [GSC-991]).

Fielden (Fielden and De Rance 1878) collected collared lemming (*Dicrostonyx torquatus*), ringed seal (*Phoca (Pusa) hispida*), caribou (*Rangifer tarandus*), and muskox (*Ovibos moschatus*) specimens from raised beach deposits near Alert on northern Ellesmere Island. Presumably they are of postglacial age. It is difficult to say whether these mammals spread to this area from the adjacent Pearyland refugium or arrived by a longer route from the Banks Island refugium. Where muskoxen and caribou are concerned, fossil evidence tends to support the latter alternative (Harington 1970a).

Remains of fishes, provisionally identified as cod (Gadidae) and blenny (Stichaeidae) by D.E. McAllister (personal communication, 1975), have been collected from calcareous clay nodules of possible postglacial age from the western margin of Pelly Bay.

Records of early human occupation of the Northwest Territories are sketchy, but interesting. The earliest known sites indicate a dispersal of Plano hunters northward into the Barrenlands as the Keewatin ice retreated. Possibly they were able to subsist by shifting from hunting bison in the south to hunting barren-ground caribou (*Rangifer tarandus groenlandicus*) in the north (Gordon 1975). Projectile points about 7,000 years old are known from Acasta Lake (Noble 1971), and Agate Basin points have been collected in quantity near Grant Lake (Gordon 1975).

Fauna

22. Acasta Lake, Northwest Territories (65°24'N, 115°31'W)

Fishes - Species not determined.

Birds - Probably *Aquila chrysaëtos* (Golden Eagle) or *Haliaeetus leucocephalus* (Bald Eagle).

Mammals - *Homo* sp. (indirect evidence of man from artifacts and hearths), *Lepus* sp. (hare), *Castor canadensis* (beaver), *Ursus americanus* (black bear), *Rangifer tarandus* (caribou).

Suggested Age - Postglacial, 7,000 B.P. Charcoal from the site has yielded radiocarbon dates of 4,900 ± 150 B.C. (GaK-3277) and 5,020 ± 360 B.C. (I-3957).

Remarks - Fossils are from sand below 4 inches (10.2 cm) of leaf mold on the eastern end of an esker. Fish, beaver and black-bear remains suggest the presence of forest with streams or lakes during the early postglacial. Caribou fossils may indicate that the tundra–boreal forest margin was nearby. Evidently Plano people periodically hunted caribou in the area.

References - Forbis 1961; Noble 1971.

Yukon Territory

During the ice age, much of Alaska and the Yukon were unglaciated, and were occupied by a homogeneous, relatively rich vertebrate fauna. Unglaciated areas, such as this part of the Beringian refugium, often provide more productive fossil vertebrate localities than do regions that have undergone many glaciations, such as most of the rest of Canada. However, stratigraphic differentiation of glacial and nonglacial deposits is more difficult in an unglaciated region because the till layers that mark the limits of the different glacial phases are absent.

Robert Campbell of the Hudson's Bay Company was the first European to comment on Quaternary vertebrate fossils from the Yukon Territory. Between 1840 and 1852 he saw bones of extinct bison and mammoth on the Pelly River near the Dawson area and forwarded a mammoth tibia to the British Museum. The first recorded ice-age mammal remains from the Old Crow area were collected on the Porcupine River prior to 1873 by the Anglican missionary the Reverend Robert McDonald. A concerted effort to study the abundant and interesting ice-age vertebrate fossils of the Yukon region began in 1966, when long-term projects near Dawson and the Old Crow Basin were initiated by the National Museums of Canada (Harington 1970b). Besides these important areas, Sixtymile River and Herschel Island are yielding increasing numbers of specimens. As a result of this work, sixty-four species of Pleistocene mammals alone have been described from unglaciated parts of the northern Yukon (Harington 1976 MS).

Most Pleistocene vertebrate remains in the Dawson area come from near the base of frozen "muck" deposits and the surface of underlying gold-bearing gravels, which are usually exposed during placer-mining operations. The fossils are mainly of Wisconsin age, and have a rather fresh appearance because of their preservation in frozen ground. Shreds of dessicated flesh have been found on mammoth and extinct-horse remains enclosed in permafrost at Sixtymile River. A well-preserved cranium, with articulating mandible, of an American lion (*Panthera leo atrox*) was obtained from frozen silts on Hunker Creek (Figure 13). At Dawson and Old Crow, the commonest remains collected are horse, mammoth, and bison, suggesting the presence of extensive grasslands in the unglaciated Yukon during the late Quaternary, thus corroborating Guthrie's observations (1968a) on Alaskan Pleistocene mammals.

Late Pleistocene mammalian faunas from the two areas differ in that the remains of beaver, giant beaver (Figure 14) and muskrat are common in the

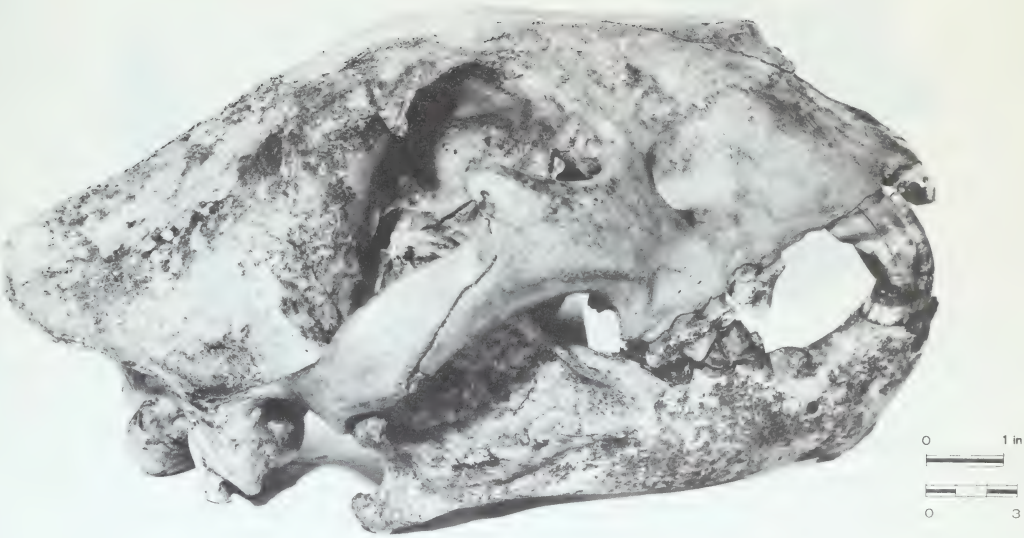

FIGURE 13. *Right side of the skull of an American lion* (Panthera leo atrox) *from late-Wisconsin deposits near Hunker Creek, Dawson area, Yukon Territory.*

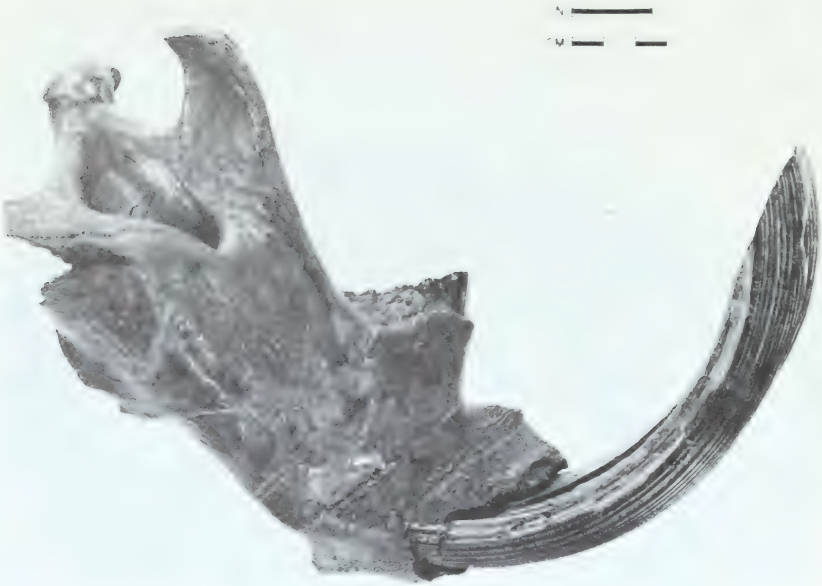

FIGURE 14. *Lateral view of the right mandible of a giant beaver* (Castoroides ohioensis) *from Porcupine River near Old Crow, Yukon Territory. Note the long, characteristically ribbed cutting-tooth. These large rodents reached lengths of 8 feet (2.4 m) and may have weighed over 400 pounds (180 kg).*

Old Crow area, but extremely rare at Dawson (only one specimen of *Castor* is known from Quartz Creek). On the other hand, mountain-sheep remains (*Ovis* cf. *dalli*) are fairly common in the Dawson deposits, but so far have not been recognized from Old Crow sediments. Pending further evidence, it can be inferred that the Dawson area had more of an alpine-grassland environment during the mid-Wisconsin than did the Old Crow Basin, which apparently consisted of extensive grassy uplands with spruce woodland, lakes, ponds and sluggish streams in lower areas (McAllister and Harington 1969; Crossman and Harington 1970).

In the Old Crow Basin, most ice-age vertebrate remains are derived from oxidized sands and sandy gravels underlain by grey lacustrine clay that shows signs of periglacial influence of possibly Illinoian age. Therefore, most of the vertebrate fossils appear to be of late-Pleistocene age (Sangamon to Wisconsin). A large, deep glacial lake that occupied much of the basin during the Wisconsin glaciation evidently drained about 11,000 years ago. As the winding Old Crow River cut down through the basin deposits in postglacial time, many fossil sites were exposed. They range in age from the close of the Wisconsin (Locality 11(1)), through mid-Wisconsin (for example, many bones from Locality 14N) to Sangamon age (Locality 44). Some specimens appear to represent elements of an Illinoian or pre-Illinoian fauna.

In 1967, a layer of late-Wisconsin sediments containing abundant freshly preserved skeletal remains of the large-horned bison (*Bison crassicornis*) was discovered at Locality 11(1) well above the level of the Old Crow River. Radiocarbon analyses of bison bone from the site have yielded dates of 11,910 ± 180 B.P. (I-7765) and 12,460 ± 220 B.P. (I-3574). A horncore from a *Bison crassicornis* cranium, located near the surface of the first gravel bar downstream from Locality 11(1) and presumably washed down from that site during the spring flood, gave a radiocarbon date of 12,275 ± 180 B.P. (I-7764). This concentration of bone may have resulted from a herd of bison breaking through lake ice and dying, their bones eventually being transported a short distance down slope to the present locality. Lack of signs of butchering on the bones and an absence of artifacts indicate that Locality 11(1) is not a site where bison were killed by people.

Although most vertebrate fossils from the Old Crow Basin seem to be of Sangamon interglacial age or later, specimens of steppe mammoth (*Mammuthus* cf. *armeniacus*), large horse (*Equus* cf. *E. (Plesippus) verae*), giant moose (*Alces latifrons*), Soergel's muskox (*Soergelia* cf. *elisabethae*), and Staudinger's muskox (*Praeovibos priscus*) suggest the presence of a middle-Pleistocene fauna. Unfortunately, none of the specimens has been found in its initial state of deposition. These faunal elements show greatest affinity to

the Olyor fauna described from the Kolyma Lowland of eastern Siberia (Appendix, see Fauna 4), and probably occupied a steppe–tundra environment. All of the species mentioned, or their close counterparts, are represented in the Olyor fauna, which Sher (1971a) considers to be of Mindel (= ?Kansan) age. These or similar species are also represented in early middle-Pleistocene faunas from Norwich, England (Cromer series (McWilliams 1967)), Süssenborn and Mosbach in the German Democratic Republic, and Tiraspol in the southern area of the European part of the U.S.S.R. (Vangengeim and Sher 1970; Kahlke 1973). Steppe mammoths (*Mammuthus armeniacus* — see Maglio 1973) are common and widespread in Eurasian middle-Pleistocene deposits. The large horse *Equus (Plesippus) verae* was originally described from early middle-Pleistocene beds in the Kolyma Lowland of Siberia. It, or a closely related form, is known from the Old Crow Basin, but has not yet been recognized elsewhere in North America. *Alces latifrons* evidently had a Holarctic distribution from England to North America. A radiocarbon date of 33,800 ± 2,000 B.P. (I-4225) on an antler beam of a giant moose from the Old Crow Basin suggests that it survived until mid-Wisconsin time in North America. It has been described from the Fairbanks area of Alaska under the name *Cervalces alaskensis* (Frick 1937). *Soergelia*, once called a steppe-goat but which appears to be a primitive muskox, had an early middle-Pleistocene distribution extending from Germany to Texas, where it has been recorded from Kansan deposits and described under the name *Preptoceras mayfieldi* (Troxell 1915). *Soergelia* has not yet been reported from Alaska, although undoubtedly it lived there. *Praeovibos* is known from England, Germany, Siberia, Alaska, and the Yukon. Péwé (1975a, b) considers that *Praeovibos* specimens from the Fairbanks area of Alaska are probably Illinoian in age. Unlike *Soergelia*, and probably *Alces latifrons*, it did not penetrate southern North America.

Remains attributed to early Pleistocene mammals such as the southern mammoth (*Mammuthus meridionalis*), the giant pika (*Ochotona* cf. *whartoni*) and the plains shrew (*?Planisorex* cf. *dixonensis*) have also been collected from sediments in the Old Crow Basin (Harington 1976 MS).

A few miles downstream from Old Crow on the Porcupine River (Locality 100), a lens of beaver-cut sticks about 24 feet (7.3 m) long and 2 feet (0.6 m) thick was found. It appeared to be part of an ancient beaver dam, compressed by the weight of 175 feet (53.3 m) of overlying sediments. The beaver-cut sticks are considered to be of Yarmouth interglacial age or older. Large spruce cones as well as tree trunks up to 2 feet (0.6 m) in diameter project from this basal layer of compact oxidized sand (Harington 1971c). Fish scales excavated at this locality from a well-defined shell horizon approximately 40 feet (12.2 m) from the surface indicate that Arctic grayling

(*Thymallus arcticus*) occupied a large, cool, shallow lake that existed there some 32,000 years ago. Teeth of the brown lemming (*Lemmus sibiricus*) from the same horizon suggest that this species occupied wet meadow habitat near the margins of the lake (McAllister and Harington 1969).

An interesting find from Miller Creek in the Sixtymile area consisted of Arctic lupine seeds probably more than 10,000 years old, which were found in collared-lemming (*Dicrostonyx torquatus*) burrows deeply buried in perennially frozen silt. The seeds had evidently been part of a food store of the lemmings. Seven of the two dozen seeds collected germinated, and one blossomed in a greenhouse at the Central Experimental Farm in Ottawa (Porsild, Harington and Mulligan 1967; Black 1967).

Remains of the following vertebrates, evidently eroded from ice-age deposits, have been collected from Herschel Island: dog (*Canis familiaris*), mammoth (*Mammuthus* sp.), Yukon wild ass (*Equus (Asinus) lambei*), large-horned bison (*Bison* cf. *crassicornis*), extinct muskox (?*Boötherium* sp.), and tundra muskox (*Ovibos moschatus*). Of these specimens, the dog mandible with teeth is perhaps the most interesting, because it could indicate the presence of early man along the Arctic coast of the Yukon in late-Pleistocene time. It was collected with mammoth ivory from the southwesternmost spit of the island. I suspect that it is of Pleistocene age, because both ramus and teeth are deeply stained, and the worn surfaces of the teeth are black as are similar specimens of Pleistocene age from the Old Crow Basin.

Pleistocene vertebrates are rarely found in their original state of deposition in the Yukon Territory. The Whitestone mammoth is a notable exception. In 1967, much of the articulated skeleton of a woolly mammoth (*Mammuthus primigenius*), including a complete skull, was excavated on the Whitestone River. Bone from this specimen was radiocarbon dated at 30,300 ± 2,000 B.P. (I-3576).

No fish fossils have been found, and only one bird specimen is known from late-Pleistocene deposits in the Dawson area. It consists of a coracoid fragment of a hawk (*Buteo* sp.), probably the Red-tailed Hawk (*B. jamaicensis*) or the Rough-legged Hawk (*B. lagopus*) (H. Savage, personal communication, 1974), from muck deposits on Dominion Creek.

Fish and bird specimens are not uncommon in the Old Crow Basin deposits. Many good fossils of pike (*Esox lucius*) have been identified. Among the birds recorded are: ducks, geese, loons, grebes, gulls, shore birds, grouse or ptarmigan, and birds of prey (G.R. Fitzgerald, personal communication, 1976).

Only indirect evidence of early man is available in the Yukon Territory. In 1966, a fleshing tool made from a caribou tibia was found at Locality 14N on the Old Crow River. A radiocarbon analysis of bone apatite from this artifact yielded a date of 27,000 $^{+3,000}_{-2,000}$ B.P. (GX-1640), while similar analyses of mammoth long-bone fragments flaked by man from this site gave dates of 25,750 $^{+1,800}_{-1,500}$ B.P. (GX-1568) and 29,100 $^{+3,000}_{-2,000}$ B.P. (GX-1567). Evidence suggests that these artifacts had been worked when the bone was fresh. Collagen from unworked mammoth and bison bones from Locality 14N gave dates of 22,600 ± 600 B.P. (I-3573) and 33,800 ± 2,000 B.P. (I-4227) respectively. Since that time, approximately 100 artifacts have been identified from more than 30 fossil localities in the Old Crow Basin, and perhaps more than 100 bones have been broken by man (as indicated by spiral fractures; further research is needed to establish whether spiral fractures can also be caused by processes in nature) (Irving and Harington 1973; Harington, Bonnichsen and Morlan 1975; Morlan and Bonnichsen 1975). Among the more interesting of these specimens are the front part of a horse mandible bearing several polished facets and the lower part of a caribou antler with four well-defined facets on its base. The antler may have been used as a pestle. Various chert and obsidian artifacts of uncertain age, including four bifaces, have been found in sedimentary deposits of the Old Crow Basin (Harington 1975c; Irving and Cinq-Mars 1974).

In 1973 a punch made from part of a caribou antler-beam was collected with ice-age mammal remains on Hunker Creek near Dawson. Radiocarbon analysis of another caribou antler from the same site as the punch yielded a date of 23,900 ± 470 B.P. (I-8580). 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 1975d).

The oldest radiocarbon-dated evidence for man's presence in the southwestern Yukon consists of the remains of a bison hunter's camp at the Canyon Site on the Aishihik River. There, Plano-like bifaces were associated with fragments of bison (*Bison* sp.) around a buried hearth. Charcoal from the hearth has yielded a radiocarbon date of 7,195 ± 100 B.P. (SI-1117) (Workman 1974).

Faunas

23. Gold Run Creek, Yukon Territory (Dawson area — 63°43.5'N, 138°41'W)

Mammals - *Canis lupus* (wolf), *Arctodus simus yukonensis* (Yukon short-faced bear), *Taxidea taxus* (badger), *Panthera leo atrox* (American lion), *Mammut americanum* (American mastodon),

Mammuthus primigenius (woolly mammoth), *Equus (Asinus) lambei* (Yukon wild ass), *Equus (Asinus)* cf. *kiang* (Kiang-like wild ass), *Alces alces* (moose), *Rangifer tarandus* (caribou), *Bison alaskensis* (Alaskan bison), *B. crassicornis* (large-horned bison), *?Boötherium* sp. (extinct muskox).

Suggested Age - Probably late Wisconsin. *Bison crassicornis* (Frontispiece: Figure 1) and mammoth bone have yielded radiocarbon dates of 22,200 ± 1,400 B.P. (I-3570) and 32,350 ± 1,750 B.P. (I-4226) respectively. *B. alaskensis* is evidently older than the remainder of the fauna, for bone from a specimen gave a date of >39,900 B.P. (I-5405).

Remarks - Fossils are from muck (frozen silt, generally consisting of loess or reworked loess with some organic matter) near the surface of underlying gold-bearing gravel, which may be of interglacial age. The mammals represented suggest that extensive tracts of cool steppe-like grassland covered upland areas in the region during the late Wisconsin. Patches of forest may have been located in valleys. Because of the relatively high density of the bones, it would appear that many of the vertebrates were transported down-slope from the former grassland toward the end of the Wisconsin glaciation and became concentrated near the surface of local creek-gravels. Perhaps 8 of the 13 species represented are extinct, and 2 are no longer living in the Yukon Territory.

Reference - Harington and Clulow 1973.

24. Upper Hunker Creek, Yukon Territory (Dawson area — 63°55'N, 138°52'W)

Mammals - *Homo* sp. (indirect evidence of man from an artifact), *Spermophilus parryi* (arctic ground squirrel), *Canis lupus* (wolf), *Panthera leo atrox* (American lion), *Mammuthus primigenius* (woolly mammoth), *Equus (Asinus) lambei* (Yukon wild ass), *Rangifer tarandus* (caribou), *Bison crassicornis* (large-horned bison), *Symbos cavifrons* (extinct muskox), *Ovis* cf. *dalli* (large mountain sheep).

Suggested Age - Probably late Wisconsin. Radiocarbon analysis of a caribou antler from the site yielded a date of 23,900 ± 470 B.P. (I-8580).

Remarks - The stratigraphic sequence is like that at Gold Run Creek. Fossils are mainly from muck near the surface of the underlying gold-bearing gravel. The muck layer reaches a thickness of

about 30 feet (9.1 m) at this locality. Paleoenvironment is similar to that postulated for the Gold Run Creek fauna. A bullet-shaped artifact made from caribou antler was found with remains of other Pleistocene mammals from the locality. It suggests that people occupied this region during the late Wisconsin. On the basis of this evidence, I speculate that they had means of making bone tools, and were able to produce stone tools using the indirect percussion technique.

Reference - Harington 1975d.

25. Sixtymile River, Yukon Territory (64°00'N, 140°47'W)

Mammals - *Panthera leo atrox* (American lion), *Mammuthus primigenius* (woolly mammoth), *Equus (Asinus) lambei* (Yukon wild ass), *Equus* cf. *scotti* (Scott's horse), *Camelops hesternus* (western camel), *Rangifer tarandus* (caribou), Cervidae (caribou-like cervid), *Bison crassicornis* (large-horned bison), *Ovibos moschatus* (tundra muskox), *Ovis* cf. *dalli* (large mountain sheep).

Suggested Age - Probably late Wisconsin, according to affinities with faunas considered to be of this age from Upper Hunker Creek, Yukon Territory (Fauna 24) and Lost Chicken Creek, Alaska (Fauna 28).

Remarks - Fossils lay between 2 and 10 feet (0.6 to 3.1 m) from the bottom of a layer of muck 10 to 20 feet (3.1 to 6.1 m) thick that overlies 6 feet (1.8 m) of gold-bearing gravel, which, in turn, rests on bedrock. A well-preserved *Bison crassicornis* skull was collected in place in muck 2.5 feet (0.8 m) above the gravel surface. The mammals suggest a cool steppe-like grassland. Collared lemming (*Dicrostonyx torquatus*), woolly mammoth (*Mammuthus* cf. *primigenius*), Yukon wild ass (*Equus (Asinus)* cf. *lambei*) and caribou (*Rangifer tarandus*) have previously been identified from muck deposits near the mouth of Sixtymile River (Porsild, Harington and Mulligan 1967). Earlier still, L.M. Lambe identified remains of mammoth, bison, and a horse smaller in size than *Equus scotti* (probably the Yukon wild ass) in the lower part of the muck overlying thick bench gravels of Claims 11 to 19 on the left limit of Sixtymile River (Cockfield 1921).

References - Cockfield 1921; Harington, 1975 field notes; Porsild, Harington and Mulligan 1967.

26. Old Crow River, Yukon Territory (Locality 14N — 67°51'N, 139°46'W)

Fishes - Species not determined.

Birds - Tetraonidae (ptarmigan or grouse) and other undetermined species.

Mammals - *Homo* sp. (indirect evidence of man from artifacts), *Ochotona* cf. *whartoni* (giant pika), *Lepus arcticus* (arctic hare), *Lepus americanus* (snowshoe hare), *Castor canadensis* (beaver), *Castoroides ohioensis* (giant beaver), *Ondatra zibethicus* (muskrat), *Microtus (Stenocranius) miurus* (singing vole), *Cuon* sp. (dhole), *Alopex lagopus* (arctic fox), *Gulo gulo* (wolverine), *Panthera leo atrox* (American lion), Felidae (?scimitar or sabretooth cat), *Mammut americanum* (American mastodon), *Mammuthus primigenius* (woolly mammoth), *Equus* cf. *(Plesippus) verae* (large horse), *Camelops hesternus* (western camel), *Alces alces* (moose), *Rangifer tarandus* (caribou), *Bison crassicornis* (large-horned bison).

Suggested Age - Evidently most of the specimens are of mid-to-late Wisconsin, but the giant pika fossil may be of early Pleistocene age. Five radiocarbon dates on mammal bone fall between 22,000 and 36,000 B.P. (see section on early man, p. 58, for details of these radiocarbon dates). Radiocarbon dates on the wood and the mollusc shells associated with the vertebrate remains show that organic material of mixed ages has been deposited at the site. A careful stratigraphic study of Locality 14N indicates that the fossil-bearing sediments are point-bar deposits formed within the last few thousand years.

Remarks - Fossils are from an oxidized unit of grey sandy gravel averaging about 1.5 feet (0.5 m) thick, overlain by approximately 13 feet (4.0 m) of brown sandy clay, and underlain by more than 2 feet (0.6 m) of jointed, oxidized clay evidently corresponding to the basal clay unit at Locality 44. The fossil-bearing unit and the overlying sandy clay unit were probably laid down in postglacial time. Vertebrate faunal evidence suggests that the species represented lived in a parkland type of environment during a period of transition to a cool climate (Wisconsin) from a warmer one (?Sangamon interglacial). This site provided the first evidence that man occupied eastern Beringia before the peak of the Wisconsin glaciation.

References - Harington 1970b, 1975c; Irving and Harington 1973.

27. Old Crow River, Yukon Territory (Locality 44, Unit 2 — 68°12.6'N, 140°00'W)

Fishes - Species not determined.

Birds - Anatinae or Aythyinae (surface feeding or diving ducks), Anserinae (geese), Tetraonidae (ptarmigan or grouse).

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. (canid), *Alopex lagopus* (fox), *Mustela* sp. (weasel), *Gulo gulo* (wolverine), *Spilogale* sp. (spotted skunk), *Mammuthus* sp. (mammoth), *Equus* cf. *(Plesippus) verae* (large horse), Camelini (large camel), *Rangifer tarandus* (caribou).

Suggested Age - Possibly of Sangamon interglacial age (more than 54,000 years old). Five radiocarbon dates on specimens from Unit 2 are infinite: bone from *Equus* sp. and *Mammuthus* sp. both yielded dates of >39,900 B.P. (I-4223, I-4228); a sample of unidentified wood gave the same age (I-3572); spruce (*Picea* sp.) wood yielded dates of >44,000 B.P. (GSC-1593) and >54,000 B.P. (GSC-2066).

In addition to the radiocarbon dates provided, the following evidence suggests that the fossil-bearing unit is of Sangamon age:

(a) analysis of plant macrofossils and invertebrates indicates that the climate was probably as warm as at present;
(b) a significant change in climate from cold (dwarf birch) to warmer (spruce-birch) is reflected in pollen assemblage changes from the basal clay unit to the fossil-bearing unit;
(c) the presence of the spotted skunk over 1,000 miles (1,600 km) north of its modern range possibly indicates a phase of warmer climate;
(d) large conifer logs with roots in the fossil-bearing unit indicate a relatively warm climate;
(e) radiocarbon dates on wood (*Picea* or *Larix*, and *Salix*) of >42,000 B.P. (GSC-1589, GSC-1297) from positions about 25 to 70 feet (7.6 to 21.3 m) above the contact of the fossil-bearing unit and basal-clay unit at nearby sites imply a

long time-lapse between these points in the sedimentary sequence;

(f) an important erosional surface appears to exist between the basal-clay and fossil-bearing units;

(g) the great depth of burial of the fossil-bearing unit and the fact that it lies between two geographically widespread, thick lacustrine units (the upper being of late Wisconsin age) that apparently mark peaks of successive glaciations.

Remarks - Vertebrate fossils are from the base of Unit 2, which consists of 1.5 feet (0.5 m) of fine grey gravel with unreworked shells and grades upwards through rooted logs and layers of sticks to brownish clay silt. The top of this unit appears to be best defined by a change in pollen assemblages that occurs approximately 30 feet (9.1 m) above its base. This unit is underlain by oxidized clay, occasionally containing organic detritus, which is more than 11 feet (3.4 m) thick. Overlying Unit 2 are approximately 30 feet (9.1 m) of buff silt and clay, about 7 feet (2.1 m) of varved glaciolacustrine clay of late-Wisconsin age, and approximately 20 feet (6.1 m) of silty postglacial deposits. Many species represented by plant and invertebrate macrofossils and vertebrate remains have aquatic affinities, and suggest the former presence of ephemeral shallow ponds and lakes in a river floodplain with sandy margins in places, and with forest areas or open forest nearby. Forest—tundra may best describe the vegetation that existed when Unit 2 was deposited, but probably more grasses were present than in the contemporary forest—tundra of the region.

References - Harington 1971c, 1974; Lichti-Federovich 1973; Matthews 1975.

QUATERNARY VERTEBRATE FAUNAS IN ALASKA

Since the Russian Admiral Kotzebue first published an account in 1821 mentioning ice-age mammal fossils from Eschscholtz Bay, a great deal has become known about Pleistocene vertebrates of Alaska. The bulk of this information has come from the Fairbanks area, where an extensive collecting program was initiated in 1928 with the beginning of large-scale gold mining there. Although tens of thousands of specimens from placer localities near Fairbanks are stored in the Frick Collection of the American Museum of Natural History in New York, their potential value is diminished by the lack of accompanying stratigraphic data.

Detailed and extensive stratigraphic studies of Pleistocene deposits, by T.L. Péwé and D.M. Hopkins in particular, have contributed greatly to overcoming this problem (Péwé and Hopkins 1967; Péwé 1975a, b). Largely as a result of their work, an approximate idea of the chronological sequence of Alaskan Pleistocene mammal faunas can be provided (Table 1). This preliminary model must be reviewed carefully in the future, and corrected and augmented as better biostratigraphic evidence becomes available.

Another weakness in our knowledge of Alaskan Pleistocene vertebrates is the lack of detailed published descriptions with illustrations, measurements and comparative data. At least 48 per cent of the species listed at present must be regarded as floating names lacking firm scientific anchors (Table 1).

As in the Yukon Territory, most Pleistocene vertebrate fossils are from the unglaciated parts of Alaska. The Fairbanks area in central Alaska is extremely important in discussions of Alaskan ice-age vertebrates. Much of it lies within the Tanana River floodplain at an altitude of 400 feet (120 m), and the rest lies within the upland, where hills have summits varying from 1,250 to 1,800 feet (380 and 550 m) above sea level. It is situated south of the Brooks Range and north of the Alaska Range, both of which were covered by masses of ice during peaks of Pleistocene glaciation.

Quaternary sediments consisting of loess and reworked loess and stream deposits are found mainly in and near valleys. Creek gravel of local origin underlies wind-blown sediments in the valley bottoms, and solifluction debris underlies this windblown material on lower and middle slopes. The sediments are periglacial in nature and now are mainly perennially frozen (Péwé 1975b).

At Eva Creek mining cut near Fairbanks, an exposed sedimentary sequence provides a key to understanding the depositional history and consequently the Pleistocene vertebrate faunal sequence of the region. There, more than 1 metre* (3.3 ft) of Fox Gravel (?pre-Yarmouth) is overlain by 1 metre (3.3 ft) of highly organic silts of the Dawson Cut Formation (?Yarmouth interglacial); 20 metres (66 ft) of Gold Hill Loess (Illinoian glacial) containing bones of mammoth and bison; 1 metre (3.3 ft) of silt of the Eva Formation (Sangamon interglacial) containing loess and tree stumps, one of which has yielded a radiocarbon date of >56,900 B.P. (HV-1328); 15 metres (50 ft) of frozen silt with ice wedges of the Goldstream Formation (Wisconsin glacial) containing

*Péwé (1975a, b) cites measurements in metres. In such cases metric quantities are given first, followed by their English equivalents.

TABLE 1. Suggested Chronological Sequence of Alaskan Pleistocene Mammals (modified from Péwé and Hopkins 1967 and Péwé 1975 a, b).

Age	Pleistocene Mammals Recorded
Postglacial (includes only the portion from about 10,000 to 5000 B.P.)	*Castor* sp. (beaver) *Microtus xanthognathus* (chestnut-cheeked vole) *Alces alces** (moose) *Bison bison* (small-horned bison)
Wisconsin Glacial	*Sorex* cf. *arcticus** (arctic shrew) *Megalonyx* sp. (ground sloth) *Lepus* sp.* (hare) *Spermophilus parryi* (ground squirrel) *Castor* sp.* (beaver) *Dicrostonyx torquatus* (collared lemming) *Synaptomys* sp.** (bog lemming) *Lemmus sibiricus* (brown lemming) *Clethrionomys* sp. (red-backed vole) *Microtus (Stenocranius) miurus* (singing vole) *Erethizon* sp.* (porcupine) *Canis lupus** (wolf) *Canis dirus*** (dire wolf) *Canis latrans** (coyote) *Alopex lagopus** (arctic fox) *Vulpes vulpes** (red fox) *Arctodus simus yukonensis** (Yukon short-faced bear) *Ursus arctos** (brown bear) *Gulo* sp.* (wolverine) *Taxidea* sp.* (badger) *Lynx canadensis** (lynx) *Panthera leo atrox* (American lion) *Smilodon* sp.** (sabretooth cat) *Homotherium* sp.** (scimitar cat) *Mammut americanum* (American mastodon) *Mammuthus primigenius* (woolly mammoth) *Equus (Asinus) lambei* (Yukon wild ass) *Equus (Asinus)* cf. *kiang** (Kiang-like wild ass) *Equus* sp. (horse) *Camelops* sp. (camel) *Cervus elaphus* (wapiti) *Alces latifrons (= Cervalces alaskensis)* (giant moose) *Alces alces** (moose) *Rangifer tarandus* (caribou) *Bos* sp. (yak-like bovid) *Bison alaskensis* (Alaskan bison) } *(= Bison priscus?)* *Bison geisti* (Geist's bison) } *(= Bison priscus?)* *Bison crassicornis* (large-horned bison) } *(= Bison priscus?)* *Bison bison* (small-horned bison) *Saiga tatarica (= Saiga ricei)* (saiga antelope) *Boötherium sargenti* (extinct muskox) *Symbos cavifrons* (extinct muskox) *Ovibos moschatus* (tundra muskox) *Ovis dalli* (Dall sheep)

TABLE 1. cont'd...

Age	Pleistocene Mammals Recorded
Sangamon Interglacial	*Ondatra zibethicus** (muskrat) Cetacea* (large whale) *Eumetopias* sp.* (sea lion) *Odobenus* sp.* (walrus) *Hydrodamalis* sp. (sea cow) *Bison crassicornis* (large-horned bison) Castoridae* (beaver) *Alces* sp.* (moose)
Illinoian Glacial	*Ochotona ?whartoni* (?giant pika) *Spermophilus parryi* (ground squirrel) Castoridae (beaver) *Dicrostonyx torquatus* (collared lemming) *Lemmus sibiricus* (brown lemming) *Microtus (Stenocranius) miurus* (singing vole) *Canis* sp.* (wolf) *Vulpes* sp.* (fox) *Cuon* sp.* *(= Xenocyon)* (dhole) *Ursus* sp.* (bear) *Panthera leo atrox** (American lion) *Mammut* sp.* (mastodon) *Mammuthus* sp.* (mammoth) *Equus* sp.* (horse or wild ass) *Cervus* sp.* (wapiti) *Alces latifrons** *(= Cervalces* sp.*)* (giant moose) *Alces* sp.* (moose) *Rangifer* sp.* (caribou) *Bison crassicornis** (large-horned bison) *Saiga tatarica** (saiga antelope) *Praeovibos* sp.* (Staudinger's muskox) *Boötherium* sp.* (extinct muskox) *Symbos cavifrons** (extinct muskox) *Ovibos moschatus* (tundra muskox) *Ovis* sp.* (mountain sheep)
?Yarmouth Interglacial	*Dicrostonyx torquatus** (collared lemming) *?Rangifer* sp.* (caribou) *Bison crassicornis** (large-horned bison)
?Kansan Glacial	*Pliomys* sp. (meadow mouse) *Microtus* sp. (vole) *Mammuthus* sp.* (mammoth) ?Kansan ?Nebraskan *Bison crassicornis** (large-horned bison) ?Kansan ?Nebraskan

TABLE 1. cont'd...

Age	Pleistocene Mammals Recorded
?Nebraskan Glacial	*Sorex* sp. (shrew) *Ochotona whartoni* (giant pika) *Marmota* sp. (marmot) *Spermophilus* sp. (ground squirrel) *Predicrostonyx hopkinsi* (Hopkins' lemming) *Lemmus* cf. *sibiricus* (brown lemming) *Pliomys deeringensis* (Deering meadow mouse) *Microtus deceitensis* (Cape Deceit vole) *Canis* sp. (?wolf) *Equus* sp. (large horse) *Cervus* cf. *elaphus* (wapiti) *Rangifer* sp. (caribou)

* Detailed published descriptions of specimens are lacking.

** Doubtfully represented.

bones of ground squirrel (*Spermophilus parryi*), collared lemming (*Dicrostonyx torquatus*), brown lemming (*Lemmus sibiricus*), singing vole (*Microtus (Stenocranius) miurus*) and mammoth (*Mammuthus* sp.); 2 metres (6.6 ft) of reworked loess of the Ready Bullion Formation (postglacial), containing wood at the base that yielded a radiocarbon date of 10,000 ± 500 B.P. (L-1375). Deposits that I correlate with this formation can be recognized in both the Old Crow and Dawson areas of the Yukon Territory.

As Péwé (1975b:15) has indicated, the Goldstream Formation is the "greatest repository of remains of Pleistocene vertebrates in Alaska, if not North America". He accounts for this concentration of bones as follows: the Goldstream Formation is a valley-bottom deposit, and most bones are transported down-slope to valley bottoms; older Illinoian valley-bottom sediments have been mostly removed; and sediments of this formation were frozen soon after deposition. The commonest fossils of large mammals from this formation are, in order of abundance, bison, mammoth and horse (Guthrie 1968a). Among the small late-Pleistocene mammals sampled from near Fairbanks, the singing vole (*Microtus (Stenocranius) miurus*) was most common, indicating that the area was above tree line and had well-drained soil (Guthrie 1968b).

Probably the most interesting specimens from the Goldstream Formation near Fairbanks are partly preserved carcasses of pika (*Ochotona princeps collaris*), ground squirrel (*Spermophilus parryi*), lynx (*Lynx canadensis*), mammoth (*Mammuthus* sp.). horse (*Equus* sp.), moose (*Alces alces*), caribou (*Rangifer tarandus*), extinct muskoxen (*Boötherium sargenti* and *Symbos cavifrons*), and large-horned bison (*Bison crassicornis*) (Péwé 1975a). The best-known of these is the juvenile mammoth specimen collected in 1948 from Fairbanks Creek. The well-preserved hide of the head, neck, trunk and a front leg is about 6 mm (¼ in.) thick and almost hairless. A sample of the hide yielded a seemingly reasonable radiocarbon date of 21,300 ± 1,300 B.P. (L-601), but the date could be questioned because the carcass was preserved in commercial glycerine. Hair preserved with the skull and tusks of a mammoth from Dome Creek was radiocarbon dated at 32,700 ± 980 B.P. (ST-1632).

A remarkably well-preserved carcass of a large-horned bison was found in perennially frozen silt during the course of mining at Dome Creek in 1951. The specimen consists of a head, complete with hide, hornsheaths and an ear, and the lower part of the body, including the four legs with hooves (Figure 15). Hide and hair from this carcass gave a radiocarbon date of 31,400 ± 2,040 B.P. (ST-1721). Pieces of fur and hide from a *Bison crassicornis* cow from Fairbanks Creek have yielded a radiocarbon date of 11,980 ± 135 B.P. (ST-1633), which approaches the terminal date for this species in eastern Beringia (Péwé 1975a).

FIGURE 15. *Partial carcass of an extinct large-horned bison* (Bison crassicornis) *from perennially frozen silt of Wisconsin age on Dome Creek near Fairbanks, Alaska. The collector, the late Otto Geist, is examining a fragment of the hide. Photograph by T.L. Péwé.*

A nearly complete carcass of a small extinct muskox, possibly *Boötherium sargenti*, was preserved in deposits on a creek near Fairbanks. Samples of hair and dessicated flesh from the specimen gave dates of 17,210 ± 500 B.P. (SI-454) and 24,140 ± 2,200 B.P. (SI-455) respectively. A hornsheath from this species yielded a radiocarbon date of 22,540 ± 900 B.P. (SI-292). Hair and droppings were found with a skeleton of the extinct muskox *Symbos cavifrons*. The droppings, which are slightly larger than the typical winter pellets of the tundra muskox (*Ovibos moschatus*), gave a radiocarbon date of >40,000 B.P. (SI-291). Analysis of plant detritus in the *Symbos* pellets suggested that the animal had been feeding on a rather dry site with grasses and sedges (Harington 1968). A hornsheath from another *Symbos* specimen from Cleary Creek was dated at 25,090 ± 1,070 B.P. (SI-850). Probably *Boötherium sargenti* and *Symbos cavifrons* are female and male, respectively, of the same species.

Several complete ground-squirrel carcasses have been found in nests in permafrost. Radiocarbon analyses of nest material and ground-squirrel droppings from sites on the Chatanika River gave dates of 14,760 ± 850 B.P. (GX-0250) and 14,510 ± 450 B.P. (W-2703) respectively (Péwé 1975b). As the samples were below and above the Chatanika Ash Bed, they helped to provide a date for it. Such ash deposits are widespread in Alaska and the Yukon, and their mineralogical characteristics are like fingerprints, which may allow correlations of ice-age deposits over long distances. Seeds of Arctic buttercup (*Ranunculus hyperboreus*) and a cinquefoil (*Potentilla* sp.) found in a ground-squirrel cache of Wisconsin age on Dome Creek suggest the former presence of tundra-like conditions there.

The discovery of a complete mummified pika from 50 feet (15.2 m) below the surface near Chatanika indicates that the alpine fauna spread into the lowlands, and occupied a drier more steppe-like environment than now prevails there. It also suggests that *Ochotona princeps collaris* and *O. princeps princeps* subspeciated in Beringian and southern refugia respectively (Guthrie 1973).

Carcasses of ice-age mammals usually show some signs of decay, and rather than explaining such cases by a catastrophically sudden change of climate and a consequent "deep-freezing" of northern species like the mammoth (Sanderson 1960), it is most likely that many of the animals died naturally or accidentally in autumn and were covered by near-freezing sediments, such as solifluction deposits (Péwé 1975a). Various possiblities of this sort are mentioned by Farrand (1961) and Vereshchagin (1974).

A.E. Porsild (personal communication, 1970) told me about an interesting case that bears on this problem. In July 1947, about 25 of 150 reindeer (*Rangifer tarandus*) that went down to the beach for a drink at Nicholson Peninsula, Northwest Territories, became mired in solifluction muck below the sea cliffs. Porsild helped the herders to pull out 18, but 7 could not be saved and were "sucked under" in a very short time. Presumably they are well preserved in permafrost, and should they be exposed by relative uplift and erosion of the area in future would probably look like the mammal carcasses of late-Pleistocene age found in Alaska and Siberia.

Ice-age vertebrate remains have been reported from many areas other than Fairbanks. Perhaps the most important of these is Cape Deceit on Kotzebue Sound, where the oldest sediments (early Pleistocene — ?Nebraskan) contain the first North American record of the Eurasian rodent *Pliomys* and the most primitive representatives of other rodents whose members dominate contemporary tundra faunas, such as *Predicrostonyx hopkinsi* and *Microtus deceitensis* (Guthrie and Matthews 1971).

L.S. Quackenbush (1909), who led an American Museum of Natural History expedition in search of Pleistocene vertebrate remains in 1907 and 1908, made many valuable observations in the vicinity of Eschscholtz Bay, which adjoins Kotzebue Sound to the east. He reported 10 genera and 14 species of Pleistocene mammals from this region. Among the most interesting of the specimens that Quackenbush (1909:107–10) collected was a partly articulated skeleton of an individual mammoth (*Mammuthus* sp.) embedded in floodplain sediments at Historic Bluff. The skeleton comprised the following parts: right half of the pelvis, the femur, tibia and fibula, four small foot-bones, skull fragments and two tusks, mandible with teeth, six thoracic vertebrae, several caudal vertebrae including the end of the tail encased in skin and hair, several broken ribs, and some pieces of flesh, skin, underwool, and coarser hair. A small, thin patch of chewed green grass was cut out of frozen sandy silt close to the mandible. Fragments of caribou tibia and possibly caribou dung (four small oval droppings), a wolf skull, and a complete horse phalanx appear to have been associated with the mammoth.

Other faunas are known from Tofty and Lost Chicken Creek.

Pleistocene vertebrate fossils have been reported on the Arctic Coastal Plain for many years (Péwé 1975a). I have identified the following mammals from a collection of fossils made by W. Quaide along the Kuk and Ikpikpuk rivers: *Canis* cf. *lupus* (wolf), *Ursus* cf. *arctos* (brown bear), *Mammuthus primigenius* (woolly mammoth), *Equus (Asinus) lambei* (Yukon wild ass), *Alces alces* (moose), *Rangifer tarandus* (caribou), *Bison crassicornis* (large-horned

bison), *Saiga tatarica* (saiga antelope), *Ovibos moschatus* (tundra muskox). These specimens are probably of late-Pleistocene age.

Remains of woolly mammoth (*Mammuthus primigenius*) have been discovered occasionally on St. Paul Island in the Pribilofs and on Unalaska and St. Lawrence islands (Ray 1971). They provide direct evidence that mammoths occupied these parts of the Bering Isthmus during glacial phases of the late Pleistocene.

Marine-mammal remains are known from sites mainly near the west coast of Alaska. C.A. Repenning has provided unpublished preliminary identifications of many of these fossils. Walrus (*Odobenus* sp.) fossils have been reported from Sangamon interglacial deposits at Nome and near Point Lay at the mouth of the Kokolik River, from late-Pleistocene sediments south of Kuk Inlet, and from Nelson and St. Lawrence islands. Remains of sea lion (*Eumetopias* sp.) have been reported from Sangamon deposits on St. Paul Island and Amchitka. Fossils of northern fur seal (?*Callorhinus* sp.), harbour seal (*Phoca vitulina*) and ringed seal (*P. (Pusa) hispida*) have been reported from various Pleistocene strata in western Alaska. Whale vertebral discs of possible Pleistocene age were collected near the mouth of the Inglutalik River (Péwé 1975a). A radius fragment of a large whale was found in Sangamon gravels on Amchitka.

Of great interest is the discovery of remains of Steller's sea cow (*Hydrodamalis gigas*) from beach deposits 35 metres* (115 ft) above sea level on Amchitka in the Aleutian Islands (Gard, Lewis and Whitmore 1972). A piece of sea-cow bone was submitted for uranium series dating. The Th^{230} and Pa^{231} dates (135,000 ± 12,000 B.P. and >122,000 B.P.) are considered concordant, and, in conjunction with the presence of unweathered till overlying the beach deposit, indicate that Steller's sea cow occupied this part of the North Pacific during Sangamon time. *Hydrodamalis* may have evolved from an ancestor such as *Metaxytherium* on the margins of the North Pacific during the early Pliocene. During glacial maxima, sea cows — like walruses — evidently ranged much farther south than they did in historic time, as is indicated by a radiocarbon date of 18,940 ± 1,100 B.P. (SI-115) on a *Hydrodamalis gigas* skull-fragment brought up in a trawl from the bottom of Monterey Bay, California (Jones 1967).

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*See footnote on p. 64.

Fishes are rarely reported from Alaskan Pleistocene deposits. Remains of small freshwater fishes have been identified from Unit B at Tofty, which may range from late Pleistocene to Recent in age (Repenning, Hopkins and Rubin 1964). Fish remains recovered from estuarine silt of Sangamon age at Nome (Hopkins, MacNeil and Leopold 1960; D.M. Hopkins, personal communication, 1976) include most of a postcranial skeleton of a starry flounder (*Platichthys stellatus*), identified by W.I. Follett, and two premaxillae and a mandible of a rock sole (*Lepidopsetta bilineata*), identified by J.E. Fitch. This material was found with a pair of walrus tusks and a mollusc fauna that is distinctive of Pelukian (Sangamon) marine deposits in northwestern Alaska.

Bones of unspecified birds of Pleistocene age have been reported from the Fairbanks area, but they are rare (Péwé 1975a). The shaft of an eagle (?*Aquila* sp.), possibly of late-Pleistocene age was collected by Quaide on the Kuk River. Gizzard stones of birds from Wisconsin loess at Eva and Ready Bullion creeks near Fairbanks were probably mainly produced by ptarmigan or grouse (Hoskin, Guthrie and Hoffman 1970).

Artifacts associated with late-Pleistocene mammal remains that were exposed in the course of placer-mining operations in central Alaska were reported as early as 1933. During 1933 to 1938, 19 artifacts were recorded from the muck deposits along six streams near Fairbanks. Two fluted points were found *in situ* 60 feet (18.2 m) from the surface. One of these was directly associated with bones of a young "mastodon" (Rainey 1940), which I suggest were probably from a woolly mammoth.

Evidence concerning 1960 to 1970 research on early man in Alaska has been summarized by Irving (1971). A series of bison bones, including a calcaneum, that were broken by man were found in the lowest levels of Cave 9 near Trail Creek (Larsen 1968). The calcaneum gave a radiocarbon date of 13,070 ± 280 B.P. (K-1327), and bone from a horse scapula found in front of the cave was radiocarbon dated at 15,750 ± 350 B.P. (K-1210). At the Village Site near Healy Lake, radiocarbon analysis of burnt bone yielded a date of 11,090 ± 170 B.P. (GX-1341). Six teardrop-shaped points and other stone artifacts are evidently associated with the radiocarbon-dated material. Fluted points have been reported from a number of sites in Alaska. Notable among these are obsidian fluted points from Batza Tena (Clark 1972; Clark and Clark 1975), and four fluted points with Clovis affinities from a site in the Sagavanirktok Valley (Alexander 1971). The latter may be of early postglacial age. Perhaps these fluted-point sites are indicative of a northward dispersal of Palaeo-Indian hunters into Alaska that paralleled their movement into the Canadian Shield (e.g. Acasta Lake and Grant Lake sites in the Northwest Territories). But more evidence is required to determine

whether fluted points originated in southern or northern North America.

Faunas

28. Lost Chicken Creek, Alaska (placer locality below highway — 64°03.2'N, 141°52.6'W)

Mammals - *Panthera leo atrox* (American lion), *Mammuthus primigenius* (woolly mammoth), *Equus (Asinus) lambei* (Yukon wild ass), *Equus (Asinus)* cf. *kiang* (Kiang-like wild ass), *Cervus elaphus* (wapiti), *Rangifer tarandus* (caribou), *Bison crassicornis* (large-horned bison), *Symbos cavifrons* (extinct muskox), *Ovis* cf. *dalli* (large mountain sheep).

Suggested Age - Late Wisconsin. Horse (*Equus* sp.) and bison (*Bison* sp.) bone yielded radiocarbon dates of 26,760 ± 300 B.P. (SI-355) and 10,370 ± 160 B.P. (I-8582) respectively.

Remarks - Presumably the fossils are mainly from the base of the frozen black organic silt. This muck unit reaches thicknesses of 8 to 12 feet (2.4 to 3.7 m). It is underlain by 1.5 to 15 feet (0.5 to 4.6 m) of gold-bearing gravels and sands that cover the local bedrock, and is overlain by 1 to 4 feet (0.3 to 1.2 m) of buff silt. The mammals probably occupied a cool steppe-like grassland.

References - Harington 1974 field notes; Whitmore and Foster 1967.

29. Fairbanks area, Alaska (Fairbanks Creek, Engineer Creek, Cripple Creek, Gold Hill, Eva Creek, Ready Bullion Bench, Sheep Creek, Chena Ridge, West Dawson Cut — see Guthrie 1968a, b for locality details)

Mammals - *Lepus* sp. (hare), *Spermophilus parryi* (ground squirrel), *Dicrostonyx torquatus* (collared lemming), *Lemmus sibiricus* (brown lemming), *Microtus (Stenocranius) miurus* (singing vole), *Microtus xanthognathus* (chestnut cheeked vole), *Canis lupus* (wolf), *Canis latrans* (coyote), *Ursus arctos* (brown bear), *Panthera leo atrox* (American lion), Felidae (?*Homotherium* sp., scimitar cat), *Mammut americanum* (American mastodon), *Mammuthus primigenius* (woolly mammoth), *Equus* sp. (horse), *Camelops* sp. (camel), *Cervus elaphus* (wapiti), *Alces latifrons* (giant moose), *Alces alces* (moose), *Rangifer tarandus* (caribou), *Bos* sp. (yak-like bovid), *Bison crassicornis* (large-horned bison), *Saiga tatarica* (saiga antelope), *Boötherium* sp. (extinct muskox), *Symbos cavifrons* (extinct muskox), *Ovibos moschatus* (tundra muskox),

Ovis dalli (Dall sheep).

Suggested Age - Late Pleistocene (Illinoian to Wisconsin, but mainly Wisconsin).

Remarks - Deposits at Fairbanks, Engineer and Cripple creeks consist mainly of Wisconsin-age silt, but pre-Wisconsin sediments are present. The Gold Hill site is on a bench of Cripple Creek, and although Wisconsin sediments are present most deposits are of Illinoian age.

The section at Eva Creek has been described previously in the text. The Goldstream Formation (Wisconsin) and the Gold Hill Loess (Illinoian) produce most of the vertebrate fossils. At Ready Bullion Bench, two gravel layers are separated by about 2.5 metres* (8.2 ft) of brown silt at the base of the section. Overlying these gravels is a greenish silt unit 2 metres (6.6 ft) thick (?Illinoian) and 12 to 14 metres (40 to 60 ft) of frozen loess (Wisconsin). There is a thin surface deposit of postglacial age. At Sheep Creek, brown silt with fossil tree-roots overlies basal gravel on the west wall. Woody silts, peat and volcanic ash are exposed 3.5 to 5 metres (11.5 to 16.4 ft) above the basal gravel. On the east wall, part of a greenish silt unit (?Illinoian) was exposed. The contact between it and the overlying unit, possibly containing reworked Sangamon fossils in Wisconsin deposits, lay approximately 15 metres (49 ft) above the basal gravel. Unreworked loess containing an ash layer was exposed at Chena Ridge. Organic loess enclosing a partial mammoth skeleton was exposed at the West Dawson Cut. Wood from this deposit has been radiocarbon dated at >29,000 B.P.

Bison, horse and mammoth are the commonest species recorded from the large mammal localities (Fairbanks, Engineer and Cripple creeks, and Gold Hill). The high percentage of grazing mammals suggests that this part of central Alaska was basically a grassland environment during the late Pleistocene (Illinoian and Wisconsin). Trees were present in interglacial times. Giant moose (*Alces latifrons*), moose (*A. alces*) and American mastodon (*Mammut americanum*) suggest the presence of trees, although specimens representing these mammals are rare. The singing vole (*Microtus (Stenocranius) miurus*) dominates Illinoian and Wisconsin rodent faunas, indicating that the region was above the tree line and was characterized by well-drained grassland.

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* See footnote on p. 64.

Extinction of the singing vole, ground squirrel and collared lemming in interior Alaska suggests a rapid reduction of their preferred grassland habitat at the end of the Wisconsin.

Matthews's study (1974b) of pollen and of plant and invertebrate macrofossils from a 27-metre (90 ft) core from the Fairbanks area provides a palaeoenvironmental profile of the latter half of the Wisconsin glaciation. He suggests that from 35,000 to 32,000 B.P., during a mid-Wisconsin interstadial, the spruce tree-line was lower than at present. The late-Wisconsin environment was characterized by steppe—tundra vegetation and a severe Arctic climate. By 8,500 B.P., spruce forests and some associated boreal species had returned to the area.

References - Frick 1930, 1937; Geist 1953; Guthrie 1968a, 1968b, 1972; Matthews 1974b; Péwé 1975b; Skinner and Kaisen 1947.

30. Sullivan Pit, Alaska (Tofty Placer District — 65°05'N, 150°52'W)

Fishes - "Small fish" (species not determined).

Mammals - *Lepus* sp. (hare), *Spermophilus parryi* (arctic ground squirrel), *Castor* sp. (beaver; indirect evidence from gnawed wood), *Dicrostonyx torquatus* (collared lemming), *Synaptomys* sp.* (bog lemming), *Lemmus sibiricus* (brown lemming), *Clethrionomys* sp. (red-backed vole), *Microtus (Stenocranius) miurus* (singing vole), *Microtus* sp. (large vole), Proboscidea (mammoth or mastodon), *Equus (Asinus)* sp. (wild ass), ?*Alces* sp. (moose), ?*Rangifer* sp. (caribou), *Bison* sp. (bison), Caprini (probably sheep).

Suggested Age - Late Pleistocene (probably Wisconsin to postglacial).

Remarks - Four stratigraphic units are recognized. Evidently the upper two, units A and B, were deposited between 1760 and 1916, when material was excavated or eroded from older sediments higher on the slopes and redeposited. Unit A consists of 10 to 30 feet (3.1 to 9.1 m) of silt. Logs extracted from a mass of beaver-gnawed wood near the top of the unit yielded radiocarbon dates of 6,730 ± 260 B.P. (W-1108), while wood from one foot (0.3 m) above the base of the unit is more than 38,000 years old (W-1113). Remains of moose (?*Alces* sp.) and bison were found in this unit. Most vertebrate fossils are from unit B, which is a

*C.A. Repenning (personal communication, 1976) considers this identification untrustworthy. The specimen is lost.

discontinuous channel fill consisting of gravel, sand and silt cut 2 to 15 feet (0.6 to 4.6 m) into sediments of unit C. Wood from unit B yielded dates of less than 200 B.P. (W-1106, W-1111), 200 ± 200 B.P. (W-937) and 2,520 ± 200 B.P. (W-891). This unusual sequence of dates may have resulted from reworking of sediments in the course of placer operations. Shells of pelecypods and gastropods and remains of insect and plant macrofossils were also derived from unit B. Unit C consists of 5 to 20 feet (1.5 to 6.1 m) of grey muck, whose base grades into unit D. Wood from near the top of unit D, which consists of 10 to 20 feet (3.0 to 6.1 m) of gravel, sand and silt, gave a radiocarbon date of more than 39,000 B.P. (W-895). Units C and D are probably of Wisconsin age. Unit D is underlain by slate, phyllite, and greywacke of Cretaceous age.

It is difficult to interpret this fauna in palaeoenvironmental terms. Fossils from units A and B represent a mixture of forest (e.g. rooted spruce stumps, beaver-gnawed wood, and remains of red-backed vole, *Clethrionomys* sp.) and steppe–tundra forms (the remainder of the fauna). Presumably the steppe–tundra mammals have been 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.

Reference - Repenning, Hopkins and Rubin 1964.

31. Cape Deceit, Alaska (66°05'N, 162°50'W — Cape Deceit Formation)

Mammals - *Sorex* sp. (shrew), *Ochotona whartoni* (giant pika), *Marmota* sp. (marmot), *Spermophilus* sp. (ground squirrel), *Predicrostonyx hopkinsi* (Hopkins's lemming), *Lemmus* cf. *sibiricus* (brown lemming), *Pliomys deeringensis** (Deering meadow mouse), *Microtus deceitensis* (Cape Deceit vole), *Canis* sp. (?wolf), *Equus* sp. (large horse), *Cervus* cf. *elaphus* (wapiti), *Rangifer* sp. (caribou).

Suggested Age - ?Nebraskan (pre-Cromerian). Matthews (1974a) considers that the Cape Deceit Formation was deposited between 400,000 and 900,000 years ago, but this estimate may be too young. The early evolutionary stages represented by *Predicrostonyx hopkinsi* and *Microtus deceitensis* are important indicators of the age of this fauna.

*Chaline (1975) argues that this animal represents the oldest known heather vole and should be called *Phenacomys deeringensis*.

Remarks - Vertebrate fossils are from sand and silt facies of the Cape Deceit Formation, which consists of two units separated by a peat layer. Most of the large mammal fossils are from Unit 1, which consists mainly of gravels, sands and organic silts 2.5 metres* (8.2 ft) thick with interbedded peaty zones. Solifluction structures are present. Mammal fossils are concentrated in thin sand beds throughout the grey organic silt 3.5 metres (11.5 ft) thick that dominates Unit 2. This unit contains frost structures and is capped by silty peat. The overlying Inmachuk Formation of ?Kansan (?Mindel) age is approximately 4 metres (13.1 ft) thick, and consists of oxidized sand and reworked loess, with a deformed and truncated zone of peaty silt near the contact with the overlying Deering Formation. Sparse remains of *Pliomys* sp. and *Microtus* sp. are reported from the Inmachuk Formation. The Deering Formation of ?Yarmouth to postglacial age is 3 to 4 metres (9.8 to 13.1 ft) thick, and consists of two mainly organic silty units bounded by peat zones. Frost cracks occur near the surface of Unit 1. Teeth of Hensel's lemming (*Dicrostonyx* cf. *henseli*) came from near the base of Unit 1, which appears to be of Illinoian age. Fossils of the collared lemming (*D. torquatus*), brown lemming (*Lemmus* cf. *sibiricus*) and vole (*Microtus* sp.) have also been reported from the Deering Formation. Peat separating Units 1 and 2 yielded a date of >39,900 B.P. (I-4099), and appears to be of Sangamon age. Radiocarbon analyses of wood below the surface peat of Unit 2 and from the base of the surface peat yielded dates of 12,420 ± 180 B.P. (I4781) and 9,150 ± 150 B.P. (I4780) respectively. They indicate that Unit 2 includes deposits of Wisconsin to postglacial age.

Stratigraphic features demonstrate that mammals from the Cape Deceit Formation lived in a tundra environment. Palaeobotanical data support the idea that a herbaceous tundra with rare alders and birches and abundant cinquefoils (*Potentilla* sp.) covered the region during ?Nebraskan time.

Guthrie and Matthews (1971) infer from the evidence at Cape Deceit that the contemporary mammal fauna of the tundra has had a longer time to adapt to Arctic tundra conditions than was previously suspected. They postulate the existence of a Beringian mammal realm that periodically contributed to the faunas of more southerly regions of Eurasia and North America.

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*See footnote on p. 64.

References - Guthrie and Matthews 1971; Matthews 1974a.

DISCUSSION AND SUMMARY

In conclusion, I wish to review briefly some of the important features of the Quaternary vertebrate faunas of Canada and Alaska in sequence from oldest to youngest, and in relation to a few of the better-known faunas of northeastern Siberia (Appendix) and the Great Plains of the United States. The preliminary nature of much of the faunal evidence from northern North America and consequently of the conclusions I draw from it must be emphasized.

Only in the last ten years has it become clear that early- and middle-Pleistocene vertebrate faunas are present in Canada and Alaska. The oldest of these are faunas from Cape Deceit, Alaska, and Wellsch Valley, Saskatchewan. The former appears to be of ?Nebraskan age, and evidently lived in herbaceous tundra surroundings. The Cape Deceit lagomorphs and rodents are particularly interesting. *Ochotona whartoni* is a giant pika that may have lived in grasslands rather than on scree slopes, as do its living North American relatives. It may have survived in Alaska until Illinoian time, for a complete skull with mandibles, which Péwé (1975b) considers to be of that age, was collected from the Gold Hill Cut near Fairbanks. However, the mandible of the Gold Hill specimen is smaller than those of giant pika described from Cape Deceit and Old Crow (Harington 1976 MS), and it may only represent the upper size range of *Ochotona princeps* during the late Pleistocene in eastern Beringia. I have referred two giant-pika mandibles from the Old Crow Basin to *O.* cf. *whartoni*. I think they could be of early Pleistocene age. *Predicrostonyx hopkinsi* is more primitive in tooth characteristics than the collared lemming *Dicrostonyx torquatus*, and slightly more primitive than an early species of *Dicrostonyx* described from the Olyor fauna (?Kansan) of the Kolyma Lowland in northeastern Siberia. The earliest North American record of *Pliomys (P. deeringensis)* is from Cape Deceit. It seems to be more primitive than *P. episcopalis* and *P. lenki* from early middle Pleistocene assemblages in Eurasia. There appears to be little difference between *Microtus deceitensis* and some *Microtus* specimens from the Olyor fauna (Matthews 1974a).

The Cape Deceit fauna also includes the earliest known North American records of caribou (*Rangifer* sp.) and wapiti (*Cervus* cf. *elaphus*). Until recently these deer were considered to be late Pleistocene immigrants from Eurasia to North America (Guthrie 1966; Hibbard et al. 1965). The hoof of a large horse (*Equus* sp.) represented in the fauna may be comparable to a large horse (*E. (Plesippus)* sp.) that Sher (1971a) reports from the Begunov suite

(?Nebraskan) of the Kolyma Lowland.

Of great interest is the identification of fossils of *Microtus deceitensis* and *Pliomys* cf. *deeringensis* at Wellsch Valley, which may indicate a roughly similar age for the Cape Deceit and Wellsch Valley faunas and a southern invasion from Beringia about Aftonian time. Perhaps the muskox represented at Wellsch Valley travelled a similar route. Crucial in this fauna are fossils of the southern mammoth (*Mammuthus* cf. *meridionalis*) and the bone-eating dog (*Borophagus diversidens*). The former is the most primitive North American species of mammoth (Maglio 1973). It probably entered from Eurasia near the beginning of the Pleistocene, about 2 million years ago, and this record could be one of the earliest for North America. *Borophagus diversidens* may be a late survivor. Again, it suggests a very early Pleistocene age for the Wellsch Valley fauna. The species has also been reported from the Blanco fauna, which Hibbard (1970) considered to be of Aftonian age.

Thus, the Wellsch Valley fauna consists of northern and southern elements. The former includes *Pliomys*, *Microtus*, *Synaptomys*, *Mammuthus*, and a muskox (Ovibovini). Most of the remaining genera have southern North American affinities, and this faunal element is perhaps most closely related to the Cita Canyon fauna of Texas and the Cudahy fauna from Kansas and Texas. Hibbard (1970) considered these to be of Aftonian and Kansan ages, respectively.

Comparison of the fauna of Kansan age at Medicine Hat with the Wellsch Valley fauna shows that the southern mammoth (*Mammuthus meridionalis*) persisted on the southern plains of Canada, as did prongbucks and camels. The earliest record of ground sloths derived from the south may indicate the presence of more shrubs and trees, while the beaver denotes moist habitat. Bone-eating dogs had given way to primitive wolves (*Canis* cf. *etruscus*). The Etruscan wolf characterized Villafranchian faunas of Europe, and perhaps gave rise to the living wolf *Canis lupus*.

Mammoths (*Mammuthus* sp.) and large-horned bison (*Bison crassicornis*) are first recorded from Alaska in deposits that may be of Kansan age (Table 1). Primitive, small, high-horned muskoxen (*Soergelia*) dispersed rapidly throughout the Holarctic region about this time, occurring in Germany, Siberia, the Yukon Territory, and Texas.

The first record of the giant bison (*Bison* cf. *latifrons*) on the North American plains is from Yarmouth interglacial deposits near Medicine Hat. The species does not seem to have established itself in the Great Plains of the United States until early Illinoian time. It is reasonable to consider the

"blossoming" of the horns of this species a response to its competitive edge following introduction to the highly productive grassland environment of the southern plains. *Bison latifrons* survived until late Wisconsin time in Idaho (McDonald and Anderson 1975). Jefferson's ground sloth (*Megalonyx jeffersoni*) first occurs in southwestern Canada during this interglacial. Evidently it had an adaptive advantage in northern regions not found in other ground sloths, for by Sangamon time it still lived in southwestern Canada and was the only member of this group to have reached eastern Beringia. By Yarmouth time, the southern mammoth had been replaced by the Columbian mammoth (*Mammuthus columbi*).

It is worth noting that the genera and species of mammals represented in the Yarmouth fauna of Medicine Hat all occur in the following Sangamon interglacial fauna from this locality. A remarkable faunal, and by implication environmental, uniformity continued throughout this relatively long period of time. Indeed, a basically uniform dry-grassland fauna seems to have lasted in the southwestern plains of Canada until Wisconsin time, when the woolly mammoth (*Mammuthus primigenius*) reached the area.

As would be expected, there is a great similarity in the mammal faunas of eastern and western Beringia during the Illinoian glaciation. Although species may differ, every genus identified from the Utka Beds (?late Illinoian) of the Kolyma Lowland in eastern Siberia (Appendix, Fauna 3) has been reported from deposits of probable Illinoian age in Alaska (e.g. *Ochotona, Dicrostonyx, Lemmus, Microtus, Mammuthus, Equus, Rangifer, Alces,* and *Bison*) (Table 1).

So far, no vertebrate faunas of definite Illinoian age have been recorded in Canada, although horse, caribou and mammoth fossils as well as beaver-cut wood have been collected from the basal-clay unit of the Old Crow Basin, which may be of that age. However, mammals of Illinoian age are better known in Alaska, and they serve to outline major trends occurring then. The great proliferation of muskoxen during this phase should be noted. Staudinger's muskox (*Praeovibos*) and *Ovibos*, which evidently originated in Eurasia, and the *Symbos cavifrons—Boötherium sargenti* group, unknown outside of North America, suddenly appear in Alaska. Staudinger's muskox may be an index fossil of Illinoian deposits in the Beringian refugium. The rather sparse evidence available points to that conclusion. *Praeovibos* has been reported from the Olyor fauna of the Kolyma Lowland, from the Fairbanks area of Alaska, and from deposits along the Old Crow and Porcupine rivers in the Yukon Territory, but it did not reach the southern plains of North America. The *Symbos cavifrons—Boötherium sargenti* group and *Ovibos* probably stemmed from a similar ancestral stock, although the former shows a few more primitive features and may have evolved in broad alpine-valley environments, which perhaps allowed its later dispersal into the spreading steppe-like grasslands and parklands of

North America during the late Pleistocene. *Ovibos* adapted to colder tundra and Arctic-steppe conditions.

The dhole (*Cuon*) seems to have entered North America about Illinoian time (specimens are known from Alaska and the Yukon) with the American lion (*Panthera leo atrox*), moose (*Alces* sp.), saiga antelope (*Saiga tatarica*), mountain sheep (*Ovis* sp.) and possibly the brown bear (*Ursus* sp.). Brown bears had spread to eastern North America by Sangamon or early-Wisconsin time. This massive entry of Eurasian mammals into North America is related to their pre-adaptation to cool, dry conditions in northern Asia and the development of broad Arctic-steppe grasslands on the Bering Isthmus, which prompted their eastward dispersal to fresh range in another continent.

Four, or possibly five, vertebrate faunas in Canada seem to be of Sangamon interglacial age. Although land-mammal faunas of this age are lacking in Alaska so far, one appears to be present in the Old Crow Basin of the Yukon Territory. It is a peculiar mixture of cool steppe or tundra species such as arctic hare (*Lepus arcticus*), arctic fox (*Alopex lagopus*), mammoth (*Mammuthus* sp.), caribou (*Rangifer tarandus*); moist woodland species such as beaver (*Castor canadensis*), giant beaver (*Castoroides ohioensis*), muskrat (*Ondatra zibethicus*), and red-backed vole (*Clethrionomys* cf. *rutilus*); and "warmer-adapted" species such as spotted skunk (*Spilogale* sp.) and camel (Camelinae). Muskrats, and presumably the moist habitats they occupy, were widespread at this time, for specimens are also reported from deposits of possible Sangamon age in the Kotzebue Sound area of Alaska as well as in Sangamon faunas from Medicine Hat and the Great Plains of the United States (Hibbard 1970).

There is evidence of an influx of "warmer-adapted" species to eastern Beringia from the south about this time. At least for a short period, the giant beaver (*Castoroides ohioensis*), ground sloth (*Megalonyx jeffersoni*), camel (*Camelops* sp.), badger (*Taxidea taxus*), spotted skunk (*Spilogale* sp.), short-faced bear (*Arctodus simus*) and woodchuck (*Marmota* cf. *monax*) survived there. The American mastodon (*Mammut americanum*) may have arrived slightly earlier, during Illinoian time (Table 1). The American lion (*Panthera leo atrox*) may have spread south during this interglacial.

The Sangamon rodent faunas of Old Crow River (Locality 44) and Medicine Hat broadly reflect the differences that exist in the present interglacial between rodent faunas of the southern Canadian prairies and the Alaska–Yukon region.

Sangamon faunas of the Canadian prairies (Medicine Hat, Fort Qu'Appelle) have the following species in common: wolf (*Canis* sp.), Columbian mammoth

(*Mammuthus columbi*), medium-sized horse (*Equus scotti*), western camel (*Camelops hesternus*) and giant bison (*Bison latifrons*). Except for the wolf, the Saskatoon fauna, which may be of Sangamon age, has all these mammals. Bison, probably mammoth, and a moose-like deer are common to the Sangamon faunas of Fort Qu'Appelle and Toronto. The giant beaver occurs in Sangamon deposits of Toronto and the Old Crow Basin (Locality 44) without intervening records. Perhaps it was able to disperse rather rapidly northwards into the Yukon during the Sangamon through chains of lakes that evidently tend to form along the southern margin of the Canadian Shield during interglacial phases. There are no records of the giant beaver from Alaska.

Marine mammals have shifted their latitudinal ranges greatly during the late Pleistocene. Remains of walrus (*Odobenus rosmarus*), sea cow (*Hydrodamalis* sp.) and sea lion (*Eumetopias* sp.) have been reported from raised beach deposits of Sangamon age in Alaska. Evidently walruses and sea cows ranged as far south as San Francisco during the peak of the Wisconsin glaciation, and returned northwards to the Bering Strait in postglacial time. Sea cows were exterminated by man about 1768, and the fate of the Pacific-walrus herds is by no means certain.

The woolly mammoth (*Mammuthus primigenius*) is a valuable indicator of Wisconsin-age deposits in southern Canada and the northern United States. An early type of the woolly mammoth is known from ?late-Illinoian deposits in eastern Siberia (Utka Beds), and the advanced type was well established there by early-Wisconsin time (Iedoma Suite). An unknown type of mammoth (*Mammuthus* sp.) occupied Alaska during the Illinoian glaciation. The woolly mammoth was well established in Alaska and the Yukon Territory in Wisconsin time. It first appeared on the Canadian prairies (Medicine Hat) during the early Wisconsin, and had reached southern Ontario (Woodbridge) by the mid Wisconsin.

The similarity of western and eastern Beringian mammal faunas during the Wisconsin glaciation is remarkable. Unlike the situation in Illinoian time, most species were shared. Of 22 mammalian species represented in the Wisconsin deposits of eastern Siberia (Iedoma and Alioshka suites; Appendix, Faunas 1 and 2), 21 are known from Wisconsin deposits of Alaska and the Yukon Territory. The woolly rhinoceros (*Coelodonta antiquitatis*) did not migrate from Eurasia to North America. Among the Wisconsin genera of the Alaska–Yukon region not reported from faunas of similar age in the Kolyma Lowland of Siberia are: *Sorex* (shrew), *Megalonyx* (ground sloth), *Castor* (beaver), *Clethrionomys* (red-backed vole), *Erethizon* (porcupine), *Arctodus* (short-faced bear), *Taxidea* (badger), *Lynx* (lynx), *Mammut* (American mastodon), *Camelops* (camel), *Bos* (yak-like bovid), *Symbos* and *Boötherium* (extinct muskox)

and *Ovis* (mountain sheep). As mentioned previously, a number of these seem to have been survivors of a northern surge of animals from southern North America that occurred before the peak of the Wisconsin glaciation.

The Wisconsin faunas of the Canadian prairies are characterized by the woolly mammoth (*Mammuthus primigenius*), Mexican wild ass (*Equus (Asinus) conversidens*), western camel (*Camelops hesternus*), and bison (*Bison* sp.), whereas the contemporaneous faunas of eastern Beringia are characterized by the woolly mammoth, Yukon wild ass (*Equus (Asinus) lambei*), large-horned bison (*Bison crassicornis*), caribou (*Rangifer tarandus*), wolf (*Canis lupus*) and the American lion (*Panthera leo atrox*). The basic similarity of the Mexican, Yukon and living Asiatic wild asses has been pointed out previously, and a detailed comparative study is required to find whether or not they are conspecific (Harington and Clulow 1973).

Rapidly accumulating evidence from the unglaciated areas of the Yukon Territory and Alaska shows that human populations were present in eastern Beringia at least 30,000 to 25,000 years ago. Remains of a child from near Taber in southern Alberta suggest that people occupied that part of the prairies before the peak of the Wisconsin glaciation. Probably these early North Americans came from eastern Eurasia, although as yet no adequately dated archaeological sites of this general age have been described from eastern Siberia (Chard 1974). Moreover, evidence, mainly in the form of such characteristic stone tools as fluted and lanceolate spear-points, suggests a broad northward movement, as the Wisconsin ice retreated, of Palaeo-Indian hunters from southern North America to the Canadian Atlantic coast, Ontario, the northern prairies, southern British Columbia, the Canadian Shield, the Yukon, and Alaska. But it is still problematic whether fluted points originated in southern or northern North America.

The Meadowcroft Rockshelter in Pennsylvania apparently contains the earliest dated evidence of man in northeastern North America (Adovasio et al. 1977). It is a well-stratified archaeological site showing signs of human occupation beginning at least 16,000 years ago. Perhaps from this region, caribou-hunting Palaeo-Indians moved northeastwards to occupy the Debert site in Nova Scotia about 10,600 years ago, and northwards to occupy the Parkhill site in southern Ontario between about 10,500 and 9,700 years ago. Farther west, in the United States and the southern Canadian prairies, where Palaeo-Indian sites are more common, mammoths and bison were important prey. Palaeo-Indian hunters killed and butchered bison at the Fletcher site in southern Alberta during early postglacial time. At approximately the same time (9,000 years ago), they occupied sites on the Fraser River in British Columbia, where salmon fishing seems to have been their basis of subsistence.

These people gradually spread northwards into the southwestern Yukon Territory, killing bison at the Canyon site approximately 7,000 years ago. By about that time, they had also occupied the Acasta Lake and Grant Lake sites in the Northwest Territories, where, as at Debert, caribou (this time the barren-ground rather than the woodland subspecies) were probably their basic prey. The ability of Palaeo-Indian hunters to adapt to survival on various kinds of prey in vastly differing habitats is worth noting.

Many characteristic ice-age mammals died out between approximately 10,000 and 8,000 years ago. This can be readily observed, for Canadian postglacial faunas such as those at Toronto, Hamilton, Ottawa, Oxbow Dam, Medicine Hat (Fauna 1) and Acasta Lake, include only living species. The latest reliable radiocarbon date on a member of the extinct Quaternary megafauna in Canada appears to be about 7,700 B.P. for a mammoth (probably *Mammuthus primigenius*) from the Peace River region of Alberta. Many American mastodons died in southern Ontario between 12,000 and 9,000 years ago. Once-numerous herds of Yukon and Mexican wild asses died out completely. The most recent radiocarbon date pertaining to the extinction of the Mexican wild asses in Canada is about 11,000 B.P. (Cochrane), although Churcher and Stalker (1970) suggest that, on the basis of stratigraphy, the species may have survived until 8,000 years ago near Pashley, Alberta. Radiocarbon dates on large-horned bison (*Bison crassicornis*) from Fairbanks and Old Crow indicate that they survived until 12,000 years ago in eastern Beringia. The western bison (*B. bison occidentalis*) seems to have given way to the smaller horned plains bison (*B. b. bison*) and wood bison (*B. b. athabascae*) later in the postglacial. Large specialized predators of the extinct Quaternary megafauna, such as the American lion (*Panthera leo atrox*), the scimitar cat (*Homotherium serum*), the sabretooth cat (*Smilodon floridanus*) and the short-faced bear (*Arctodus simus*), similarly died out. It is widely known that mammals of other continents also suffered late-Quaternary extinctions (Martin 1967).

Why did such conspicuous extinctions of seemingly well-adapted, abundant mammals occur so late in the Quaternary? After all, many had survived earlier severe glacial phases. Although the question is not yet resolved, it should be noted that the extinction of large ice-age mammals in North America coincided with a rapid environmental warming and a rise in the number of people highly skilled in big-game hunting. Perhaps both these factors contributed to the extinctions.

On the basis of my experience in studying Quaternary palaeoenvironmental conditions in eastern Beringia, I am inclined to consider rapid environmental change as the most important cause of extinction in that region. Widespread peat deposits in the Yukon and Alaska, which originated about 11,000 years ago

according to many radiocarbon dates on their bottom layers, and a simultaneous spreading of spruce forest at the expense of cool steppe-grasslands, which evidently prevailed during the coldest phases of the Wisconsin glaciation, must have increasingly restricted the range and number of many of the large grazers, such as woolly mammoths, wild asses and large-horned bison. The apparent scarcity of important early-postglacial mammoth, horse, and bison archaeological kill-sites in eastern Beringia militates against extermination by hunters, although the probable killing of these animals by early man in the Old Crow Basin about 30,000 to 25,000 years ago may have depleted prey locally. Another point not readily explained by the human overkill hypothesis is that perhaps the most easily killed herd-animals, the economically valuable muskoxen (*Ovibos moschatus*), survived in the Yukon until about 2,800 years ago and in northern Alaska until about 1858 (Harington 1970a), despite the presence of human hunters since at least mid-Wisconsin time.

Concerning the extinction of the large Quaternary mammals in southern North America, it is worth emphasizing that although mammoth and bison archaeological kill-sites are known, bison still survive, and relatively few mammoths were killed at any of perhaps a dozen recorded sites (Wheat 1971). Caribou seem to have been heavily hunted by Palaeo-Indians in eastern North America, yet they survived.

Horses — notably *Equus (Asinus) lambei* in the northwest, and *E. (A.) conversidens* and *E. scotti* in the south — were so numerous and widespread in North America during the late Wisconsin that the lack of horse archaeological kill-sites suggests a cause of extinction other than man. Further, despite abundant finds of mastodon remains in late-Wisconsin deposits, sites where they have been killed by man are virtually unknown (MacDonald 1971). On the basis of existing evidence, I think it is an oversimplification to select human overkill as the main reason for late-Quaternary megafaunal extinctions in North America.

Although many scientists have studied this problem and much radiocarbon evidence is available on the times of extinctions of various species, there is still no generally accepted explanation. Perhaps a useful approach to the problem is to study it region by region. Detailed research on sensitive palaeoenvironmental indicators — such as insects, plant macrofossils, pollen and mollusc shells in the extremely well preserved sediments of unglaciated Alaska and the Yukon Territory — accompanied by finer geochronological control and more extensive archaeological and vertebrate palaeontological evidence, may help to solve the problem in eastern Beringia.

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APPENDIX — QUATERNARY VERTEBRATE FAUNAS OF NORTHEASTERN SIBERIA

Several of the most important Quaternary vertebrate faunas from northeastern Siberia are listed below so that they may be readily compared with those of Canada and Alaska. In addition to the lists of species, associated information, where available, is provided for each of these western Beringian faunas.

FAUNAS

1. Kolyma Lowland (Alioshka Suite — lower Kolyma River)

   Mammals - *Lepus* cf. *tanaiticus* (hare), *Mammuthus primigenius* (woolly mammoth), *Equus caballus* (very small horse), *Rangifer tarandus* (caribou), *Bison priscus* ssp. (very small bison), *Saiga tatarica* (saiga antelope).

   Suggested Age - Late Pleistocene (late Wisconsin).

   Remarks - Fossils are from sands which form a large, low depositional plain on the lower Kolyma River. The mammals represented, particularly the saiga antelope, suggest dry, level grasslands with little snow cover in winter.

   References - Sher 1971a, 1971b.

2. Kolyma Lowland (Iedoma Suite — right bank of the Kolyma River between the mouths of the Omolon and Anyui rivers)

   Mammals - *Ochotona* sp. (pika), *Lepus* cf. *tanaiticus* (hare), *Spermophilus* cf. *parryi* (arctic ground squirrel), *Dicrostonyx torquatus* (collared lemming), *Lemmus obensis* (=?*Lemmus sibiricus*) (Ob or ?brown lemming), *Microtus (Stenocranius)* sp. (vole), *Canis lupus* (wolf), *Alopex lagopus* (arctic fox), *Vulpes vulpes* (red fox), *Ursus arctos* (brown bear), *Gulo gulo* (wolverine), *Panthera leo spelaea* (cave lion), *Mammuthus primigenius* (late type of woolly mammoth), *Equus caballus* (small type of caballine horse), *Coelodonta antiquitatis* (woolly rhinoceros), *Cervus elaphus* (red deer), *Alces alces* (moose), *Rangifer tarandus* (caribou), *Bison priscus longicornis* (= *Bison crassicornis*) (large-horned bison), *Bison* sp. (small bison with short horncores), *Ovibos moschatus* (tundra muskox).

   Suggested Age - Late Pleistocene (early Wisconsin).

Remarks - This suite of sediments consists of a thick succession of silty, fine sands and loams with a high ice content. It forms the upper part of the section in the high interfluves of the Kolyma Lowland. Analyses of fossil spores and pollen in these deposits indicates a change from dry, cold steppe-tundra to forest-tundra characterized by birch and larch. Most of the mammals represented are indicative of cool, steppe grasslands.

References - Sher 1971a, 1971b.

3. Kolyma Lowland (Utka Beds — right bank of the Maly Anyui River)

Mammals - *Ochotona* sp. (pika), *Dicrostonyx* cf. *torquatus* (collared lemming), *Lemmus obensis* (=?*Lemmus sibiricus*) (Ob or ?brown lemming), *Microtus* cf. *oeconomus* (tundra vole), *Mammuthus primigenius* (early type of woolly mammoth), *Equus caballus* (large caballine horse), *Rangifer tarandus* (caribou), *Alces* sp. (large moose), *Bison* sp. (bison).

Suggested Age - Middle Pleistocene (Riss II = late Illinoian).

Remarks - Fossils are from sands overlying bedrock and underlying silty fine sands containing a late Upper Palaeolithic mammal fauna. In some localities peat separates the Utka Beds from more recent deposits. The Utka Beds are characterized by fossil spores and pollen of tundra and forest-tundra. Palaeobotanical analysis of a peat deposit in these sediments indicates the former presence of birch-larch forest in the region. The mammals represented are indicative of a cool, steppe grassland.

References - Sher 1971a, 1971b.

4. Kolyma Lowland (Olyor Suite — right bank of Chukochiya River; see Sher 1971b, Figure 1)

Fishes - *Dallia* sp. (blackfish).

Birds - *Gavia immer* (Common Loon).

Mammals - *Sorex* cf. *daphaenodon* (shrew), *Ochotona* sp. (pika), *Lepus* sp. (hare), *Spermophilus* sp. (ground squirrel), *Trogontherium* sp. (Eurasian giant beaver), *Dicrostonyx* spp. (two species of collared lemming), *Lemmus* cf. *obensis* (=?*Lemmus* cf. *sibiricus*) (Ob or ?brown lemming), *Clethrionomys* sp. (red-backed vole), *Microtus* cf. *(Stenocranius) gregalis* (singing vole), *Microtus* sp. or *Allophaiomys* sp. (vole), *Canis* sp. (?wolf), *Panthera* cf. *leo spelaea* (cave lion),

Ursus sp. (bear), *Mammuthus* sp. (mammoth), *Equus (Plesippus) verae* (large horse), Cervidae (deer), *Alces latifrons* (giant moose), *Rangifer* sp. (caribou), *Bison* sp. (bison), *Soergelia* sp. (Soergel's muskox), *Praeovibos beringiensis* (Bering muskox).

Suggested Age - Remarkable faunal similarities between the mammals of the Olyor Suite and those from Tiraspol, Süssenborn and Mosbach indicate an early middle Pleistocene age (Mindel = ?Kansan) for the fauna.

Remarks - The Olyor Suite consists of a sequence of horizontal beds of fine loamy sands separated by thin layers of alluvial and autochthonous peat. At their irregular upper surface, the fine sands of the suite are overlain by late Pleistocene fine loamy sands with ice wedges suggestive of a cool periglacial environment. Bones from the Olyor Suite are so dark from deep staining by minerals in the groundwater that they can be recognized even when they have been washed out of the source beds. Analysis of spores, pollen and plant macrofossils from the Olyor sediments indicate that the environment was much like the present in that region. Of the 60 plant species identified from macrofossils, only a few species of *Potamogeton* and *Ceratophyllum* are unknown in the present Arctic flora in the lowland. The only tree remains are of larch, willow and birch. Fossil spore and pollen spectra indicate the prevalence of cool, tundra-like grasslands with steppe elements were predominant when this fauna lived. Similar conclusions about the environment are suggested by the vertebrate fauna. Blackfish (*Dallia pectoralis*) occupy heavily-vegetated ponds, streams and lakes. They are most common in tundra, but also occur in forested areas. Common Loons indicate the presence of freshwater lakes. Patches of moist woodland are suggested by Eurasian giant beaver. The red-backed vole remains suggest the presence of shrub habitat. Most of the remaining species are indicative of cool, tundra-like grasslands.

References - Sher 1971a, 1971b; Giterman 1973.

5. Kolyma Lowland (Begunov Suite — right bank of the Kolyma River between the mouths of the Omolon and Berezovka rivers)

Mammals - *Mimomys* sp. (vole), *Equus (Plesippus)* sp. (large horse), *Praeovibos* cf. *priscus* (Staudinger's muskox).

Suggested Age - Probably early Pleistocene (=?Nebraskan).

Remarks - Fossils are from a basal unit that grades from pebbles at the bottom to sands in the upper part of the deposit. Analyses of fossil pollen and plant macrofossils from the sediments suggest a gradual development of larch-spruce-birch forests in the region. It is a cooler flora than Pliocene floras of the Omoloi type. The presence of vole, large horse and Staudinger's muskox fossils may indicate the former existence of a cool parkland (e.g. grassy tracts among clumps of coniferous and birch forest).

References - Sher 1971a, 1971b.

6. Aldan River (tributary of the Lena River, below its juncture with the Amga River; see Vangengeim 1961, Figure 1)

Mammals - *Ochotona hyperborea* (pika), *Lepus timidus* (varying hare), *Spermophilus parryi* (arctic ground squirrel), *Castor fiber* (beaver), *Dicrostonyx torquatus* (collared lemming), *Lemmus obensis* (= *?Lemmus sibiricus*) (Ob or ?brown lemming), *Clethrionomys nutilus* (red-backed vole), *Microtus oeconomus* (tundra vole), *Microtus hyperboreus* (northern vole), *Microtus (Stenocranius) gregalis* (singing vole).

Suggested Age - Late Pleistocene (Illinoian). The fauna most likely corresponds to the period of maximal (Riss) glaciation.

Remarks - Fossils are from a number of exposures of deposits of the second terrace above the floodplain of the Aldan River. The sedimentary sequence in the second terrace progresses upward from gravels and sands (about 10 to 30 metres (32.8 to 98.4 ft) above stream level) through alluvial sandy clay (about 30 to 50 metres (98.4 to 164.0 ft) above stream level) and soliflucted sandy clay (about 50 to 100 metres (164.0 to 328.1 ft) above stream level). Generally, the faunal remains indicate a cool steppe grassland environment. The beaver fossil suggests that patches of moist woodland were present, and the red-backed vole remains may indicate that shrubby areas once existed there. Permafrost features in the sediments indicate the prevalence of periglacial conditions. Furthermore, many of the species represented by fossils are far south of their present arctic range.

Reference - Vangengeim 1961.

7. Bolshoi Lyakhov Island, New Siberian Islands (southern tip)

Fishes - *Esox lucius* (northern pike).

Mammals - *Lepus timidus* (varying hare), *Dicrostonyx torquatus* (collared lemming), *Lemmus obensis* (=?*Lemmus sibiricus*) (Ob or ?brown lemming), *Canis lupus* (wolf), *Alopex lagopus* (arctic fox), *Panthera leo spelaea* (cave lion), *Mammuthus primigenius* (woolly mammoth), *Equus caballus* (horse), *Coelodonta antiquitatis* (woolly rhinoceros), *Alces alces* (moose), *Rangifer tarandus* (caribou), *Bison priscus longicornis* (= *Bison crassicornis*) (large-horned bison), *Bison priscus* aff. *deminutus* (=?*Bison bison occidentalis*) (small-horned bison), *Bison priscus* ssp. (possibly another subspecies of bison), *Ovibos moschatus* (tundra muskox).

Suggested Age - Late Pleistocene (?Illinoian to Wisconsin).

Remarks - The bones were not found *in situ*. According to N.N. Romanowski the fossils are derived from deposits with secondary-veined masses of ice occurring on lagoonal sediments. The ice veins suggest a periglacial environment. The mammals represented strongly indicate the former presence of an arctic steppe environment at the site during the late Pleistocene. Although the bones are somewhat eroded on spits and beaches where they were found, evidently they were not transported far. The presence of pike in the fauna is particularly good evidence that Bolshoi Lyakhov Island was a part of the Siberian mainland during glacial maxima of the late Pleistocene.

Reference - Vangengeim 1961.

8. Proliv Dmitriya Lapteva (south shore, east of Mys Svyatoy Nos; see Vereshchagin 1974, Map 1)

Mammals - *Mammuthus primigenius* (woolly mammoth), *Equus* sp. (horse), *Rangifer tarandus* (caribou), *Bison* sp. (small bison), *Ovibos moschatus* (tundra muskox).

Suggested Age - Late Pleistocene (?Wisconsin).

Remarks - Fossils are from sediment approximately 20 metres (65.6 ft) below the surface in silty bluffs about 40 metres (131.2 ft) thick that contain ice veins. Probably the upper 5 to 8 metres (16.4 to 26.3 ft) of loess-like loam with remains of alder, birch and willow is of postglacial age. The mammals represented are indicative of an arctic steppe or tundra-like environment.

Reference - Vereshchagin 1974.

9. Berelekh River (western tributary of the Indigirka River at 71°N)

Birds - *Lagopus* sp. (ptarmigan).

Mammals - *Homo* sp. (indirect evidence from bone and stone artifacts found 60 to 80 metres (196.9 to 262.5 ft) downstream from the deposit), *Lepus* sp. (hare), *Canis lupus* (wolf), *Gulo gulo* (wolverine), *Panthera leo spelaea* (cave lion), *Mammuthus primigenius* (woolly mammoth), *Equus* sp. (horse), *Coelodonta antiquitatis* (woolly rhinoceros), *Rangifer tarandus* (caribou), *Bison* sp. (bison).

Suggested Age - Late Pleistocene (late Wisconsin). A mammoth tusk yielded a radiocarbon date of 12,240 ± 160 B.P. Human hunters may have occupied the area approximately 10,000 years ago (Vereshchagin 1974, p. 10), or could have been contemporaneous with the remainder of the vertebrate fauna.

Remarks - At this locality the Berelekh River cuts through a hill 16 m (52.5 ft) high exposing an upper unit of light grey loess approximately 5 metres (16.4 ft) thick. This loess of late Wisconsin age is underlain by approximately 11 metres (36.1 ft) of organic alluvial silt of mid-Wisconsin interstadial age. The bones are derived from the upper loess unit. The vertebrate fauna and the grey loess from which it was derived suggest a cool loess steppe environment.

Reference - Vereshchagin 1974.

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