Plants, bugs, and a giant mammoth tusk: Paleoecology of Last Chance Creek, Yukon Territory

Grant D. Zazula[1]
Department of Biological Sciences, Simon Fraser University[2]

Duane G. Froese
Department of Earth Sciences, Simon Fraser University[2]

Alice M. Telka
PALEOTEC Services[3]

Rolf W. Mathewes
Department of Biological Sciences, Simon Fraser University[2]

John A. Westgate
Department of Geology, Earth Sciences Centre, University of Toronto[4]

Zazula, G.D., Froese, D.G., Telka, A.M., Mathewes, R.W. and Westgate, J.A., 2003. Plants, bugs, and a giant mammoth tusk: Paleoecology of Last Chance Creek, Yukon Territory. *In:* Yukon Exploration and Geology 2002, D.S. Emond and L.L. Lewis (eds.), Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, p. 251-258.

ABSTRACT

An exceptional, complete tusk of a mature male woolly mammoth (*Mammuthus primigenius*) was recovered from a placer mining exposure on Last Chance Creek, Yukon Territory in July, 2002. The tusk is associated with peat dated to 25 700 ± 400 ^{14}C yrs BP. The direct association of Pleistocene fossils with past vegetation is rare, and allows a comparison between the local vegetation of Last Chance Creek and megafauna during the last glaciation. Preliminary analyses of plant and insect macrofossils from the peat indicate a vegetation cover composed of a mosaic of mesic riparian meadows with sedges, mosses, and willows, and well-drained grasslands or steppe with diverse herbs and sage. This discovery supports the interpretation that the “Mammoth-Steppe” biome existed near the onset of the last glaciation in eastern Beringia.

RÉSUMÉ

En juillet 2002, on a récupéré une défense exceptionnelle de mammouth mâle mature laineux (*Mammuthus primigenius*) dans un gîte placérien sur le ruisseau Last Chance (Yukon). La défense est associée à une tourbe datée à 25 700 ± 400 ans BP (^{14}C). Il est rare de faire une association directe entre des fossiles pléistocènes et la paléovégétation; elle permet de comparer la végétation locale du ruisseau Last Chance avec la mégafaune de la dernière glaciation. Les premières analyses de macrofossiles de plantes et d’insectes contenus dans la tourbe indiquent une couverture végétale composée d’une mosaïque de prés ripicoles mésiques avec des laîches, des mousses et des saules ainsi que des prairies ou une steppe bien drainées avec diverses herbes et sauges. Cette découverte appuie l’interprétation selon laquelle il existait un biome productif « mammouth-steppe » à l’approche de la dernière glaciation dans la Béringie orientale.

[1]*gdzazula@sfu.ca*

[2]*8888 University Drive, Burnaby, British Columbia, Canada V5A 1S6*

[3]*PALEOTEC Services, 1-574 Somerset Street W. Ottawa, Ontario, Canada K1R 5K2*

[4]*22 Russell Street, Toronto, Ontario, Canada M5S 3B1*

INTRODUCTION

In July, 2002, two of the authors (Froese and Zazula) were conducting fieldwork on Last Chance Creek in the Klondike goldfields as part of the Ancient Pacific Margin NATMAP program (Fig. 1). Part of the program involves collecting sediment samples to establish ages and environmental settings of placer gold deposits. After finishing sample collection, Froese noticed the mid-portion of a tusk exposed in the creek gravel. After two hours of excavation, a complete tusk was recovered of exceptional quality from an adult mammoth and peat beds associated with the tusk and gravel. Given the rarity of recovering Pleistocene fossils with a clear geologic setting, this afforded a unique opportunity to examine the paleoenvironment inhabited by the mammoth. The following is a summary of the preliminary results of that work. A context for this work is also provided in relation to larger controversies regarding the paleoenvironments associated with large mammals in unglaciated Yukon and Alaska (eastern Beringia) during the last glaciation.

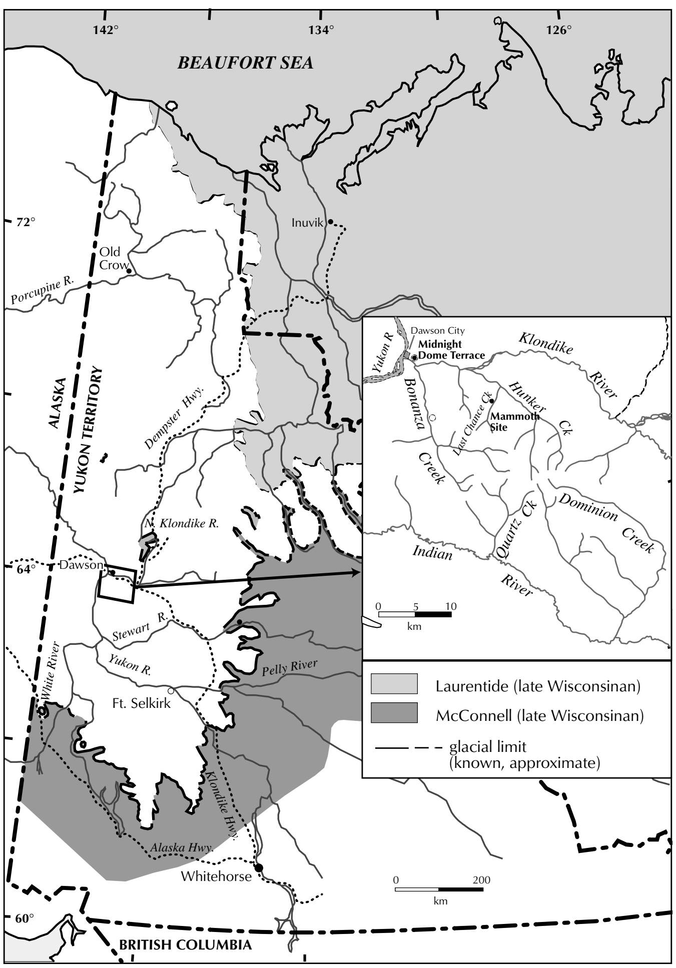

Figure 1. *Location of Last Chance Creek site in relation to late Wisconsinan and McConnell age continental ice margins (after Westgate et al., 2001).*

THE BERINGIA REFUGIUM

During the last glaciation or late Wisconsinan, *ca.* 27 000 to 12 000 years ago, the Laurentide ice sheet advanced from centres in the Northwest Territories to the eastern flanks of the Richardson and Mackenzie mountains, while the northern Cordillera was covered by the Cordilleran ice sheet from the south (Duk-Rodkin and Froese, 2001). Coalescence of these glaciers formed a barrier between the unglaciated region of interior Yukon and Alaska and the rest of North America. A drop in global sea level, by as much as 120 m, exposed the Bering Land Bridge between western Alaska and northeastern Siberia. The unglaciated landmass from Yukon to Siberia is known collectively as Beringia, a region that functioned as a refugium for plants and animals, and a migration corridor between the Old and New Worlds (Hopkins et al., 1982).

PALEOENVIRONMENTS OF BERINGIA

Early paleoenvironmental research portrayed Late Pleistocene Beringia as a productive arctic grassland inhabited by diverse megafauna (Colinvaux, 1964; Hopkins, 1967; Guthrie 1968). Pollen analyses of lake cores and alluvial sections from Alaska and Yukon (Colinvaux, 1964; Rampton, 1971) indicates that Beringian vegetation was dominated by grasses (Poaceae), sedge (Cyperaceae), sage (*Artemisia*) and a variety of arctic herbs during the last glaciation (reviewed in Schweger, 1997). Investigation of fossils recovered from Alaska and Yukon placer mines indicates that the Pleistocene fauna was dominated by large mammal grazers, including steppe bison (*Bison priscus*), woolly mammoth (*Mammuthus primigenius*), and horse (*Equus* sp.) which relied heavily on grasses for their diet (Guthrie, 1968; Harington, 1979, 1989).

The hypothesized Beringian grassland or "Mammoth-Steppe" as synthesized by Guthrie (1990) has been challenged by other paleoecologists, and the nature of the full glacial environment of Beringia became a topic of heated debate. Cwynar and Ritchie (1980), for instance, emphasized that fossil pollen influx from lake sediments, an indirect measure of vegetation cover, was very low during glacial times and included many tundra species. This suggested that Beringian vegetation was more similar to a sparse herb tundra such as found in the high arctic today and not grassland or steppe (Cwynar and Ritchie, 1980), and implied a marginal environment for megafauna (Colinvaux, 1980, 1996; Colinvaux and West, 1984). The conflicting observations of limited vegetation cover and a diverse and abundant grazing megafauna has been termed the "productivity-paradox" (Schweger et al., 1982). Simply put, how could Beringia support large mammals during a time of extensive glaciation and limited plant productivity when present vegetation and milder climate in this region cannot maintain such a fauna? A solution to this problem rests in the detailed reconstruction of Beringian environments through the study of paleoecological data, including pollen, spores, and plant and insect macrofossils from sites that also contain Pleistocene mammal fossils. Discovery of the mammoth tusk frozen in gravel and associated with peat at Last Chance Creek affords a unique opportunity to directly study Late Pleistocene environments incontrovertibly inhabited by woolly mammoth and other Beringian megafauna.

KLONDIKE PALEONTOLOGY IN THE 'MUCKS'

The investigation of Beringian environments in the Klondike has largely focussed on the abundant Pleistocene bones that are readily observed during placer mining. Efforts to study Pleistocene bones in the Klondike were initiated through the efforts of C.R. (Dick) Harington of the National Museum of Canada during the 1960s (Harington, 1978). Harington and others collected Pleistocene bones from placer mines, including specimens of woolly mammoth, horse, bison, American lion, mountain sheep, giant beaver, mastodon, muskox, caribou, moose, camel, brown bear, and saiga antelope (Harington, 1978, 1989). Typically, the bones were recovered from near the base of 'muck' deposits, an informal name for the unconsolidated, fine-grained, ice-rich silts that are found in valley-bottom sites overlying gold-bearing gravel. These deposits originate from the reworking of loess (windblown silts) by small streams and hillslope processes in the Klondike (Fraser and Burn, 1997). In rare circumstances, mummified flesh from these animals has been recovered. The most dramatic discovery was a partial adult horse (*Equus lambei*) carcass found at Last Chance Creek in 1993, dating to about 26 300 years ago (Harington and Eggleston-Stott, 1996; Harington, 2002). Recently, J. Storer has continued with collection and analysis of mammal fossils in the Klondike (Storer, 2001). Although much research has focussed on Pleistocene bones, little systematic attention has been given to studying fossil pollen, spores or plant and insect macrofossils from the Klondike.

LAST CHANCE CREEK LITHOSTRATIGRAPHY

In late 2001, local miner Lee Olynyk started excavating at 5-Above-Discovery-Pup (local name) along the left limit of Last Chance Creek. By mid-summer of 2002, hydraulic monitoring had cut through the middle of a loess/muck fan on the margin of Last Chance Creek. The cut produced a 15-m section consisting of cobble-gravel, 3 m thick, overlain by up to 12 m of massive- to weakly stratified silt (Fig. 2). Paleocurrent indicators within the gravel indicate a flow direction parallel to Last Chance Creek, suggesting the gravel is derived from the creek. A prominent silty peat bed approximately 5-10 cm thick occurring within the gravel was traced over a lateral distance of *ca.* 5 m, and represents a former floodplain surface. Within the silt, 3-4 m above the gravel-silt contact, a prominent volcanic ash (tephra) was found (Fig. 3). The tephra is a fine-grained, glass-rich bed with a white to pinkish colour. The bed lacks the coarse texture, pumice and hornblende typically associated with tephra beds from the Wrangell volcanic field (Type II beds such as the White River or Sheep Creek tephras). Given the appearance of this bed and its stratigraphic setting, we ascribe it to the Late Pleistocene Dawson tephra (Westgate et al., 2000; Froese et al., 2002). The tephra can be traced laterally in each face of the exposure,

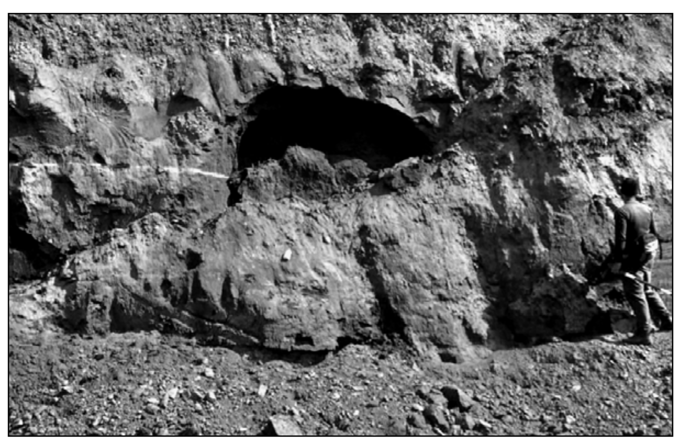

Figure 2. *Exposure at Last Chance Creek. Gravel at base, overlain by silt, with Dawson tephra. Photo by D. Froese, July, 2002.*

Figure 3. *Tephra bed, assumed to be Dawson tephra (ca. 24 000 years old), occurring 4 m above the mammoth tusk and peat. Photo by B. Alloway, July, 2002.*

indicating the entire gravel and silt sequence below is older than 24 000 ^{14}C yrs BP (Froese et al., 2002). Stratigraphy observed at Last Chance Creek is consistent with other Late Pleistocene 'muck' exposures in the Klondike (Fraser and Burn, 1997; Kotler and Burn, 2000).

THE MAMMOTH TUSK

The mammoth tusk was recovered from the frozen gravel within the peat, 4 m below Dawson tephra. It weighs 85 kg (183 lbs), is 2.8 m (10' 6") long and has a maximum circumference of 0.56 m (22") (Fig. 4). The authors identified the tusk as an adult male woolly mammoth (*Mammuthus primigenious*) based on its double helical spiral and large size. This designation was made because tusks from female mammoths and both sexes of mastodon tend to be thinner, shorter and straighter (Vereschagin and Baryshnikov, 1982; Kubiak, 1982). This

Figure 4. *Mammoth tusk excavated from Last Chance Creek gravel and peat. Left to right are D. Froese, L. Olynyk and S. Armstrong. Photo by G. Zazula, July, 2002.*

specimen displayed exceptional preservation, with minimal longitudinal desiccation cracking and minimal post-mortem scratching or scouring. These conditions suggest that the animal died and was rapidly buried in close proximity to the site of recovery with little reworking by the stream. The gravel was examined further for other bones from the mammoth or other mammals but none were found. Other bones observed at the mine, however not in direct association with the tusk, included a partial skull of both a bison (*Bison priscus*) and a horse (*Equus lambei*).

A prominent abrasion zone is visible at the tip of the tusk on both the lower and upper surfaces (Fig. 5). Abrasion on the lower surface is common on many tusks recovered in Beringia. This has been hypothesized to represent a wear facet that developed as the mammoth used their tusks to sweep aside snow to assist with winter grazing (Vereschagin and Baryshnikov, 1982; Kubiak, 1982).

Figure 5. *Abrasion zone at the distal end of the mammoth tusk. Photo by B. Alloway, July, 2002.*

However, abrasion zones on juvenile tusk specimens typically only appear on the bottom of the tusk. The observation of abrasion zones on both the upper and lower surfaces of our tusk also suggests it was from an adult. (Vereschagin and Baryshnikov, 1982). Because tusks grow continually through life and spiral with age, the observed abrasion pattern probably reflects wear incurred both during young and old age (Kubiak, 1982). This abrasion feature provides potential insight regarding the behaviour of this extinct mammal.

ANALYSIS OF FOSSIL PEAT

During excavation, three bags (*ca.* 2.0 l) of frozen silt-rich peat were collected from around the tusk. For laboratory analyses, 500 ml of peat was measured by water displacement and washed through stacked 2.00, 0.25 and 0.125 mm sieves. From the retained material, plant macrofossils were isolated and identified by Zazula. A portion of the sample was submitted to Telka for the identification of insects. Several sedge (*Carex*) seeds were submitted for AMS radiocarbon dating and yielded a date of 25 700 ± 400 yrs BP (BETA-171748), placing the deposition of peat and the mammoth tusk near the onset of the late Wisconsinan glacial interval.

The peat contains diverse and abundant, well preserved plant remains. The plant macrofossil assemblage is dominated by well preserved sedge (*Carex*) rhizomes and stems, various mosses, willow (*Salix*) twigs and persistent buds, various seeds, and smaller herbaceous plant fragments. Seeds of grasses and grass-like plants are common, and there was an abundance of sedge achenes, with occasional specimens of wild-rye (*Elymus*), fescue (*Festuca*), blue grass (*Poa*), and rushes (*Juncus*). Flowers of sage (*Artemisia*) are present but rare in the assemblage. Seeds of herbaceous flowering plants are diverse, but comprise a minor component of the assemblage and consistently show more evidence of abrasion than other specimens. These include seeds of yarrow (*Achillea millefolium*), chickweed (*Cerastium*), sandwort (*Minuartia rubella*), campion (*Silene*), goosefoot (*Chenopodium*), knotweed (*Polygonum*), mountain sorrel (*Oxyria digyna*), mustards (*Draba type*), cinquefoil (*Potentilla*), buttercup (*Ranunculus*), fairy-candelabra (*Androsace septentrionalis*) and poppy (*Papaver*). No large pieces of wood or other macrofossils from trees were recovered.

Insect remains are abundant and generally well preserved in the peat. These are dominated by ground beetles (*Carabidae*), rove beetles (*Staphylinidae*) and weevils

(*Curculionidae*). Most of the insects recovered are presently common to moist stream-side environments. A few specimens indicate better drained environments. Importantly, specimens of the weevil *Connatichela artemisiae* were recovered, which is known to presently inhabit southern steppe habitats today, including dry south-facing slopes where it feeds on sage (*Artemisia*). Other insects observed in lower frequencies include the rare fossil remains of Hymenoptera (*Cheloninae*), leafhopper (*Cicadellidae*) and leaf-beetle *Chrysolina*. These taxa are common to open grassland vegetation dominated by grasses and other forbs. The authors did not recover any remains of forest insects. However, the presence of the fly *Xylophagus*, whose larvae live in decaying wood, suggests that some large shrubs were probably present.

LATE PLEISTOCENE VEGETATION AND MEGAFAUNA

The sedimentary context of the peat suggests it is primarily autochthonous, formed by small overbank flood events burying local riparian vegetation. However, the diverse habitat preferences for many taxa identified in the macrofossil assemblage suggests a mosaic of habitats and vegetation types were dispersed locally. Particularly, the habitat preferences of taxa differ in their tolerance to either mesic or xeric conditions. Thus, some taxa found within the peat were probably incorporated as detrital components derived from habitats adjacent to the riparian zone during stream aggradation events. The location of vegetation types was probably controlled primarily by available moisture, soil conditions and topographic setting. The combined macrofossil assemblage, however, suggests that trees were either absent or a minor component of the vegetation near Last Chance Creek near the onset of the last glaciation, 25 000 years ago.

Concordant with the sedimentological interpretation of our autochthonous peat, the macrofossil assemblage is dominated by well preserved macrofossils representing mesic sedge-moss meadows with willows buried *in situ* by silt within the riparian zone. The predominance of these taxa probably reflects the availability of water within the riparian zone of Last Chance Creek. The availability of abundant vegetation, as well as a water source, suggests that riparian meadows may have been an important habitat for woolly mammoths. Further, several taxa in the macrofossil assemblage have preferences for dry sites, suggesting the local presence of grassland or steppe vegetation, with sage and flowering forbs. The relative rarity of these taxa and in most cases poorer preservation suggests that they probably have origins from vegetation that inhabited dry open slopes adjacent to the valley bottom. Recovery of plant and insect specimens confirming the local presence of sage (*Artemisia*) are important ecologically because this taxon is a key component of dry steppe vegetation. Bunch-grasses, and perennial herbs, too, were probably important sources of fodder for grazing megafauna.

The deposition of fine-grained loess sediments, the retransported components of which form the Klondike 'muck' deposits, may have been an important factor in the formation of productive soils and the maintenance of open grassland or steppe vegetation (Laxton et al., 1996; Schweger, 1992). The established ages for the Dawson tephra (*ca.* 24 000 yr BP) and our radiocarbon date from the peat indicate that loess began rapidly accumulating in the Klondike shortly after 25 700 ±400 yr BP. Thus, these ages place important chronological context to the dramatic environmental changes in the region associated with the onset of late Wisconsinan glaciation and climates.

Macrofossils associated with the Last Chance Creek mammoth tusk are contemporaneous and similar to those recovered from around the carcass and within the intestinal contents of the Last Chance Creek horse mummy (Harington, 2002). Macrofossil analysis indicates that this horse had been feeding on grassland vegetation similar in composition to that found in our peat. The abundance of plant remains within the intestinal tract, especially grasses, indicates the horse did not die of starvation and did not inhabit a marginal habitat with sparse vegetation (Harington, 2002). Analyses of intestinal contents and plant fragments preserved in tooth pits of Beringian woolly mammoths concluded that they relied heavily on grasses and herbs for their diet (Guthrie, 2001; Ukraintseva, 1993). The diversity of habitats near Last Chance Creek was probably important to provide sufficient fodder year round for Pleistocene megafauna. One can readily imagine mammoths foraging in meadows, drinking water from Last Chance Creek during the spring and summer, and sweeping the light snow cover away with their tusks to eat dried grasses and other forage during the long, cold winter.

The vegetation reconstructed for Last Chance Creek is similar to the Late Pleistocene vegetation near Old Crow in the northern Yukon as proposed by Zazula (2002).

Multi-proxy paleoecological data, including pollen, insects and plant macrofossils from the Bluefish Basin also indicate a mosaic of vegetation types dominated by open steppe vegetation with sedge-moss riparian meadows (Zazula, 2002). The Bluefish Basin was also home to a community of grazing megafauna during the last glaciation (Cinq-Mars, 1990; Cinq-Mars and Morlan, 1999; Harington, 1989). These combined results suggest that the Yukon refugium probably constituted the easternmost extension of a more widespread biome that is hypothesized to have spanned across Beringia. Several lines of evidence suggest that a widespread "Mammoth-Steppe" biome was alive and well in Yukon during the last glaciation.

ACKNOWLEDGEMENTS

We extend many thanks to Lee Olynyk, Sandford Armstrong, Simon Hambrook and other placer miners of the Klondike for their support, encouragement and assistance with our research. Our work in the Klondike area was supported by research funds to L. Jackson (GSC) through the Ancient Pacific Margin NATMAP program and J. Westgate (U of Toronto) through the Yukon Geology Program. Jeff Bond (YGP) arranged for the radiocarbon dating of the plant remains associated with the site. Brent Alloway kindly provided the digital photographs in Figures 3 and 5. Froese is supported at SFU by a post-doctoral fellowship from the Natural Sciences and Engineering Research Council (NSERC) and research funds through John Clague (SFU). Zazula is supported by a SFU graduate fellowship scholarship and funds through an NSERC grant to R. Mathewes. This paper greatly benefited from discussions with Dick Harington and John Storer. We appreciate the constructive comments on a draft of this paper by Paul Matheus, John Storer and Alberto Reyes.

REFERENCES

Cinq-Mars, J., 1990. La Places des Grottes du Poisson-Bleu dans la Préhistoire Béringienne. Revista de Arqueologia Americana, vol. 1, p. 9-32.

Cinq-Mars, J. and Morlan, R.E., 1999. Bluefish Caves and Old Crow Bas*In:* A New Rapport. *In:* Ice Age People of North America: Environments, Origins, and Adaptations. R. Bonnichsen and K.L. Turnmire (eds.), Oregon State University Press, Corvallis, Oregon, p. 200-212.

Colinvaux, P.A., 1996. Low-down on a land bridge. Nature, vol. 382, p. 21-22.

Colinvaux, P.A., 1980. Vegetation of the Bering land bridge revisited. Quarterly Review of Archaeology, vol. 5, p.10-16.

Colinvaux, P.A., 1964. The environment of the Bering land bridge. Ecological Monographs, vol. 34, p. 297-329.

Colinvaux, P.A. and West, F.H., 1984. The Beringian ecosystem. Quarterly Review of Archaeology, vol. 5, p. 10-16.

Cwynar, L.C. and Ritchie, J.C., 1980. Arctic steppe-tundra: a Yukon perspective. Science, vol. 208, p. 1375-1377.

Duk-Rodkin, A. and Froese, D.G., 2001. Yukon Glacial History. *In:* Field Guide to Quaternary Research in Central and Western Yukon Territory, CANQUA 2001, August 25-29, 2001. D.G. Froese, A. Duk-Rodkin and J.D. Bond (eds.), Yukon Heritage Branch, Whitehorse, p. 14-16.

Froese, D.G., Westgate, J.A., Preece, S.J. and Storer, J., 2002. Age and significance of Dawson tephra in eastern Beringia. Quaternary Science Reviews, vol. 20-21, p. 2133-2138.

Fraser, T.A. and Burn, C.R., 1997. On the nature and origin of "muck" deposits in the Klondike area, Yukon Territory. Canadian Journal of Earth Sciences, vol. 34, p. 1333-1344.

Guthrie, R.D., 2001. Origin and causes of the mammoth steppe: a story of cloud cover, wooly mammal tooth pits, buckles, and inside-out Beringia. Quaternary Science Reviews, vol. 20, p. 549-574.

Guthrie, R.D., 1990. Frozen Fauna of the Mammoth Steppe: The Story of Blue Babe. The University of Chicago Press, Chicago, 323 p.

Guthrie, R.D., 1968. Palaeoecology of the large-mammal community in interior Alaska during the Late Pleistocene. American Midland Naturalist, vol. 70, p. 346-363.

Harington, C.R., 1989. Pleistocene Vertebrate Localities in the Yukon. *In:* Late Cenozoic History of the Interior Basins of Alaska and the Yukon. L.D. Carter, T.D. Hamilton and J.P. Galloway (eds.), U.S. Geological Survey Circular 1026, p. 93-98.

Harington, C.R., 1978. Quaternary vertebrate faunas of Canada and Alaska and their suggested chronological sequences. National Museum of Natural Sciences, Syllogeus no. 15, Ottawa, 105 p.

Harington, C.R. and Eggleston-Stott, M., 1996. Partial Carcass of a small Pleistocene Horse from Last Chance Creek near Dawson City, Yukon. Current Research in the Pleistocene, vol. 13, p. 105-107.

Harington, C.R., 2002. Yukon Horse, Beringian Research Notes, No. 14. Yukon Heritage Resources Unit, 4 p.

Hopkins, D.M. (ed.), 1967. The Bering Land Bridge. Stanford University Press, Stanford, California, 495 p.

Hopkins, D.M., Matthews, J.V. Jr., Schweger, C.E. and Young, S.B. (eds.), 1982. Paleoecology of Beringia, Academic Press, New York. 489 p.

Kotler, E. and Burn, C.R., 2000. Cryostratigraphy of the Klondike "muck" deposits, west-central Yukon Territory. Canadian Journal of Earth Sciences, vol. 37, p. 849-861.

Kubiak, H. 1982. Morphological characteristics of the Mammoth: An adaptation to the arctic-steppe environment. *In:* Paleoecology of Beringia, D.M. Hopkins, J.V. Matthews, Jr., C.E. Schweger and S.B. Young (eds.), Academic Press, New York, p. 281-290.

Laxton, N.F., Burn, C.R. and Smith, C.A.S., 1996. Productivity of Loessal Grasslands in the Kluane Lake Region, Yukon Territory, and the Beringian "Production Paradox." Arctic, vol. 49, no. 2, p. 129-140.

Rampton, V.N., 1971. Late Quaternary vegetational and climatic history of the Snag-Klutlan area, southwest Yukon Territory, Canada. Geological Society of America Bulletin 82, p. 959-978.

Schweger, C.E., 1997. Late Quaternary palaeoecology of the Yukon: A review. *In:* Insects of the Yukon, H.V. Danks and J.A. Downes (eds.), Biological Survey of Canada (Terrestrial Arthropods), Ottawa, p. 59-72.

Schweger, C.E., 1992. The Full-Glacial ecosystem of Beringia. Prehistoric Mongoloid Dispersal Project, Report 7, Tokyo, Japan, p. 35-51.

Schweger, C.E., Matthews Jr., J.V., Hopkins, D.M. and Young, S.B., 1982. Paleoecology of Beringia – a synthesis. *In:* Paleoecology of Beringia, D.M. Hopkins, J.V. Matthews Jr., C.E. Schweger and S.B. Young (eds.), Academic Press, New York, p. 425-444.

Storer, J., 2001. Vertebrate Palaeontology of the Dawson City Area. *In:* Field Guide to Quaternary Research in Central and Western Yukon Territory, CANQUA 2001, August 25-29, 2001, D.G. Froese, A. Duk-Rodkin and J.D. Bond (eds.), Yukon Heritage Branch, Whitehorse, p. 24-26.

Ukraintseva, V.V., 1993. Vegetation cover and environment of the Mammoth Epoch in Siberia. *In:* The Mammoth Site of Hot Springs, South Dakota, L.D. Agenbroad, J.I. Mead and R.H. Hevly (eds.), S. Dakota, 309 p.

Vereschagin, N.K. and Baryshnikov, G.F., 1982. Paleoecology of the mammoth fauna in the Eurasian arctic. *In:* Paleoecology of Beringia, D.M. Hopkins, J.V. Matthews, Jr., C.E. Schweger and S.B. Young (eds.), Academic Press, New York, p. 267-280.

Westgate, J.A., Preece, S.J., Froese, D.G., Walter, R.C., Sandhu, A.S. and Schweger, C.E., 2001. Dating Early and Middle (Reid) Pleistocene Glaciations in Central Yukon by Tephrochronology. Quaternary Research, vol. 56, p. 335-348.

Westgate, J.A., Preece, S.J., Kotler, E.C. and Hall, S., 2000. Dawson Tephra: a prominent stratigraphic marker of late Wisconsinan age in west-central Yukon, Canada. Canadian Journal of Earth Sciences, vol. 37, p. 621-627.

Zazula, G.D., 2002. Full-glacial macrofossils, paleoecology and stratigraphy of the Bluefish Exposure, northern Yukon. Unpublished M.A. thesis, University of Alberta, Canada, 195 p.