APPENDIX A — Joint ADF&G and FWS review of wood bison restoration on Yukon Flats

A REVIEW OF INFORMATION ON WOOD BISON IN ALASKA AND ADJACENT CANADA, WITH PARTICULAR REFERENCE TO THE YUKON FLATS

by

Craig L. Gardner
Alaska Department of Fish and Game
Division of Wildlife Conservation
1300 College Road
Fairbanks, Alaska 99701-1599

and

Anthony R. DeGange
U.S. Fish and Wildlife Service
1011 E. Tudor Road
Anchorage, Alaska 99503

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EXECUTIVE SUMMARY

Bison were part of Alaska's fauna for over a hundred thousand years. Bison skeletal remains from throughout this period have been found including one dated as recently as 170 years ago. Based on skeletal measurements, wood bison (*Bison bison athabascae*) were the last bison subspecies that occurred in Alaska. Archaeological and paleontological evidence in combination with historic accounts from Alaska Native elders indicate that bison persisted in Alaska into the nineteenth and early twentieth centuries and were once a subsistence resource for Alaska's indigenous people. Factors that are responsible for the extirpation of wood bison from Alaska may never be known with certainty. However the combined effect of changes in habitat and harvest by humans is the most likely cause. Recent habitat studies concluded that substantial suitable habitat for wood bison exists on the Yukon Flats and in other areas of Alaska. A low to medium density wood bison population is unlikely to have negative effects on waterfowl, moose or other wildlife. Wood bison are susceptible to a variety of diseases, most notably bovine brucellosis and bovine tuberculosis. Although diseased herds of wood bison exist in Canada, only disease-free stock are used in transplants of wood bison to unoccupied range and additional protocols are in place to minimize the risk of disease transmission.

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INTRODUCTION

The establishment of wood bison populations in Alaska and in particular on the Yukon Flats has been considered by the U.S. Fish and Wildlife Service (FWS), the Alaska Department of Fish and Game (ADF&G), and communities of the Yukon Flats since the early 1990s. ADF&G conducted assessments of the habitat and feasibility of establishing a population of wood bison in the upper Yukon Valley and concluded that the habitat is suitable (Berger et al. 1995) and the overall project feasible (ADF&G 1994). The release of wood bison in Alaska is supported by the Canadian National Wood Bison Recovery Team and the International Union for the Conservation of Nature – Bison Specialist Group and in the Yukon Flats by local villages, Alaska Native organizations, and hunting organizations.

In December 1997, FWS's Regional Director informed ADF&G that the FWS could not support a proposal to establish wood bison on the Yukon Flats National Wildlife Refuge (NWR) because the information provided by ADF&G was insufficient for FWS to conclude that wood bison inhabited the Yukon Flats in historical times. FWS also concluded that wood bison likely disappeared from Alaska as a result of natural environmental changes, and therefore they are no longer part of the natural diversity of the Yukon Flats NWR. As a result the proposed introduction would likely be incompatible with one of the primary purposes for which the Refuge was established, namely, "…to conserve fish and wildlife populations and their habitats in their natural diversity…."

In subsequent discussions and correspondence, FWS also questioned the taxonomic status of late Holocene bison; the origin and date of the most recent bison specimen in Alaska; whether late Holocene bison accounts represented resident, viable populations; the reliability of oral accounts of bison on the Yukon Flats; and whether possible interactions between bison and other wildlife, in particular moose and waterfowl, have been adequately addressed.

Since the 1997 decision by FWS, additional paleontological, archaeological, and historical data on wood bison in late Holocene Alaska and adjacent Canada were analyzed and presented in Stephenson et al. (2001) and a technical review of the feasibility assessment for establishing wood bison on the Yukon Flats by *The Wildlife Society*–Alaska Chapter (Griffith et al. 1998) was completed. In June 2002, Safari Club International requested that the FWS Director reverse the 1997 decision not to establish a population of wood bison on the Yukon Flats NWR, and to support Canada in their wood bison conservation program.

In light of Safari Club International's request and the availability of new information on bison in Alaska, in September 2002 the Director of FWS, the Regional Director of FWS in Alaska, and the Director of ADF&G's Division of Wildlife Conservation agreed that a joint review of the information on wood bison in Alaska, focusing on the identified concerns was needed. This review would then provide the basis to determine whether establishing wood bison in the Yukon Flats is consistent with FWS policies.

This paper is part of that review and summarizes information on wood bison in Alaska and Canada with particular emphasis on taxonomic status, historical accounts, factors influencing wood bison extirpation in Alaska, and wood bison ecology.

Historic Range of Holocene Bison In Alaska

McDonald (1981) and Gates et al. (1992) estimated the historic range of wood bison, including Alaska, based on the locations of subfossil specimens. A more recent estimate by Stephenson et al. (2001) is based on additional archaeological and paleontological specimens as well as oral and written accounts, and is reproduced here (Fig 1). This map indicates that the range of bison in Alaska within the last 5,000 years was widespread, including the Tanana and Yukon basins in eastern Interior Alaska, north to the Brooks Range, south to Anchorage and west to about Ruby along the Yukon River. The historic range of Holocene bison in Alaska continues to be refined. It is well known that preservation of specimens during the Holocene was poor because of the moist, acidic conditions of the boreal forest. Nevertheless, additional specimens continue to be found (R. Stephenson, ADF&G, pers. commun.) that will hopefully improve the description of the former range of bison in Alaska.

Taxonomic Status of Holocene Bison in Alaska

North American bison, *Bison bison*, descended from ancestral stock that originally colonized North America from Eurasia via the Bering land bridge. Morphological and taxonomic studies indicate that wood bison and plains bison were the only bison subspecies that existed in North America during the late Holocene and that wood bison were the last type to occupy Alaska (Harington 1977; McDonald 1981; van Zyll de Jong 1986, 1993; Guthrie 1990).

Of the 58 Holocene bison specimens from Alaska and adjacent Canada (Table 1), 27 have been identified as wood bison, many based on measurements that fall within the ranges of those published for wood bison by van Zyll de Jong et al. (1995) (R. Stephenson, ADF&G, pers. commun.). Most of the remaining 31 specimens from the Holocene are also most likely wood bison since it is unlikely that two similar but distinct taxa of bison would coexist. Fifteen of the wood bison specimens are from Alaska, including 11 from the Yukon Flats. The most recent wood bison specimen from Alaska has a radiocarbon date of 170 years Before Present (BP); the most recent specimen from the Yukon Flats has a radiocarbon date of 1,730 years BP (Table 1).

Paleontological, Zooarchaeological, and Ethnographic Information On Wood Bison in Alaska

The historical evidence for wood bison in Alaska and adjacent Canada is detailed in Stephenson et al. (2001). Table 1 lists 58 Holocene bison specimens from 55 locations in Alaska and adjacent Canada. At least 15 of these specimens are from archaeological sites found in Alaska indicating human use of this taxon. Twenty-five of these specimens are from Alaska, including 15 from the Yukon Flats. Radiocarbon dates for the Alaska specimens range from 170 years BP to 8,860 years BP; the specimens from the Yukon Flats range from 1,730 years BP to 9,000 years BP. Table 1 also includes some bison specimens from the late Pleistocene in Alaska and nearby Canada. Many of these are from the Yukon Flats attesting to the long occupancy of the area by bison.

The 170-year-old specimen is a well-preserved male skull with horn cores, suggesting that bison were present in Alaska until recently. It was found in 1969 emerging from the bank of Chester Creek in Anchorage, and has attracted attention, not only because of its recency but because some other bones found nearby have been dated as post-World War II (T. Heuer, FWS, pers.

commun.). However, comparative analyses of the bones at the University of Alaska (Fairbanks) Museum and simultaneous redating of the skull and the other bones indicate these were not bison bones, but represent a small or medium-sized mammal (Gerlach, pers. commun.). A 370-year-old bison molar from adjacent Yukon, Canada and a 420-year-old skull from northwestern Northwest Territories also indicate the relatively recent occurrence of bison in the general region.

Stephenson et al. (2001) presented oral accounts of bison in Alaska from 15 Alaska Native elders describing the recent presence of bison in Alaska. Most of the accounts were stories passed down through generations describing the presence of bison, the importance of bison as a source of food and clothing, and how they were hunted. They also provided Athabascan names for bison. There were two secondhand and one firsthand account of bison on the Yukon Flats during the late 1800s and early 1900s. Stephenson et al. (2001) recognized the possibility of bias in oral accounts and attempted to reduce bias by conducting multiple interviews with individuals. They also compared their results with the results of two independent researchers who interviewed two of the elders and reviewed the other accounts.

Based on the narratives provided by the elders, and the specimen record, Stephenson et al. (2001) concluded that wood bison were widely distributed in the upper Yukon and Tanana River drainages until late in the Holocene and that they were sufficiently abundant to be an important natural resource to people of the area as recently as 200–300 years ago. Historic accounts have also been provided by First Nation elders in Yukon, Canada indicating that bison were also present during the late Holocene in this area and disappeared during the same general period (Lotenberg 1996).

Stephenson et al. (2001) conducted a "substantial but not exhaustive" search for early written documentation of wood bison in Alaska; they found little. Independent searches by FWS staff have been similarly unfruitful (T. Heuer and J. Stroebele, pers. commun.). We did not conduct an independent search for early written records.

There are two written accounts of bison in Alaska from the early to mid-1990s (Stephenson et al. 2001). Stephenson et al. (2001) reference the journal of James Geoghegan, who noted the presence of bison near Donnelly, Alaska in 1918 or 1920. They noted that the Geoghegan journal entries are confusing in terms of dates and he may have been referring to the plains bison that were released at Delta in 1928. C. Gardner examined a copy of the journal and concurs with the conclusion of Stephenson et al. (2001).

Stephenson et al. (2001) also mentions McKennan's (1965) formal ethnographic studies with the Chandalar Gwich'in and his interview with Chief Christian. McKennan (1965) stated "Muskoxen, now extinct in the area, were said to have frequented the Chandalar territory in former days, and a small mountain near the forks of Smoke Creek is known to the Natives as ch'itthay ik; which they translate as Muskox Shirt Mountain." However, McKennan's original field notes (copy of original document located in the archives, University of Alaska Fairbanks) documenting information obtained from Chief Christian differed from that statement. McKennan's field notes indicate that Chief Christian referred to this mountain as Buffalo Shirt Mountain but McKennan assumed this reference was incorrect. Stephenson et al. (2001) interviewed T. E. Taylor, a U.S. Geological Survey engineer who visited Venetie in 1956. He was told by the village elders and other residents that the mountain near Smoke Creek was called Buffalo Shirt Mountain because buffalo were formerly hunted there. Stephenson et al. (2001) recognized that the ambiguity of McKennan's notes remain difficult to explain because there were a few muskox present in the eastern Brooks Range until the late 1800s (Lent 1998).

FACTORS INFLUENCING THE DECLINE AND EXTIRPATION OF BISON FROM ALASKA

Skeletal remains and oral history accounts suggest that bison had largely disappeared from Interior Alaska during the last 200–400 years (Guthrie 1990; Stephenson et al. 2001). The possible cause(s) of extirpation were explored by Stephenson et al. (2001). They analyzed how various factors including predation, harvest by humans, habitat availability, and meteorological or climatic factors could have acted alone or in combination. This analysis concluded that habitat availability or environmental and climatic factors did not cause the extirpation of bison. Bison persisted in Alaska for at least several hundred thousand years despite climatic fluctuations that were far more variable during the Pleistocene compared to those during the Holocene (Stephenson et al. 2001).

The warmer and less arid conditions that occurred during the Pleistocene–Holocene transition favored the expansion of trees and shrubs in Interior Alaska resulting in a change from treeless steppe to boreal forest, with an accompanying reduction of grassland habitat (Guthrie 1990). Some other grazing species, such as horses and mammoths, disappeared from the region by the end of the Pleistocene. Bison, however, persisted in Interior Alaska and adjacent parts of Canada until recently. By the late Holocene, the amount of bison habitat in Alaska had become much reduced and discontinuous. Recent habitat studies, together with the successful introductions of plains bison in Alaska and wood bison in parts of Canada, suggest that the remaining grasslands could have supported viable bison herds (Berger et al. 1995).

If changes to climate and habitat alone did not cause the extirpation of bison, they may have increased the vulnerability of bison to predation, hunting, and stochastic effects through a reduction in herd size and increased isolation of herds. Various studies show that isolated populations of birds and mammals are more vulnerable to extinction than are contiguous populations (MacArthur and Wilson 1967; Brown 1978, 1986; Grayson 1991). Once a wood bison subpopulation became extirpated, geographic separation from other herds by large expanses of forest would have reduced the chance of recolonization (Gates and Larter 1990; Stephenson et al. 2001).

Studies of bison herds in Alaska and Yukon suggest it is unlikely that predation by wolves and bears caused the extirpation of bison in Alaska (Gates and Larter 1990; DuBois and Stephenson 1998; Whitman and Stephenson 1998). In disease-free herds, wood bison are not the primary prey for bears or wolves. The history and status of the Farewell, Copper River, and Chitina plains bison herds in Southcentral Alaska illustrates how predators might affect relatively small, isolated herds. The Copper River and Chitina herds are limited by habitat (Tobey 2000, 2002). Wolf and grizzly bear populations are not limited by human harvest in these areas. Predators have been observed on bison kills but the occurrence is low. Fall composition data suggest that predators take some bison calves during the summer, and yearlings throughout the year, but predation has a minor effect on these three populations (Whitman and Stephenson 1998; Tobey 2000, 2002; Boudreau 2002). Harvest and accidents, and starvation in the Copper River and

Chitina herds, are the primary limiting factors. The fact that predation has not reduced these isolated herds, two of which are habitat limited, suggests that predation alone did not cause the extirpation of wood bison from Alaska.

Archaeological data and oral accounts indicate that native peoples hunted wood bison in Alaska until wood bison disappeared during the last few hundred years. Several factors may have increased the vulnerability of small and discontinuous herds of bison to hunting: 1) the juxtaposition of late Holocene bison habitat with human settlements; 2) the scarcity of moose during the late Holocene that may have elevated the importance of bison as a subsistence resource, 3) behavioral traits of bison that increase their vulnerability to hunters and the likelihood that more than one animal would be killed during an encounter with humans; and 4) improvements in hunting technology, including the development of archery and the use of dogs, during the late Holocene (Stephenson et al. 2001) and the acquisition of metals through trade (D. Guthrie, pers. commun.).

There is evidence that aboriginal hunting in Alaska caused declines or local extirpation of other large mammals in the late Holocene, including Dall sheep, muskox, moose, and brown bears (LeResche et al. 1974; Campbell 1978; Coady 1980; Birkedal 1993; Lent 1998; Stephenson et al. 2001). Aboriginal hunting appears to have been an important factor in the decline or extirpation of muskoxen in parts of Canada and Alaska (Gunn et al. 1984; Will 1984; Lent 1998). The timing and causes for the disappearance of muskoxen and wood bison from Alaska appear to be similar (Stephenson et al. 2001).

CURRENT DISTRIBUTION, POPULATION SIZE, AND TAXONOMIC STATUS OF WOOD BISON

The history and population status of wood bison in Canada is summarized in Gates et al. (2001) and the number of wood bison currently found in Canada is summarized in Table 2. By September 2002, there were about 3,100 wood bison in six disease-free, free-ranging herds, including about 2,000 bison in the McKenzie population of Northwest Territories, 170 bison in the Nahanni/Laird River herd in the Northwest Territories, 530 wood bison in the Nisling River herd in Yukon Territory, 234 bison in the Hay–Zama population in northwestern Alberta, 70 bison in the Chitek Lake population in Manitoba, and 60 bison in the Nordquist Flats population in British Columbia. An additional free-ranging population of 40–50 wood bison was established in 2002 in southeastern British Columbia at Enhithun Lake (C. Gates, pers. commun.). The status of these herds has a major bearing on any decisions by the Canadian and U.S. governments to delist or downlist this subspecies under Canada's list of threatened and endangered species and the U.S.'s Endangered Species Act.

In addition, there are more than 4,000 other wood bison in four free-ranging herds that are either infected or exposed to bovine tuberculosis and bovine brucellosis (C. Gates, pers. commun.). Almost 900 additional wood bison are found in publicly-owned, captive breeding herds or privately-owned herds (Table 2).

All of the wood bison in the free-ranging, disease-free herds originated from bison discovered in 1957 in the Nyarling River area of Wood Buffalo National Park that were believed, at that time, to have escaped hybridization with plains bison introduced to Wood Buffalo National Park in 1925. The McKenzie population was founded with 18 wood bison from the Nyarling River area.

All of the remaining disease-free herds came from stock from Elk Island National Park, which was founded with 21 wood bison from Nyarling River. Thus all existing wood bison originated from a relatively small number of animals. Wilson and Strobeck (1999) found that all wood bison herds today likely contain some plains bison genetic material in their gene pool, and that wood bison would be even more distinct genetically from plains bison had the introduction of plains bison to Wood Buffalo National Park not occurred.

Geist (1991) challenged the subspecific status of wood bison contending that phenotypic differences in size and pelage were the result of environmental influences such as food quality. Van Zyll de Jong et al. (1995) however, contend that differences in phenotypic characters between wood and plains bison are heritable. Molecular studies provide some clarity to the controversy from a management perspective, but do not completely resolve the question of subspeciation. Studies of blood characteristics, restriction fragment length polymorphisms, mitochondrial DNA haplotypes, and DNA microsatellites all found varying degrees of difference between plains and wood bison (Peden and Kraay 1979; Bork et al. 1991; Polziehn et al. 1996; Wilson and Strobeck 1999). Polziehn et al. (1996) did not dispute the subspecific status of plains and wood bison but conclude that they have only recently been separated from each other and neither is a well-defined taxon. Wilson and Strobeck (1999) concluded that the three populations of wood bison they studied were “functioning as entities distinct from plains bison, and should continue to be managed separately.”

ECOLOGICAL ISSUES AND CONCERNS

FWS and Griffith et al. (1998) pointed out several ecological concerns relative to establishing wood bison in Alaska, specifically on the Yukon Flats. These are the effects of bison on vegetative communities, the effects of bison on waterfowl, and the direct and indirect effects of bison on moose. We address these issues below. More thorough treatments of wood bison ecology and behavior are available elsewhere (ADF&G 1994; Gates et al. 2001).

HABITAT AND FORAGING REQUIREMENTS

Wood bison are primarily grazers, foraging primarily on a variety of sedges and grasses, but also on shrubs, and where available, lichens on a seasonal basis (Reynolds et al. 1978; Reynolds and Hawley 1987; Gates and Larter 1990; Larter and Gates 1991). Wood bison show seasonal changes in habitat use and diet, selecting for forage that provides the highest amounts of crude protein (Larter and Gates 1991). During spring and summer, wood bison primarily use mesic meadows and eat a variety of sedges, grasses, and shrubs. They use a greater variety of habitats during the fall as forage quality declines. During winter, wet meadows are most often used and sedges constitute nearly 100% of the diet (Larter and Gates 1991). During most of the year, wood bison occur in small groups ranging from 1–60 animals. The larger groups include primarily cows, calves, and juveniles. Wood bison move frequently, generally remaining in a meadow for less than one day and moving before forage is depleted (Reynolds et al. 1978; Komers et al. 1993). Bison usually select only part of a plants annual growth (Reynolds et al. 1978).

Larter and Gates (1991) found that meadows represent 5–20% of most wood bison ranges in Canada. The Nisling herd in Yukon has increased 10–20% annually (M. Oakely, pers. commun.)

on range that is comprised of less than 5% meadow habitat (Reynolds 1982), indicating that wood bison can thrive in areas where the proportion of meadow habitat is relatively low.

Snow depths up to 30 inches (76 cm) and 24 inches (61 cm) do not restrict foraging behavior of adult and calf bison, respectively (Van Camp 1975). Wood bison can withstand deeper snows without affecting mortality or productivity as long as wind or icing does not increase snow density. Plains bison have been observed foraging in snow about 4' deep in Yellowstone National Park (Meagher 1973). Wood bison are well adapted for cold weather and are commonly observed grazing in open meadows on calm days at temperatures approaching -50^{o} F (Fuller 1962).

Berger et al. (1995) evaluated wood bison habitat on the Yukon Flats by sampling vegetation in 30 meadows greater than 200 acres and 88 meadows smaller than 200 acres in two areas totaling 1043 mi^2 near Fort Yukon. Meadows covered 7 and 11% of the two study areas, including both wet and dry meadows that supported plant communities similar to those in wood bison ranges in northern Canada. Berger et al. (1995) found that slough sedge (*Carex atherodes*) and other plant species commonly used by bison are abundant on the Yukon Flats. When available, slough sedge is the most important forage species for wood bison (Reynolds et al. 1978; Larter and Gates 1990; Fortin et al. 2003). Based on foraging models and comparisons with other wood bison habitat, Berger et al. (1995) estimated that the two intensively studied areas could support at least 2,000 wood bison. High quality bison habitat is interspersed within an area of approximately 3,800 mi^2 (ADF&G 1994).

Climatological data indicate that temperature, wind, and snow conditions on the Yukon Flats are similar to areas in northern Canada that support wood bison. There are numerous small, sheltered meadows (<200 acres) with plentiful forage that bison could use on the Yukon Flats if snow hardness becomes restrictive or wind chill too severe in large meadows (ADF&G 1994; Berger et al. 1995; Stephenson et al. 2001).

EFFECTS OF WOOD BISON ON VEGETATION COMMUNITIES

Ungulates can have a profound effect on plant species composition, richness, diversity, productivity, and physiognomy of plant communities (Smith 1990). Grazing intensity, frequency, and season influence the degree of impact. In general, ungrazed areas tend to have low species richness and diversity, overgrazed areas are species-poor and provide little forage value, while moderate grazing results in increased species diversity, richness, and quality (Smith 1990). Within preferred meadows, plant diversity will eventually increase as well as the presence of bare ground due to the development of bison wallows and trails (Smith 1990; S. DuBois, pers. commun.).

Smith (1990) studied the effects of wood bison on meadow habitats used as summer range in the Mackenzie Bison Sanctuary in Northwest Territories. This habitat is similar to the Yukon Flats, being characterized by open boreal forest interspersed with wet and dry meadows (Larter and Gates 1990). Smith (1990) found that moderate grazing caused increased productivity in many graminoid species, in part due to the reduced accumulation of dead material. Knapp et al. (1999) concluded that it is primarily the aboveground accumulation of dead plant material that limits productivity in undisturbed tallgrass prairie, and that like fire, bison grazing reduces dead biomass. Berger (1996) found that moderate grazing during the summer by the Delta bison herd did not affect aboveground primary productivity, but did enhance forage quality and cause changes in plant composition by reducing preferred grass species and leguminous plants in favor of less palatable sedges and forbs.

Smith (1990) hypothesized that wood bison increased plant productivity by acting as nutrient conduits, moving nutrients among vegetative sites, and as nutrient concentrators, harvesting nutrients over large areas and concentrating them in smaller areas. Bison grazing and wallowing can shift species composition of meadows from graminoid dominated, species-poor assemblages with low species diversity to species-rich, and more diverse associations of graminoids and forbs. Smith (1990) also found that grazing can temporarily reduce (by ≤10%) the height of meadow sedges and grasses. Wood bison grazed between 30% and 50% of the individual plants that were preferred species, selecting for the annual growth, and any changes to the physiognomy of meadow vegetation was limited to patches that quickly recovered. S. DuBois (ADF&G, pers. commun.) has observed that the effects of grazing and trampling in the preferred wintering areas on the Delta Junction Bison Range were not detectable during the following spring.

Grasslands and wild ungulates have coexisted for millions of years indicating the high sustainability of the grazing ecosystem (Frank et al. 1998). The key factors are the large spatial and temporal variation in mineral-rich forage, the ability of defoliated grass and sedges to regrow, and the migratory nature of bison and other grazers. Typically, these grazers are continually on the move and grazing at any one site may be intense but never lasts long (Frank et al. 1998). When the grazers are removed, the functional character of the ecosystem is changed, transforming a consumer-controlled, rapidly cycling system into one that is detritivore based and slow cycling (Frank et al. 1998).

POSSIBLE EFFECTS OF WOOD BISON ON WATERFOWL

The Yukon Flats is one of the most productive waterfowl breeding areas in North America producing approximately 1.6 million ducks, geese, and swans annually (U.S. Fish and Wildlife Service 1987). The significance of the Flats for waterfowl breeding has increased because of waterfowl habitat loss in Canada and the continental United States. In terms of continental waterfowl populations, the Yukon Flats area is most important for production of lesser scaup and white-winged scoters; for Alaska, the Flats is most important for canvasback, mallard, American widgeon, green-winged teal, northern shoveler, and possibly Barrow’s goldeneye (Hodges et al. 1996; M. Lindberg, UAF, pers. commun.). During 1988–1991, 26% of the breeding ducks in Alaska were found on the Yukon Flats (Grand 1995). The number of ducks observed per square mile of habitat was 116.2 on the Yukon Flats, the highest of any of the waterfowl survey areas in Alaska (Conant and Groves 2002). This area is also of continental importance in the number of molting ducks it supports. The possible effects of bison on waterfowl were raised as an issue by FWS and Griffith et al. (1998) because of the importance of the Flats for waterfowl.

Information regarding waterfowl nest distribution and density on the Yukon Flats is limited. The available data indicate that nest density is low compared to areas with less extensive habitat in the prairie pothole region and in Colorado. Grand (1995) intensively searched about 1,025 acres including meadow, shrub, and forested habitats along two lakes over three summers in the western portion of the Yukon Flats. The greatest number of nests found during any one year was

87 (0.08 nests/acre). M. Lindberg (UAF, pers. commun.) studied waterfowl nesting near five waterbodies and found that the most common nesting habitats for lesser scaup and canvasbacks were wet meadows adjacent to waterbodies. Nest density was low, with the greatest density on islands. White-winged scoter nests occurred at low density from water's edge to 400 m.

Sample sizes and sample areas were small in the Yukon Flat's studies because determining nest density was not the focus, but initial indications are that waterfowl nests are dispersed over the vast amount of suitable nesting habitat (about 7250 mi^2 or 4.64 million acres reported in Platte and Butler 1992). Waterfowl nests are much more concentrated in other nesting areas in North America. Gilbert et al. (1996) summarized nesting densities for areas in the prairie pothole region and in Colorado. The highest density occurred in a wet meadow habitat in Colorado (2.4 nests/acre) and an idle agricultural area in South Dakota (1.4 nests/acre). Nesting habitat in these areas was limited compared to the Yukon Flats, the largest being 58 mi^2.

There are numerous studies assessing the effects of cattle grazing on waterfowl (examples include Kirsch 1969; Mundinger 1976; Kantrud 1986; Gilbert et al. 1996) but none on bison and none in taiga wet meadows. Cattle grazing has been used as a tool to manage and improve waterfowl nesting habitat in some areas, but its usefulness has been questioned (Kirsch 1969; Gilbert et al. 1996). Kirsch (1969), Mundinger (1976), and Gilbert et al. (1996) reported that even light grazing (evaluated grazing densities were 43–320 cattle/mi^2) by cattle was detrimental to ducks. However, it is difficult to infer much about the effects of bison grazing on waterfowl from cattle grazing because the grazing behavior of cattle differs from that of bison, and the cattle grazing intensities that have been evaluated are much higher than those that would be associated with a free-ranging bison population.

Based on range use patterns of wood bison populations in Canada, densities approximate 5–7 bison/mi^2 of meadow habitat. The densities of cattle at which some negative effects of grazing have been documented range from approximately 43–320 cattle/mi^2 or more (Kirsch 1969; Mundinger 1976; Gilbert et al. 1996). Grazing during winter by cattle at densities ranging from approximately 116–320/mi^2 was found to reduce nesting habitat (Mundinger 1976) and nest density (Gilbert et al. 1996). Wood bison select for wet meadows during winter (Gates and Larter 1990) where probably most waterfowl nesting occurs on the Yukon Flats. Based on the regression models presented by Gilbert et al. (1996), and assuming wood bison population densities as described above, the effect of wood bison grazing on nesting density and success should approximate that in an ungrazed system. S. DuBois (ADF&G, pers. commun.) reports that extensive grazing by the Delta bison herd in preferred habitats during winter does not appear to affect the height or density of vegetation during the following summer.

Bison select different habitats during the year (Gates and Larter 1990; Larter and Gates 1991). Intensive grazing during nesting is more likely to hinder waterfowl production than grazing at other times of year (Glover 1956; Mundinger 1976). However, wood bison avoid wet meadows, the primary waterfowl nesting habitat (M. Lindberg, UAF, pers. commun.) during spring and summer (Larter and Gates 1991). This would tend to minimize nest disturbance and other potential effects of grazing. Bison are also unlikely to occur on nesting islands during this period. Wood bison select for dry meadows during the spring and summer. Waterfowl nesting occurs less frequently in these habitats, but they are still important for several species (D. Groves, pers.

commun.). Larter and Gates (1994) observed no difference in the standing crop of vegetation in grazed and ungrazed dry meadows in an area supporting a herd of about 550 bison.

Bison generally graze in a given area for short periods (Reynolds et al. 1978) and differ from cattle in that they allocate less time to grazing during a set period (Peden 1996), select primarily for annual growth, and spend less time in an area before moving (Hein and Preston 1998). Because of these behavioral differences, the effect of bison on habitats will be different than that of cattle. Gilbert et al. (1996) suggest that grazing by native herbivores such as bison may provide a more suitable way to manage waterfowl habitat where some vegetation removal is necessary.

Although the effects of grazing by bison on waterfowl have not been studied in detail, there are relevant case studies. Elk Island National Park (75.5 mi^2) includes boreal and aspen parkland habitat that supports approximately 227 bird species, including 50 wetland species (Burns and Cool 1986). Ungulate density is about 40/mi^2, with bison densities of 10–12/mi^2 relative to the total park area, and more than 30 bison/mi^2 in grassland, sedge meadow, and shrub habitat (Blyth and Hudson 1987; Blyth et al. 1993). The number of lesser scaup, bufflehead, ring-necked ducks, blue-winged teal, gadwall, mallard, American widgeon and red-necked grebes that use the park during spring and fall migrations is in the tens of thousands (Burns and Cool 1986). American widgeon, lesser scaup, buffleheads, ruddy duck, common goldeneye, blue and green-winged teal, and mallard are common nesters in the park, using wet and dry meadows and tree cavities as nest sites (Burns and Cool 1986). Waterfowl have been inventoried in the park since the early 1900s with more intensive data collected since the 1930s. No management problems/concerns were reported for any of the waterfowl species due to competition with large mammals (Burns and Cool 1986). In the opinion of park biologists, the presence of bison has a beneficial effect on waterfowl populations by maintaining or increasing productivity and diversity of meadow vegetation (ADF&G 1994).

The status of bison and waterfowl in the Mackenzie Bison Sanctuary and Wood Buffalo Park also suggest a lack of any negative effect by bison on waterfowl. Both areas support substantial populations of waterfowl similar in species composition to the Yukon Flats. Biologists familiar with the ecology of these areas see no evidence of adverse effects (ADF&G 1994). There is also no indication of adverse affects of wood bison on waterfowl populations in the Mills Lake area near Fort Providence, NWT. Surveys show Mills Lake has continued to be an important premigratory and migratory staging area for large numbers of tundra swans, lesser snow and greater white-fronted geese, as well as large numbers of ducks during the past 25 years. Wood bison have used the wetlands surrounding Mills Lake on a regular basis, especially in years when water level in the Mackenzie River recedes enough to allow access to sedge meadows (P. Latour, Canadian Wildlife Service, pers. commun.). Based on his experience conducting aerial waterfowl surveys in Wood Buffalo National Park, FWS biologist C. Ferguson (pers. commun.), could see no reason to anticipate negative effects of bison on waterfowl, noting that waterfowl populations are known to be affected by numerous other factors that are far more important.

INTERACTIONS BETWEEN WOOD BISON AND MOOSE

Moose are the only ungulate that regularly occurs on the Yukon Flats. Densities on the Flats are low, ranging from 0.2–0.3 moose/mi^2 (Stephenson 2002). Griffith et al. (1998) suggested there could be possible effects of wood bison on the Yukon Flats moose population if there was competition for browse. FWS voiced concerns that if the presence of bison caused wolf numbers to increase then increased wolf predation on moose may result.

Potential Competition for Forage

In Alaska, the Delta (400–475 bison) and Farewell (350 bison) bison herds coexist with high-density moose populations (1–2 moose/mi^2). Bison and moose are commonly observed feeding and resting in close proximity, suggesting a high degree of behavioral tolerance (S. DuBois and J. Whitman, ADF&G, pers. commun.). Generally, there is little competition for food because moose and bison rely on different forage types. Wood bison are primarily grazers, consuming mainly sedges and grasses, while moose are primarily browsers, relying on willow, birch, and aspen. In Elk Island National Park, Blyth and Hudson (1987) found little overlap in the food of bison and moose despite relatively high overlap in habitat use.

Bison forage on willows shrubs to varying degrees during May and June, taking advantage of the period when willow leaves are high in protein and low in fiber (Waggoner and Hinkes 1986; Larter and Gates 1991; Berger 1996). Larter and Gates (1991) reported that shrubs comprised 50% of the Mackenzie wood bison herd's May diet. During June, the proportion of shrubs in the diet ranged from 10% to 35% and varied considerably between years. The greatest use occurred when sedges were not available. Waggoner and Hinkes (1986) reported that during June along the migration route, 94% of the bison diet in the Farewell herd was shrubs. Due to the topography in this area, bison movements are limited and there are few areas of grass or sedge. Larter and Gates (1991) reported that wood bison did not actively seek areas with the highest biomass of high-quality willow, but used willow opportunistically where available. M. Berger (pers. commun.) noted that the available biomass of sedges and grass in and around the meadows surveyed on the Yukon Flats was much higher than that of palatable willows.

High quality moose browse appears to be abundant on the Yukon Flats, as indicated by high moose calf weights and high twinning rates, and relatively low browsing intensity (Bertram and Vivion 2002; Stephenson 2002; Seaton in press; T. Seaton and C. Fleener, unpublished data). A comparison of moose browsing intensity on the Yukon Flats with other areas in Interior Alaska indicates that forage availability is not limiting population growth (Gasaway et al. 1983; Risenhoover 1987; Stephenson 2002). Most dietary overlap between moose and bison occurs during late spring/early summer when forage quality and quantity is highest and competition between species would be lowest. The amount of browse consumed during the spring by a wood bison herd at a minimum viable population level (recommended by Gates et al. 2001 at > 400 bison) would be small, would affect a relatively small area, and should not be detrimental to moose.

Potential for Indirect Effects on Wolf–Moose Relationships

FWS has questioned if the presence of wood bison would affect the wolf–moose relationship on the Yukon Flats. Their concerns are based on a hypothesis presented by Larter et al. (1994) who suggested that a large bison population could indirectly result in increased wolf predation on moose. They suggested that wolf numbers and predation rates on moose appeared to be higher, and moose numbers lower, in a portion of the Mackenzie Bison Sanctuary that supported about 1,900 bison compared to an adjacent area that supported about 550 bison.

In many areas in Alaska and northern Canada, moose populations are often maintained at low density equilibrium (0.2–1.0 moose/mi^2) due to wolf and bear predation (Gasaway et al. 1983, 1992). This situation can occur regardless if moose are the only ungulate species in an area or if other ungulate species are present and moose remain the preferred prey. Disease-free wood bison have not been found to be the preferred prey for wolves but wolves can be an important predator on bison, especially on calves (Oosenbrug and Carbyn 1985; Van Camp and Calef 1987; Carbyn and Trottier 1988; Larter et al. 1994). The hypothesis presented by Larter et al. (1994) suggests that moose continue to be the primary prey for wolves, while bison become alternate prey that allow wolf numbers to increase, resulting in yet higher predation on moose.

The Yukon Flats moose population has been at low equilibrium density since the 1970s, currently exists at 0.2–0.3 moose/mi^2, and appears to be limited by bear and wolf predation and harvest by humans. Wolves occur at low density on the Yukon Flats (4.4–5.4 wolves/1000 km^2), are lightly harvested, and are probably limited by food availability (Stephenson 2000). Evidence from areas where moose, bison, wolves and bears are present indicates that moose would continue to be the preferred prey for wolves on the Yukon Flats (Larter and Gates 1994; S. DuBois and J. Whitman, ADF&G, pers. commun.).

The conditions that would hypothetically be necessary to cause changes in wolf prey selection and increased predation on moose do not seem to occur during the first 15–20 years after wood bison are established in an area. Wolf predation on wood bison still has not been detected 15 years after their release in the Nisling River valley (B. Hayes, M. Oakley, Yukon Department of Environment, pers. commun.) and was not detected during the first 19 years in the Mackenzie Bison Sanctuary (Gates and Larter 1990). Both herds increased by at least 15% annually during these periods, suggesting low levels of predation. Few wolf kills have been documented in the 40-year history of the Farewell herd, which has numbered 300–400 bison since 1992 (Whitman and Stephenson 1998; Boudreau 2002). These studies indicate there is little interaction between wolves and bison when bison numbers are below 500 (Gates et al. 2001; Boudreau 2002; DuBois 2002) and are not limited by habitat (Gates and Larter 1990). Based on the empirical evidence, Gates et al. (2001) concluded that the potential for indirect effects of bison on moose or other ungulates can be mitigated by limiting bison population size.

Another factor that would determine how the presence of bison might affect wolf numbers is the number of packs that could be affected by an increased prey base. The range of a Yukon Flats wood bison population of about 400 animals would probably include about 700 mi^2, based on population behavior in Mackenzie Bison Sanctuary (Gates and Larter 1990). A range of this size would most likely include parts of only a few wolf pack territories. Burch (2002) reported an average home range of 886 mi^2 for wolf packs in nearby Yukon–Charley Rivers National Preserve, where moose density is similar to the Yukon Flats (0.3 moose/mi^2).

If wood bison were allowed to increase to high numbers (≥1,000) on the Yukon Flats and range expansion occurred including more wolf packs, there is evidence that the hypothesis outlined by Larter et al. (1994) would still not apply. Systematic moose surveys (Shank 1991; Bradley and Johnson 2000) conducted in Larter et al's. study area found no difference in moose densities between the two areas with different bison numbers which contradicts their hypothesis.

Predation on bison by black or brown bears has rarely been documented and does not appear to be a significant source of mortality for any bison herd, regardless of size. The existence of wood bison on the Yukon Flats is unlikely to cause changes in bear numbers or bear predation rates on moose.

Based on changes in moose composition within the range of the Yukon wood bison herd, the existence of wood bison on the Yukon Flats could eventually benefit the moose population indirectly by reducing hunting pressure on moose. The wood bison herd in southern Yukon numbers about 500 bison and hunting has been allowed since 1998. Moose density in that area was about 0.2 moose/mi^2 and was limited by predation and hunting. Harvest of cow moose was one of the factors limiting the population. The annual bison harvest quota is presently 80–100, with about 20 bison allocated to the First Nation. This has led to a reduction in the harvest of cow moose (B. Hayes, M. Oakley, Yukon Department of Environment, pers. commun.).

DISEASE ISSUES

The diseases of greatest concern in bison conservation are bovine tuberculosis, bovine brucellosis, and anthrax (Gates et al. 2001). Serologic and empirical evidence indicates that neither bovine brucellosis nor tuberculosis is present in Alaska. There are also no records of anthrax in Alaska. Wood bison are not known to harbor parasites that could adversely affect Alaskan wildlife. There is little reason to expect that wood bison might contract a pathogenic disease endemic to Alaska wildlife (ADF&G, 1994). *Brucella suis* biovar IV is serologically evident in various caribou herds and sometimes in other ungulates (Zarnke 1991). However, this disease does not appear to be pathogenic in bison, and is not a disease risk (Bevins et al. 1996).

The threat of introducing diseases in Alaska through importation of wood bison from Canada is minimal. Strict disease testing and health certification requirements would be followed (ADF&G 1994). There are certified disease-free sources for wood bison in Canada (Table 1) including Elk Island National Park in Alberta, Canada which has had been certified as disease-free for decades. Anthrax is not known to occur at Elk Island National Park (ADF&G 1994). Disease testing and disease-free certification are required for export by Elk Island National Park/Parks Canada and for import by the State of Alaska. Established and proven testing protocols for diseases are in place. As an additional precaution, bison could be treated with a broad-spectrum parasiticide (Ivermectin) before being transported. The effectiveness of this overall approach is proven with the establishment of six wild and several captive disease-free wood bison herds in Canada.

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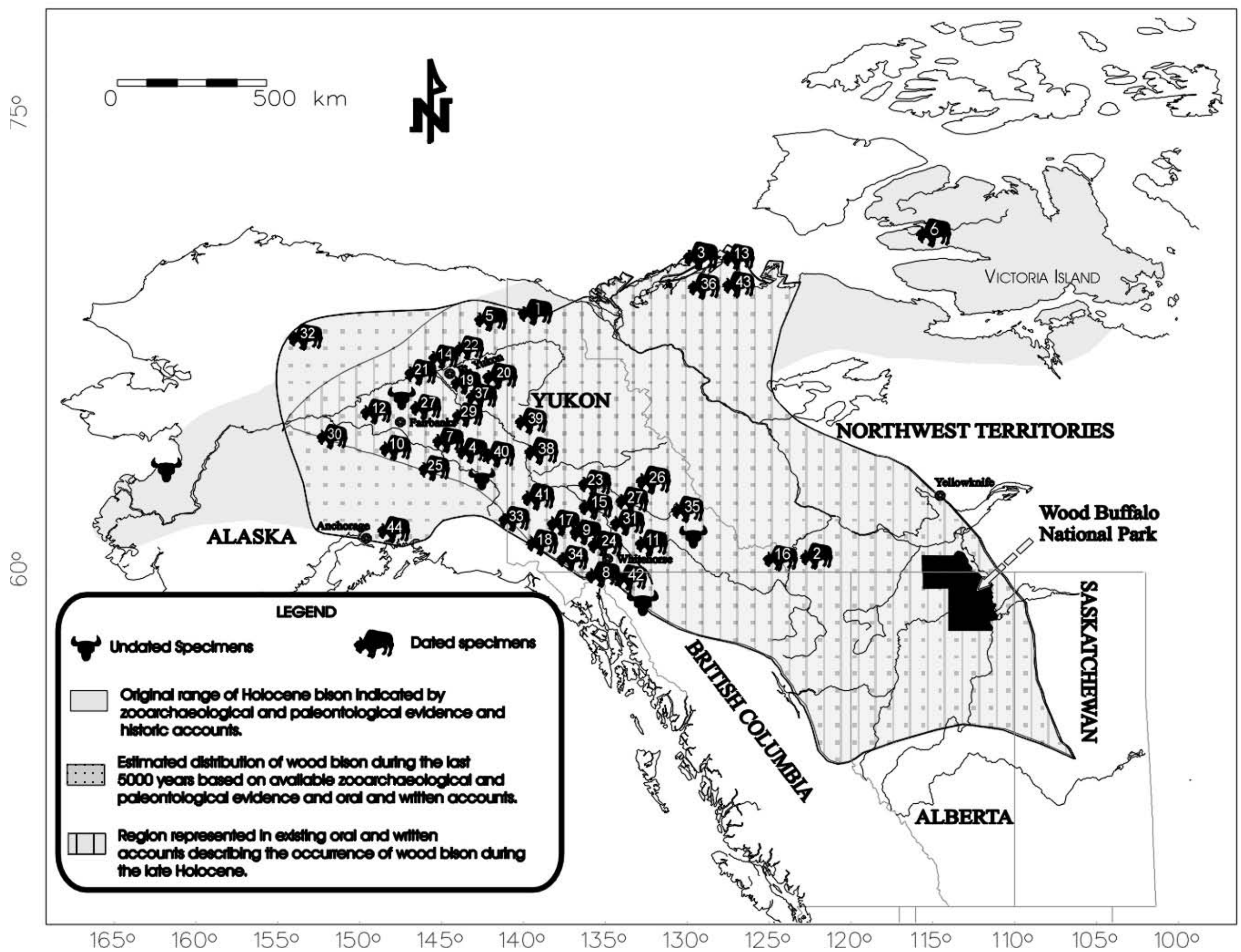

Figure 1. Approximate location of Holocene bison remains in Alaska and adjacent Canada, and estimated original and late Holocene range of wood bison in North America based on available zooarchaelogical, paleontological, oral and written historical documentation (Stephenson et al. 2001). Location numbers correspond to map numbers in Table 1. Figure does not include findings since 2001.

Table 1. Location and radiocarbon dates for bison specimens representing the end of the Pleistocene-Holocene transition or the Holocene in Alaska and adjacent Canada. Map numbers for specimens dated to within the last 10,000 years correspond with those in Figure 3. Most radiocarbon ages are corrected for isotopic fractionation. ***Note***: this table (from Stephenson et al. 2001) is being periodically updated. This version reflects additional radiocarbon dates for Holocene bison in Alaska and adjacent Canada, as well as late Pleistocene dates for the upper Yukon region. Dates added to the original table are in bold font.

Map No.	Location	Conventional Radiocarbon Age	Reference	Lab No.	Comments
	Black R. (Englishoe Bar), Yukon Flats, AK	**58,200±3900**	**B. Shapiro, *pers commun***	**OxA-11276**	**Bison radius**
	Black R. (Englishoe Bar), Yukon Flats, AK	**57,700±3200**	**B. Shapiro, *pers commun***	**OxA-11138**	**Male bison humerus**
	Black R. (Englishoe Bar), Yukon Flats, AK	**49,100±1700**	**B. Shapiro, *pers commun***	**OxA 11164**	**Bison tibia**
	Black R. (Cutoff), Yukon Flats, AK	**40,800±1600**	**B. Shapiro, *pers commun***	**OxA-11275**	**Female bison humerus**
	Black R. (Salmon Fork), eastern AK.	**37,590±660**	**S. Dickson, *pers. commun.***	**Beta-108404**	**Male bison skull and horn cores, vertebrae**
	Black R. (Englishshoe bar), Yukon Flats, AK	**36,500±2200**	**ADF&G, this study**	**AA- 49155**	**Female Bison horn core and cranium**
	Lower Rampart Cave, Porcupine R., AK	**21,050±320**	**Dixon 1984**	**DIC-1333**	**Bison metacarpal**
	Limestone Gulch, White Mts., AK	**13,300±160**	**R. Mills, BLM, *pers commun.***	**AA-44530** **AK-029-001-1**	**Bison tarsal found in small cave**
	Black R. (near mouth), Yukon Flats, AK	**12,425±45**	**B. Shapiro, *pers commun.***	**OxA-12067**	**Bison radius**
------	Old Crow, (Loc. 11-1), Y.T.,	11,990±180	Harington 1978	I-7765	Bison scapula
------	Fairbanks Creek, AK	11,980±135	Harington 1978	ST-1633	Bison bone
------	Old Crow, (Loc. 11-1), Y.T.,	11,990±180	Harington 1978	I-7765	Bison scapula
------	Birch Creek, Yukon Flats, AK	11,900±70	ADF&G, this study	Beta-67494	Female bison skull with horn sheaths
------	Cleary Creek, AK	11,735±130	Péwé 1975	ST-1631	Bison bone
------	Old Crow Flats, Y.T.	11,530±200	Harrington 1977	QU-780	Bison humerus
------	Broken Mammoth Site, Delta Junction, AK. Cultural Zone IV	11,510±120 11,420±70	Holmes 1996	WSU-4262 CAMS-5358	Bison bones with processing marks; associative charcoal dates at hearth site
------	Dry Creek, AK	10,715±225	Guthrie 1985	ST-1561	Bison bone
------	Lost Chicken Creek, AK	10,370±160	Harington 1978	I-8582	Distal portion of bison tibia, evidently modified by humans
------	Broken Mammoth Site, Delta Junction, AK. Cultural Zone III	10,290±70 10,270±110	Holmes 1996	CAMS-5357 WSU-4263	Bison bones with processing marks; associative charcoal dates at hearth site

Map No.	Location	Conventional Radiocarbon Age	Reference	Lab No.	Comments
	Bluefish Cave II (MgVo-2), Y.T.	10,230±140	Burke and Cinq-Mars 1998	RIDDL-561	Bison metacarpal at archaeological site
1	Engigstciak Site, Y.T.	9,870±180 9,770±180 9,400±230	Cinq-Mars et al.1991	RIDDL-362 RIDDL-281 RIDDL-319	Bison bones (tibia, metacarpal, and metatarsal) showing processing marks
2	Muskeg River, N.T.	9,645± 190	R. Harington, this study	I-9997	Bison cranial fragment
3	Cape Bathurst, N.T.	9,560± 60	R. Harington, this study	Beta-79861 CAMS-18424	Left scapula from bison
4	Gerstle River Site, AK	8,860±70	Potter (2001)	Beta-133750	Post-cranial remains of multiple bison in direct association with hearth features and artifacts.
5	Porcupine River, AK	9,000±250	UAF Museum, unpubl.	Beta-18552	Bison bone
6	Victoria Island, Minto Inlet, Kuujjua River, N.T.	8,080±60	R. Harington, this study	TO-3709	Partial male *B. bison* skeleton with cranium and horn cores
7	(a) Broken Mammoth Site, Delta Junction, AK. Cultural Zone II	7,600±140	Holmes 1996	WSU-4264	(a) Bison bones with processing marks; associative charcoal date at hearth site
	(b) Cultural Zone IA	2,260±40	D. Yesner*, pers commun*.	Beta-128716	(b) Bison naviculo-cuboid; associative charcoal date
8	Mt. Granger, Whitehorse, Y.T.	7,510±90	M. Hoefs, *pers. commun.*	Beta 135361	Female *B. bison* horn sheath from alpine ice patch
9	Canyon Site, Aishihik River, Y.T.	7,195±100	Workman 1974, Harington 1978	SI-1117	Fragments of bison bones around buried hearth; charcoal dated
10	Sullivan Pit, AK	6,730±260	Repenning et al. 1964	W-1108	Bison bone
11	**Porcupine R., Fort Yukon, Yukon Flats, AK**	**6,596±70**	**ADF&G, this study**	**AA-51505**	**Male *B. bison* horn core and cranium**
12	**Sucker R. - Porcupine R, Yukon Flats, AK**	**6,401±81**	**ADF&G, this study**	**AA-51506**	**Male *B. bison* horn core and cranium**
13	McIntyre Creek, Y.T.	ca. 5,840 ±70	G. Hare, this study	Beta 70100 CAMS-11243	Bison bone in association with cultural material
14	Goldstream Creek, AK	5,340±110	Péwé 1975	SI-845	Bison horn sheath
15	Harrowby Bay, Beaufort Coast, N.T.	5,230±200	Cinq-Mars 1991. Harington 1990	RIDDL-321	Metacarpal at archaeological site. Date from R. McGhee, Can.

Map No.	Location	Conventional Radiocarbon Age	Reference	Lab No.	Comments
					Museum of Civilization
16	Fort Yukon, Yukon Flats, AK	5,045±45	R.D. Guthrie, this study	AA4379, VP4157	Male *B. bison* skull
17	Carmacks, Y.T.	4,880±80	R. Harington, this study	Beta 25120	*B. bison* skull from terrace
18	Julian Site (JcRw-13), Fisherman Lake, N.T.	4,800±160	J.F.V. Millar, *pers. commun*.	S-0906	Bison bone at archaeological site
19	Canyon Site (JfVg-1), Y.T.,	4,730±320	MacNeish 1964	W-1125	Date from charcoal associated with bison bone
20	Kusawa Bluffs Site (JdVa-2), Y.T.	4,490±130	Greer 1986	Beta-14402	Date from elk bone located below bison bones in archaeological site
21	Black River, Yukon Flats, AK	4,495±60	ADF&G, this study	Beta 65662	Male *B. bison,* horn core and cranium
22	**JcVa-14, Sandpiper Ice Patch site, west of Whitehorse Y.T**	**4,660±40**	**R. Farnell, *pers commun.***	**Beta 152446**	**Mandible of immature bison**
23	Black River, Yukon Flats, AK	4390±70	ADF&G, this study	Beta 136731	Male *B. bison,* skull with horn sheaths
24	Porcupine R., Fort Yukon, Yukon Flats, AK	3,710±70	ADF&G, this study	Beta 74344	Female *B. bison* horn core and part of cranium
25	Porcupine R., Fort Yukon, Yukon Flats,AK	3,520±40	S.C. Gerlach, this study	Beta 104823	Male *B. bison* skull with both horn sheaths
26	Delta River Overlook Site (XMH-297), Delta Jct. AK	3,980±150 2,285±145	Holmes and Bacon 1982	GX-6752 GX 6750	Fragment of bison tibia at archaeological site; associative charcoal dates
27	**Friday Creek (FRI-99-19), Y.T.**	**3,500+/-60**	**R. Farnell, *pers commun***	**Beta-162359**	**Frozen bison dung from ice patch**
28	Ruby Range, Kluane District, Y.T.	3,470±70	M. Hoefs, *pers. commun.*	Beta 136362	Bison tibia at achaeological site
29	Pelly Farms Site (KfVd-2), Y.T.	3,100±70	MacNeish 1964	S-193	*B. bison;* associative charcoal date
30	Pelly Farms Site (KfVd-2), Y.T.	2,920±140	MacNeish 1964	GSC-127	*B. bison;* associative charcoal date
31	**Black River (Cut off), Yukon Flats, AK**	**3,069±42**	**ADF&G, this study**	**AA-49156**	**Male *B. bison* horn core and cranium**
32	**Friday Creek (YHB-01-56), Y.T.**	**2,840+/-60**	**R. Farnell, *pers commun***	**Beta-165096**	**Frozen bison dung from ice patch**
33	Fairbanks, AK (railroad	2,900±80	R.D. Guthrie, this study	AA3220, AMNH	Male *B. bison* skull

Map No.	Location	Conventional Radiocarbon Age	Reference	Lab No.	Comments
	terminal)			A-508-5331	
34	**Black R., (Cut-off), Yukon flats, AK.**	**2,776±36**	**B. Shapiro, *pers. commun.***	**OxA-11631**	**Male bison metacarpal**
35	Montague House, Y.T.	2,720 ± 60	G. Hare, this study	Beta 70101	Bison ribs
36	¾ mile downstream from Circle, Yukon Flats, AK	2,545±80	R.D. Guthrie, this study	AA3217, AMNH A-479-4783	Male *B. bison* skull
37	**Hadweenzic R., Yukon Flats, AK**	**2526±26**	**B. Shapiro*, pers commun***	**OxA-11989**	**Male bison metacarpal**
38	Lower Tanana River, AK	2,460±70	R.D. Guthrie, this study	Unknown	Male *B. bison* skull
39	Braeburn, Y.T.	2,460±40	M. Hoefs, *pers. commun.*	Beta 137731	*B. bison* skeleton in dry lake bed
40	**Lower mouth, Birch Creek, Yukon Flats, AK**	**2,415±25**	**B. Shapiro*, pers commun***	**OxA-11990**	**Male *B. bison* horn core and cranium**
41	Kluane Lake, (Congdon Creek) Y.T.	2,180±30	M. Hoefs, *pers. commun*.	Beta 91755	Male *B. bison* cranium
42	**Black R. (Englishoe Bar), Yukon Flats, AK**	**2,172±37**	**B. Shapiro, *pers commun***	**OxA-11248**	**Bison radius**
43	Takhini River, Y.T.	2,150±40	M. Hoefs, *pers. commun.*	Beta 91756	Male *B. bison* frontal
44	Finlayson River, Y.T.	2,130±60	R. Harington, this study	Beta-79854	Young male *B. bison* cranium
45	Baillie Islands, N.T.	1,890±90	Harington 1980	I-5407	Bison horn sheath
46	Black River, Yukon Flats, AK	1,730±60	ADF&G, this study	Beta 62999	Male *B. bison* skeleton
47	Dawson (Loc. 16), Y.T.,	1,545±85	Harington 1980	I-11051	Bison tibia, apparently fractured by humans
48	Quartz Creek, Dawson, Y.T.	1,430±95	Harington 1977	I-5404	*B. bison* horn core
49	Tetlin-Tanacross area, AK	1,270±55	R.D. Guthrie, this study	AA3218, AMNH A-393-1013	Male *B. bison* skull
50	Frenchman Lake Site (KaTx-6), Y.T.	<1250	J. Hunston, *pers. commun.*		Bison bone above White River Ash strata
51	Cowley Lake, Y.T.	940±90	R. Harington, this study	Beta 69762	Female *B. bison* skull
52	Old Horton River mouth, N.T.	420±65	Harington 1990 Morrison 1997	Beta-28765	Adult male *B. bison* skull, showing cut marks
53	**JeUx-16 Annie Ned Creek, west of Whitehorse, Y.T.**	**370±40**	**R. Farnell, *pers commun***	**Beta 152441**	**Bison molar at archeological site**
54	Anchorage, AK	170±30	S.C. Gerlach, this study	Beta 136732	Male *B. bison* skull with horn sheath

Map No.	Location	Conventional Radiocarbon Age	Reference	Lab No.	Comments
55	**Fort d'Epinette (Fort St. John), B.C. Canada**	**145±37**	**B. Shapiro, *pers commun***	**OxA-10579**	Bison bone

TABLE 2 Summary status of wood bison populations for 1978, 1987, 1999, and 2002

Herd Category/Herd name/Location	COSEWIC[a] 1978	COSEWIC[a] 1987	Recovery plan 1999	Current 2002
Wild, free-ranging herds				
Mackenzie Bison Sanctuary, NT	300	1718	1908	2000
Nahanni/Liard River, NT		30	160	170
Nisling River, YT		45[b]	500	530
Hay/Zama Lakes, AB		43[b]	130	234
Chitek Lake, MB			70	70
Nordquist Flats, BC			50	60
Subtotal:	300	1836	2818	3064
Captive breeding herds – Public				
Elk Island National Park, AB	100	256	350	350
Hook Lake Recovery, NT (for reintroduction)			65	122
Etthithun Lake, BC (for reintroduction)			43	43
Subtotal:	100	256	458	515
Captive Breeding Herds – Private				
Calgary Zoo, AB		3	-	-
Metro Toronto Zoo, ON		27	20	20
Moose Jaw Wild Animal Park, SK		37	-	-
San Diego Zoo, CA (USA)		9	9	9
Valley Zoo, AB		2	-	-
Alberta Wildlife Park, AB		44	-	-
Banff National Park, AB		13	-	-
Munich Zoo, Germany		9	9	9
Syncrude Canada Ltd., AB			150	150
LaPrairie Ranch, YT			50	
Waterhen Wood Bison Ranches Ltd., MB		106[c]	185	185
Subtotal:	0	250	423	373
TOTAL:	400	2342	3699	3952

[a] Committee on the Status of Endangered Wildlife in Canada.
[b] Captive herd established for reintroduction to the wild.
[c] Captive herd provided stock for Chitek Lake reintroduction to the wild.