National Recovery Plan
for the

WOOD BISON

(Bison bison athabascae)

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National Recovery Plan No. 21 **October 2001**

National Recovery Plan for the

WOOD BISON

(Bison bison athabascae)

prepared by
The National Wood Bison Recovery Team

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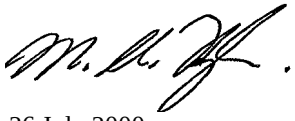
Approved: 

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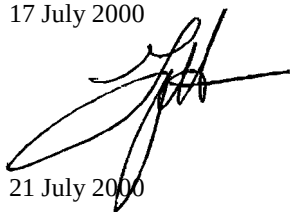
Approved: 

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Disclaimer

The National Recovery Plan for the Wood Bison was prepared by the Wood Bison Recovery Team in consultation with participants and observers to identify recovery actions that are deemed necessary, based on sound biological principles, to protect and recover the subspecies. It does not necessarily represent official positions of agencies and/or the views of all individuals involved in the plan's preparation. The goals, objectives, and recovery actions identified in the recovery document are subject to the priorities and budgetary constraints of participating jurisdictions and organizations, as well as modifications to accommodate new objectives or findings.

Acknowledgments

Planning the recovery of an animal with a long history of public interest and political controversy has benefited from the efforts of a wide variety of people. Numerous individuals and communities have contributed to the recovery and enlightened stewardship of wood bison. The Recovery Team recognizes the special contributions of Chief Harvey Nepinak of the Waterhen First Nation; Danny Beaulieu, Chief Don Balsillie, Maurice Boucher, Tom Unka, and Ron Boucher of the Deninu Kue' First Nation; Billy Schaefer of the Salt River First Nation; Harvey Denechoan and Angus Apannah of the Dene Tha First Nation; the Fort Providence Resource Management Committee; Vern Neal, advisor to Little Red River Cree and Tall Cree First Nations; the communities of the Yukon Flats, Alaska; Craig Fleener of Fort Yukon; and Dan Patten and Norm Moore of the Canadian Bison Association.

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Definition of Terms and Risk Categories

Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (November 2000)

SPECIES: any indigenous species, subspecies, variety, or geographically defined population of wild fauna and flora.
EXTINCT: a species that no longer exists.
EXTIRPATED: a species no longer existing in the wild in Canada, but occurring elsewhere.
ENDANGERED: a species facing imminent extirpation or extinction.
THREATENED: a species likely to become endangered if limiting factors are not reversed.
SPECIAL CONCERN (formerly "vulnerable"): a species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
NOT AT RISK (formerly "not in any category"): a species that has been evaluated and found to be not at risk.
DATA DEFICIENT (formerly "indeterminate"): a species for which there is insufficient scientific information to support status designation.

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Executive summary

Section I provides an introduction, current status and background information. The wood bison (*Bison bison athabascae*) was nearly extinct by the late 1800s. The history of the decline and subsequent conservation efforts is documented in the 1987 status report prepared for the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) by the Wood Bison Recovery Team and is summarized in this plan. The subspecies was designated as "endangered" by COSEWIC in 1978, and subsequent progress towards recovery resulted in its downlisting to "threatened" status in 1988. This recovery plan was prepared as part of a collaborative effort by the various range jurisdictions for wood bison in Canada and the United States under the umbrella of the Recovery of Nationally Endangered Wildlife (RENEW) Program.

Three conservation principles have been endorsed by the Recovery Team and are identified in the plan: 1) preserving intraspecific and biological diversity; 2) restoring and maintaining the interaction of wood bison with their natural environment to perpetuate evolution; and 3) promoting recovery efforts within original range.

Under the "Current status" section, factors that influence vulnerability and contribute to threatened status, a review of the current status of existing herds, and the role of wood bison in the ecosystem are presented. In 1999–2000, there were 2818 wood bison in six free-ranging, disease-free herds; 843 in six captive breeding herds; and 2939 in four free-ranging, diseased herds. There were also 500–700 wood bison on 45–60 private ranches in Canada and about 50 in a few zoos and wildlife parks; however, privately owned herds are not considered part of the recovery program. Only the Mackenzie and Yukon herds currently meet the minimum population objective for the recovery program. Continued management efforts are required to ensure that the recovery goal of four geographically separate herds of 400 in Canada is achieved.

Although wood bison are no longer considered to be in imminent danger of extinction, the scope for further recovery in the wild is constrained by a number of factors. The present abundance and distribution of wood bison in the wild may not be sufficient to ensure survival of the subspecies in the long term, although significant progress towards this goal has been made. The greatest single factor limiting range availability and the potential for further recovery of wood bison in Canada is the existence of bison herds in and around Wood Buffalo National Park (WBNP) that are infected with bovine brucellosis and tuberculosis. Eliminating these two bovine diseases from bison herds in the WBNP region would remove the greatest obstacle to the recovery of wood bison in Canada. This vast region includes some of the highest quality habitat for the subspecies, as well as being the core original range in Canada.

In Section II, "1. Recovery goals and objectives," the plan identifies four goals to advance the recovery of wood bison: 1) reestablish at least four discrete, free-ranging, disease-free, and viable populations of 400 or more wood bison in Canada, emphasizing recovery in their original range, thereby enhancing the prospects for survival of the subspecies and contributing to the maintenance of ecological processes and biological diversity[1]; 2) foster the restoration of wood bison in other parts of their original range and in suitable habitat elsewhere, thereby ensuring their long-term survival; 3) ensure that the genetic integrity of wood bison is maintained without further loss as a consequence of human intervention; and 4) restore

[1] In this report, "disease-free" means the absence of bovine brucellosis and bovine tuberculosis, "viable" means a herd of 400 or more wood bison, "discrete" refers to populations whose range does not overlap with that of other bison populations, and "free-ranging" means bison herds that forage in the wild, are not enclosed by fences, are not supplementally fed, and are subject to natural selection.

disease-free wood bison herds, thereby contributing to the aesthetic, cultural, economic, and social well-being of local communities and society in general.

In Section II, "2. General strategies," five primary strategies to achieve the plan's goals are identified: 1) continue to work towards resolution of the northern diseased bison issue; 2) undertake background studies and research to provide information needed to manage extant herds and reestablish additional free-ranging populations; 3) maintain the genetic integrity of free-ranging populations and augment genetic diversity, where possible, through salvage of disease-free bison from WBNP; 4) complete reintroduction projects where feasible — for example, in northwestern Northwest Territories and Alaska; and 5) garner public support for wood bison recovery through educational programs and develop cooperative management recovery projects with aboriginal people, other conservation groups, and resource development industries.

In Section II, "3. Stepdown outline," studies required to support recovery actions are identified. Cattle diseases are a major impediment to recovery. Assessing the feasibility of genetic salvage from brucellosis- and tuberculosis-infected herds is seen as an important research focus. Studies are required to assess the risk of infection of existing and future healthy populations and the risk to humans associated with infected herds. Because anthrax is a serious, although sporadic, problem in some northern ranges, research is required to develop field assays to detect environmental contamination with anthrax spores.

Studies are also required to evaluate the direction, rate, and extent of habitat change or loss resulting from competing land uses. Habitat enhancement may be feasible through the application of prescribed fire or water management. Wood bison are compatible with a variety of northern species and environments and coexist with them, as they have for millennia. However, studies can provide further insight into the relationships between wood bison, other large herbivores, and their predators.

Both plains bison and wood bison survived a period of extremely low numbers, or genetic "bottlenecks." Studies are required to evaluate genetic variation within and between populations, including free-ranging and captive breeding herds.

A major purpose of the recovery plan is to identify actions that will lead to the removal of wood bison from their status as a "threatened" species under COSEWIC. The recommended criterion for downlisting is the existence of at least four discrete, free-ranging, and viable populations of 400 or more wood bison, free of bovine brucellosis and tuberculosis, in Canada. The recovery plan addresses the broader issue of the recovery of the subspecies in other parts of its original range and the potential for establishing additional herds in suitable habitat elsewhere. In Section II, "Narrative for stepdown outline," management actions to address limiting factors while respecting conservation of biodiversity and human needs are identified. Ecological and sociopolitical management actions are recommended for implementation:

- enhancing habitat through prescribed fire, integrated land management, and reclamation;
- preparing contingency plans for a possible outbreak of disease in disease-free herds;
- establishing new disease-free populations;
- augmenting existing populations where feasible and necessary;
- maintaining disease-free captive breeding herds for source stock;
- establishing priorities for the transfer of wood bison from source herds;
- protecting disease-free populations from infection;
- establishing captive herds using bison salvaged from infected populations to augment the genetic diversity of bison in the national recovery program;
- reestablishing disease-free populations in areas that are currently occupied by infected bison;
- preventing further hybridization between wood and plains bison in the wild;
- encouraging development of a long-range plan to resolve problems associated with brucellosis and tuberculosis;
- developing management plans that integrate conservation and recovery values with the needs of aboriginal and rural communities; and
- fostering recovery of disease-free wood bison in the Caribou–Lower Peace river area in Alberta.

The Recovery Team supports current efforts to reintroduce wood bison to Alaska and to evaluate the potential to establish wood bison in eastern Siberia. Wood bison closely resemble and are the closest living relatives of the last bison to occur in eastern Siberia. However, additional studies are needed to determine taxonomic relationships between Holocene bison in North America and Siberia before wood bison are released to the wild in Siberia. The Alaskan and Siberian initiatives are particularly important to wood bison conservation in view of the limited availability of habitat for wood bison in Canada and the risk of infection of Canadian herds with cattle diseases. They represent additional opportunities to secure the survival of the subspecies in geographically separate

populations and to augment Canada's participation in international efforts to conserve species at risk. A wood bison recovery project in Alaska would be consistent with the international agreement, "Framework for Cooperation between Environment Canada and the U.S. Department of the Interior in the Protection and Recovery of Wild Species at Risk," signed in April 1997.

Progress towards recovery will require periodic monitoring of the status and trend of populations and the availability of habitat in relation to land use and development. The recovery plan provides an implementation schedule (Section III) as a guide for monitoring recovery activities and funding of recovery measures. The plan and implementation schedule should be reviewed on an annual basis to evaluate progress and to update activities according to changing circumstances. Implementing the recovery plan will require an estimated $3 009 500 and 51.6 person-years over five years, as identified in the implementation schedule (Section III).

Section I
Introduction/species' background/status evaluation

1. Introduction

Like the plains bison (*Bison bison bison*), wood bison (*B. b. athabascae*) were nearly eliminated during the late 1800s. The history of their near extinction and subsequent conservation efforts is documented in the 1987 status report on wood bison (Wood Bison Recovery Team 1987) and is summarized below. The Wood Bison Recovery Team prepared the status report for the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). In 1978, COSEWIC designated wood bison as "endangered." Progress towards their recovery during the subsequent decade resulted in wood bison being downlisted to "threatened" status in 1988, based on information provided in the 1987 status report.

Although wood bison are no longer in imminent danger of extinction, the scope for further recovery in the wild is constrained by a variety of factors. In view of their limited abundance and the small number of well-established wild populations, continued efforts are required to ensure survival of the subspecies. The status of wood bison in Canada is reviewed, management needs are identified, concerns and problems related to conservation are assessed, and actions necessary to secure the future of the subspecies are recommended in this recovery plan.

Activities prescribed in the recovery plan are consistent with principles embraced in "A Wildlife Policy for Canada" (Environment Canada 1990), the World Conservation Strategy for Canada (Pollard and McKechnie 1986), and the World Conservation Strategy of the International Union for Conservation of Nature and Natural Resources (IUCN 1980), as well as with guidelines established by the IUCN for reintroducing indigenous species to original range (IUCN 1987). The following conservation principles as endorsed by the Recovery Team are embodied in the recovery plan:

1) The preservation of intraspecific diversity as a part of conservation of biodiversity is paramount. The genetic integrity/separation of wood and plains bison should be maintained. All management and conservation actions should be consistent with this principle.
2) All biological attributes of a subspecies, be they genetic, morphological, or behavioural, are molded through natural selection by a particular set of environmental factors that characterize its geographic range. Ways to restore interactions between wood bison and their natural environment, allowing for continued evolution, are outlined in the recovery plan.
3) Recovery of either subspecies of bison in the wild should be effected primarily in suitable habitat within its original geographic range, secure from factors that might threaten the long-term survival and well-being of populations. Wood bison may be introduced in suitable habitat outside their original range when such introduction does not conflict with the conservation of other taxa.

2. Current status

A. Factors influencing vulnerability and contributing to threatened status

I. Biological considerations

a. Historical status

The original range of wood bison included northern Alberta, northeastern British Columbia, a small portion of northwestern Saskatchewan, the western Northwest Territories, Yukon, and much of Alaska (Skinner and Kaisen 1947; Harington 1977; van Zyll de Jong 1986; Guthrie 1990; Stephenson et al. 2001). Populations persisted in the area south of Great Slave Lake in Canada, but wood bison were extirpated in other parts of their range. There is also evidence that modern forms similar to

wood bison occurred in eastern Siberia during the mid to late Holocene (Flerov 1979; van Zyll de Jong 1993; Lazarev et al. 1998).

Written accounts by Europeans travelling in northwestern Canada during the late 18th and early 19th centuries (Gates et al. 1992) led van Zyll de Jong (1986: 51) to suggest that the "historic" range for wood bison included northern Alberta, the southwestern Northwest Territories, and parts of northeastern British Columbia and northwestern Saskatchewan, noting that "the exact boundaries of the historical distributional range of *B. b. athabascae* cannot be determined at present on the basis of the available information." The recent distribution of bison, particularly in the region in Canada where wood and plains bison populations may have overlapped, was pertinent to van Zyll de Jong's (1986) study of the taxonomic status of recent bison. Based on the occurrence of six subfossils and three accompanying radiocarbon dates in the region, van Zyll de Jong (1986: 51) suggested that the "prehistoric" range of wood bison extended "north and west into the Yukon and Alaska."

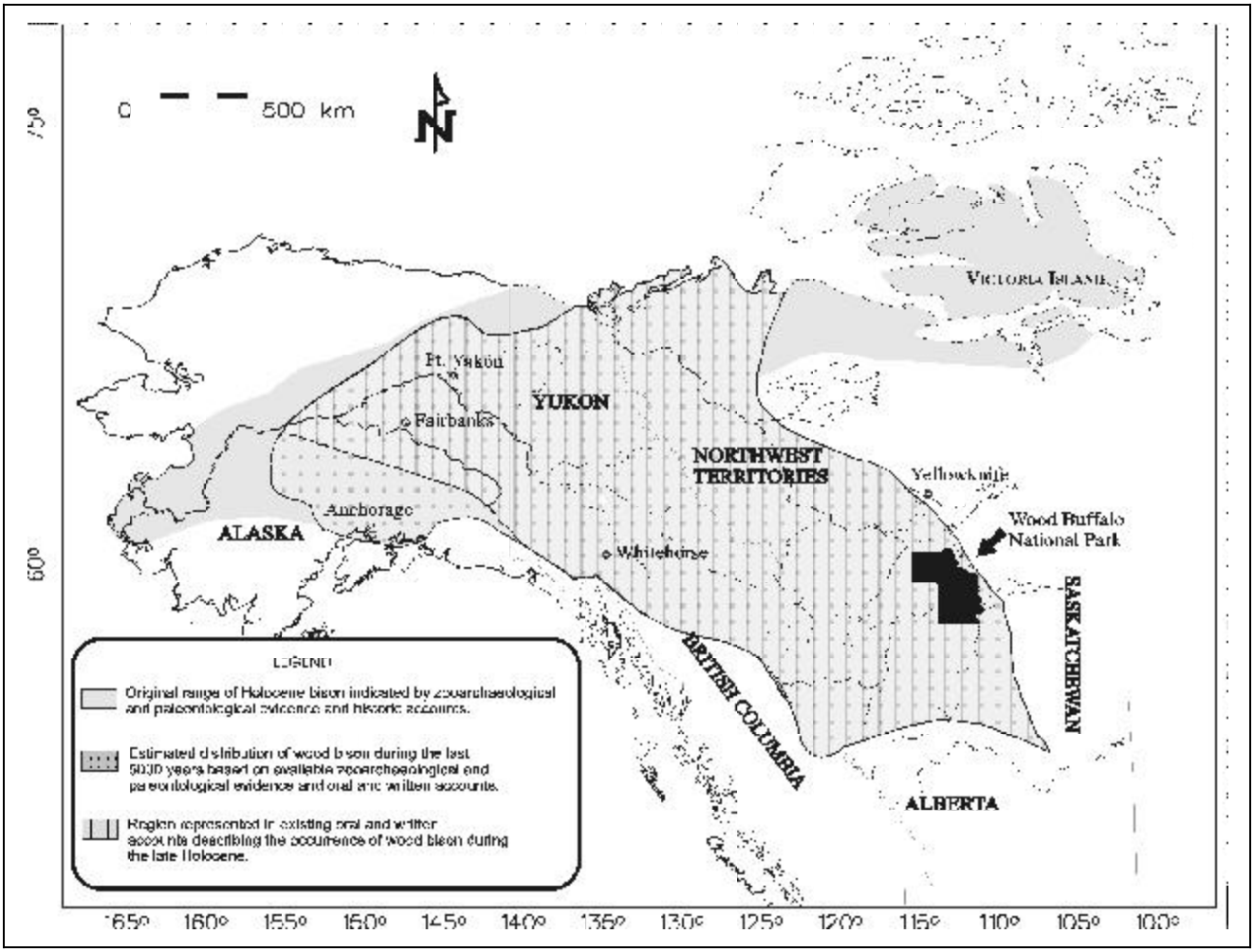
In 1987, the Recovery Team, of which van Zyll de Jong was a member, described a large part of interior and western Alaska as "prehistoric" range for wood bison (Wood Bison Recovery Team 1987). In 1992, the Recovery Team reviewed additional subfossil evidence (Harington 1990) and revised the boundaries of the original range to include a larger area in northern Alaska and Canada. Additional information regarding the original distribution of wood bison has become available since 1987, including oral accounts from Athabascan elders in Alaska and First Nations elders in Yukon and the Northwest Territories, additional written documentation, and skeletal remains from archaeological and paleontological locations (Lotenberg 1996; Stephenson et al. 2001). The available information indicates that the original range of wood bison in North America encompassed a large area northwest of the previously designated "historic range," including much of Alaska, Yukon, and the western Northwest Territories (Figure 1). Oral narratives obtained from aboriginal people, as well as radiometric data from bison remains, indicate that bison were present in Yukon and Alaska during the last few hundred years and persisted in small numbers into the early 20th century (Lotenberg 1996; Stephenson et al. 2001), similar to areas in northeastern British Columbia and southwestern Northwest Territories (Gates et al. 1992). In view of the historic documentation and physical evidence demonstrating that wood bison inhabited this region for several thousand years, the area properly constitutes "historic" range. However, we suggest that in the absence of objective and biologically meaningful criteria, the dichotomy between "historic" and "prehistoric" range is not useful for the purposes of conservation and recovery. Future discussions should recognize the continuum of history and avoid this artificial distinction, which unnecessarily confounds an understanding of the past, including the history of recent bison. The Recovery Team employs the term "original range" to represent this concept.

The history of Holocene bison in northern Eurasia is less well known. However, bison in both Eurasia and North America underwent parallel evolution from large- to small-horned forms, and skeletal remains suggest that bison similar to wood bison occurred in northern Asia during the mid Holocene (van Zyll de Jong 1993) and possibly later (Rusanov 1975; Archipov 1989). Additional research on the occurrence of small-horned forms could further clarify the history and taxonomic status of Holocene bison in northern Eurasia.

Wood bison were probably never as numerous as plains bison, although they inhabited a vast region in the boreal forest biome during the late Holocene. The accounts of several early explorers refer to wood bison as being "very plentiful" and "reasonably numerous," with "no doubt as to their abundance" (Soper 1941). Soper (1941) estimated that the total population of wood bison in 1800 was about 168 000 animals, based on an estimate of carrying capacity within the area thought to be inhabited during the early European exploration period.

Wood bison were nearly eliminated from their remaining range in Canada during the late 1800s, coinciding with the rapid decline of plains bison between 1840 and 1900 (Raup 1933). The most rapid depletion took place after 1860 (Soper 1941). In 1888, the total population was estimated at between 500 and 600 animals (Schultz 1888). By 1891, only 300 wood bison remained in the wilderness between Great Slave Lake and the Peace–Athabasca Delta (Ogilvie 1893). The population reached an estimated low of approximately 250 during 1896–1900 (Soper 1941). After 1900, wood bison were occasionally observed throughout their range in Canada, but numbers were insignificant except in the Slave River lowlands (SRL) and the area designated later as Wood Buffalo National Park (WBNP). One of the last bison reported in northeastern British Columbia was shot in 1906 (MacGregor 1952). Lotenberg (1996) cites Clarke (c. 1945), who stated that Indians killed a bull at Lower Post BC in 1939. Heavy exploitation following the advent of the fur trade played a major role in the decline of wood bison in Canada (Gates et al. 1992).

Figure 1: Original and late-Holocene range of wood bison in North America, based on available zooarchaeological, paleontological, oral, and written historical documentation (adapted from Stephenson et al. 2001)



Early conservation efforts began in 1877 with the passing of the *Buffalo Protection Act* (Hewitt 1921). However, this measure was largely ineffective because of a lack of enforcement. Legislation was reinforced in 1893, when the government of the Dominion of Canada passed a law protecting the surviving bison (Soper 1941). Enforcement of this legislation was minimal until 1897, when the enforcement mandate was assigned to the Northwest Mounted Police. The first police outpost was established at Fort Fitzgerald on the Slave River in 1907, when formal patrols of the region began. In 1911, six Buffalo Rangers were appointed to patrol the remaining range of the wood bison. The wood bison population increased slowly to approximately 500 by 1914 (Banfield and Novakowski 1960).

In 1922, WBNP was established by an Order-In-Council under the *Forest Reserves and Parks Act*, in an attempt to save the wood bison from extinction and to protect its habitat (Soper 1941; Lothian 1979). The total number of wood bison on the southern range at that time was estimated at between 1500 and 2000 (Siebert 1925; Soper 1941).

In 1905, the largest privately owned herd of plains bison in North America was threatened by the loss of grazing rights. Following negotiations between the Canadian government and the owner, 410 plains bison were purchased from the Pablo-Allard herd and shipped from Montana to Elk Island National Park (EINP) in 1907 (Lothian 1981). On completion of the newly enclosed Buffalo Park at Wainwright, Alberta, in 1909, 325 plains

bison from EINP, 218 plains bison from the original herd in Montana, and 77 plains bison from the exhibition herd in Banff were brought to Wainwright (Lothian 1981). Additional shipments over the next five years brought the total number of plains bison introduced at Wainwright to 748. A census of the Buffalo Park herd in 1913 indicated 1188 plains bison; by 1923, the herd had increased to 6780, leading to range depletion and overcrowding.

Buffalo Park administrators proposed a phased slaughter to control the herd, but the plan received intense public criticism and was temporarily abandoned. A more acceptable solution involved shipping surplus animals north to the recently created WBNP (Graham 1924). From 1925 to 1928, 6673 young plains bison were transported by rail from Wainwright to the Waterways railway terminus at Fort McMurray, Alberta. They were then taken by barge down the Athabasca and Slave rivers to Wood Buffalo Park near Hay Camp (Lothian 1981). Surviving bison were released at several sites along the west bank of the Slave River, south and north of Hay Camp, in range that was occupied by wood bison (Soper 1941). Fatal injuries were common, and the number of animals successfully released into WBNP was substantially lower than the number shipped (W. Schaefer, Salt River First Nation, pers. comm.).

The introduction of plains bison into wood bison range was challenged by the American Society of Mammalogists (Howell 1925) and by individual biologists (Harper 1925; Saunders 1925). They believed interbreeding would result in the loss of both subspecies of bison and that the wood bison population would become infected with tuberculosis, which was known to be present in the Wainwright herd.

The number of bison in WBNP increased to an estimated 12 000 by 1934 (Soper 1941), and wolf control was used to maintain the population at this level until the late 1960s. Raup (1933) speculated that the wood buffalo “as a race” was rapidly disappearing, but suggested that an intact northern herd still existed. In 1959, five specimens were collected from a herd of about 200 animals near the Nyarling River (NR) and were determined by Banfield and Novakowski (1960) to be morphologically representative of wood bison. The taxonomic affiliation of bison in other parts of the region was not studied until the 1990s (van Zyll de Jong et al. 1995; Wilson and Strobeck 1999).

During the winter of 1963, 77 wood bison were captured at Needle Lake in northwestern WBNP to establish a captive breeding herd near Fort Smith, Northwest Territories. After being tested for diseases, 19 bison were transported to a holding corral near Fort Smith. In June 1963, a second outbreak of anthrax occurred among free-ranging bison north of the holding facility, and a decision was made to transfer the captive herd to an uninhabited area several hundred kilometres away on the west side of Great Slave Lake. In August, four adult males, 10 adult females, and four calves were moved to the Mackenzie Bison Sanctuary near Fort Providence to establish a free-ranging herd. This small nucleus increased to become the largest wood bison herd that is free of bovine brucellosis and tuberculosis.

A second roundup of wood bison was held in northern WBNP in 1965. Twenty-one of 47 animals captured were successfully transferred to EINP in central Alberta. Two additional calves were transferred to EINP between 1966 and 1968. The translocated stock carried bovine tuberculosis and brucellosis. However, by 1971, a rigorous management protocol involving isolation and quarantine of neonates and elimination of all original stock had eradicated these diseases. The EINP breeding herd has since provided disease-free founding stock for six free-ranging populations, several captive breeding herds, including zoo and park herds, and private commercial herds.

A third salvage and recovery project was initiated in 1996. Over a three-year period, 62 newborn calves were captured from the Hook Lake herd in the SRL. The calves were maintained in enclosures near Fort Resolution and treated prophylactically for exposure to tuberculosis and brucellosis. One calf tested positive for tuberculosis (caudal fold test) in February 1997. This calf and its pen mate were slaughtered. Histopathological studies on the positive calf showed a minute lesion in a lymph node containing acid-fast bacteria, but mycobacteria could not be cultured. In 1999, there were 58 surviving wood bison in the captive population and seven calves born in captivity. The ultimate goal of this recovery effort is to restore a disease-free population in the Hook Lake area.

The establishment of a wild population near Fort Providence and a captive population at EINP represented the first major strides towards the recovery of wood bison in Canada. In 1973, representatives of the Canadian Wildlife Service (CWS), Parks Canada Agency, and territorial and provincial wildlife management agencies in western Canada began meeting annually to coordinate recovery efforts for wood bison. In 1975, these entities established a primary objective of establishing at least three free-ranging herds in historic range. The establishment of captive breeding herds in zoos and wildlife parks was a secondary objective, providing further protection against extinction.

Wood Bison

In 1987, the Wood Bison Recovery Team set a recovery goal of four herds of 200 or more wood bison (Wood Bison Recovery Team 1987). The Recovery Team has revised this goal to include four free-ranging populations of at least 400, which is the number currently thought to represent a minimum viable population (MVP).

b. Current abundance and distribution

Wood bison herds fall into four categories: free-ranging herds not infected with cattle diseases; free-ranging herds infected with bovine tuberculosis and brucellosis; captive breeding herds under public ownership; and captive herds under private ownership. With one exception, captive herds are classified as disease-free. A captive herd near Fort Resolution is the result of an effort to salvage wood bison from the diseased Hook Lake herd for the purpose of establishing a disease-free captive breeding herd and subsequently to reestablish a free-ranging disease-free herd. It will be maintained under quarantine until disease-free status is clearly demonstrated through testing.

In 1999–2000, there were approximately 2818 wood bison in six free-ranging, disease-free herds, 843 in six captive breeding herds, and 2939 in four diseased, free-ranging herds (Figure 2, Table 1). In addition, there are 500–700 wood bison on 45–60 private ranches in Canada and about 50 in a few zoos and wildlife parks. However, privately owned commercial herds are not regarded as contributing to the recovery program unless they are linked directly to conservation projects.

1. Public herds (free-ranging populations)

Mackenzie population

The Mackenzie population was established in 1963 with the transfer of 18 animals to an area northeast of Fort Providence. It has developed into the largest free-ranging population of disease-free (free of bovine tuberculosis and brucellosis) wood bison (Tessaro et al. 1992). During 1963–1987, the Mackenzie population increased at an average exponential rate of r = 0.215 (Gates and Larter 1990). During much of this period, the herd's range expanded at a rate commensurate with population growth and currently encompasses an area of approximately 13 000 km^2. At its initial peak in the late 1980s and early 1990s, the Mackenzie herd numbered approximately 2000 (Gates et al. 1991; Larter et al. 1993). In 1996, the population estimate was 1328 ± 138 bison (C. Gates, NWT Resources, Wildlife and Economic Development, pers. comm.). The rate of growth declined as a result of factors including wolf predation, anthrax, flooding in some key habitat, and habitat availability (Larter et al. 1993; Gates et al. 1995). Currently, the herd is stable to increasing: population size in March 1998 was estimated as 1908 ± 201 (J. Nishi, NWT Resources, Wildlife and Economic Development, pers. comm.).

The Mackenzie herd is monitored annually for the presence of brucellosis and tuberculosis, based on blood samples collected by hunters and examination of hunter-killed animals. No evidence of these diseases has been found, and the herd is considered to be disease-free (Tessaro et al. 1992).

Yukon population

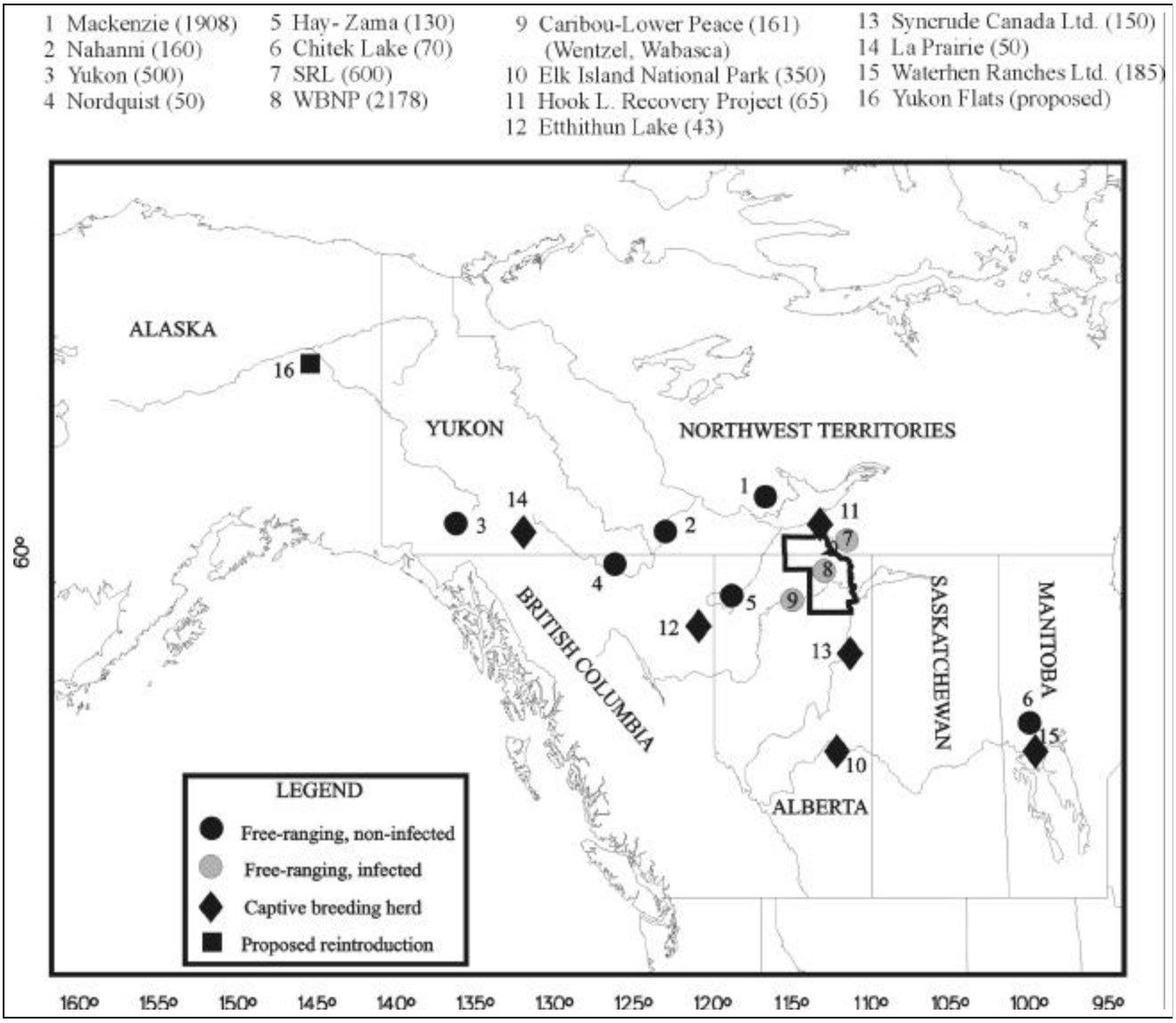
A habitat assessment indicated the valleys of the Nisling River and its tributaries, located 80–160 km west of Carmacks, Yukon, could support at least 400 wood bison (Reynolds 1982). In March 1986, 34 wood bison from EINP were released in a 5-km^2 enclosure. In addition, 10 wood bison calves were obtained from Moose Jaw Wild Animal Park in 1989 and 50 wood bison were transferred from EINP in 1990. A three-year commitment to the Yukon reintroduction project was fulfilled in March 1992, when a total of 48 additional wood bison were transferred from EINP and the Metro Toronto Zoo.

Twenty-one wood bison were released to the wild in March 1988, followed by additional releases in March of each year until 1991. A fifth and final release in the summer of 1992 brought the total number of bison released to 170. Thirty-six wood bison from several releases moved south to the Alaska Highway, creating a traffic hazard. They were captured in 1996 and moved to a farm approximately 70 km west of Whitehorse. An agreement between the operator and the Yukon government stipulates that the same number and sex ratio of bison removed from the wild are to be returned to the government within five years. This agreement has lapsed and is currently in dispute. The Yukon herd numbered about 350 in March 1998 and 450 in late winter 1998–1999 and exceeded 500 in 2000. The Yukon Bison Management Plan outlines long-term measures to maintain a herd of approximately 500 wood bison (Government of Yukon 1998).

Chitek Lake population

A free-ranging herd of wood bison was established in the northern Interlake region of Manitoba in April 1991, when 13 wood bison were released near Chitek Lake, north of the Waterhen Wood Bison Ranch. Nine additional animals (seven females and two males) were released in January 1993. This stock was obtained from the captive wood bison herd at Waterhen. The herd has remained within 30 km of the release site, except for one immature bull that

Figure 2: Distribution of captive breeding and free-roaming wood bison herds in Canada and the location of a proposed reintroduction in Alaska (numbers provide a cross-reference to the following list of herds and locations)



returned to the Waterhen enclosure in August 1991 and a mature bull that travelled 60 km to Salt Point in June 1996. The free-ranging herd increased from 31 animals in July 1995 to 50 by December 1996. Fifty- six bison were observed in one group in early 1998. Fixed-wing aerial surveys were conducted in November 1998 (53 bison including 12 calves were observed) and in February 1999 (47 bison observed). The winter 1999–2000 population was estimated to be approximately 70. The area has the potential to support 400–500 wood bison.

The Province of Manitoba and the Waterhen First Nation manage the Chitek Lake herd cooperatively. Prescribed fire is used periodically to maintain and improve grazing habitat. Severe winter weather in 1995–1996 and 1996–1997 did not appear to adversely affect the herd. However, supplemental food was provided during the winter of 1995–1996, and supplemental minerals and salt were provided in 1998 and 1999.

Wood Bison

Table 1
Status, trend, and potential of free-ranging and captive breeding wood bison herds in Canada

Public herds (free-ranging, not exposed to/infected with tuberculosis and brucellosis)

	Status	Year of estimate	Trend	Estimated year at MVP	Potential or desired population	Source of stock	Year established	Number released
Mackenzie	1908	1998	Increasing	Achieved	2000	NR[1]	1963	18
Yukon	500	2000	Increasing	Achieved	500	EINP[2]	1988–1992	170
Hay/Zama	130	2000	Increasing	2003	250	EINP	1993	49
Nahanni	160	1998	Increasing	2015	>200	EINP	1980–1989	40
Nordquist	50	2000	Decreasing	?	>200	EINP	1995	49
Chitek Lake	70	2000	Increasing	?	>400	EINP	1991–1993	22
Subtotal	2818							

Public herds (free-ranging exposed to/infected with tuberculosis and brucellosis)

	Status	Year of estimate	Trend	Estimated year at MVP	Potential or desired population	Sourcce of stock	Year established	Number released
SRL[3]	600	1998	Stable or decreasing	N/A	1500	Indigenous+ plains	1930s	
WBNP[4]	2178	1998	Decreasing	N/A	>3000	Indigenous+ plains	Indigenous and 1925–1928	
Caribou Mts.–Lower Peace								
Wentzel	110	1998	?	N/A	?	Indigenous+ plains	?	
Wabasca	51	1996	?	N/A	?	Indigenous+ plains	?	
Subtotal	2939							

Captive breeding herds (public and co-managed)

	Status	Year of estimate	Trend	Ownership	Desired population	Source of stock
EINP	350	2000	N/A	Public	350	NR
Hook Lake Recovery	65	1999	Increasing	Co-managed	150	SRL
Etthithun	43	2000	Increasing	Public	150	EINP
Subtotal	458					

Captive breeding herds (privately owned with conservation objectives)

	Status	Year of estimate	Trend	Ownership	Desired population	Source of stock
Syncrude Canada Ltd.	150	1999	N/A	Private	1200	EINP
LaPrairie Ranch	50	1998	N/A	Private	?	Yukon
Waterhen Wood Bison Ranches Ltd.	185	1995	N/A	Private	200	EINP
Subtotal	385					

[1] NR = Nyarling River.
[2] EINP = Elk Island National Park.
[3] SRL = Slave River Lowlands.
[4] WBNP = Wood Buffalo National Park.

The Province of Manitoba established a management area in the Chitek Lake region to protect wood bison and their habitat. The wood bison is a protected species under the *Manitoba Wildlife Act*.

Hay-Zama population

A program to reestablish wood bison in northwestern Alberta was initiated in 1981 in cooperation with the Dene Tha First Nation. A 3-km^2 holding corral was constructed in the vicinity of Hay-Zama Lakes, and 29 wood bison were transported to the site in February 1984. Flooding and severe winter weather resulted in the need for supplemental feeding. Poor reproduction and calf survival limited growth of the captive herd. In April 1989, there were 35 wood bison in the enclosure. Although initially scheduled to occur in 1988, the reintroduction of wood bison to northern Alberta was postponed until 1993 because of the risk of infection with bovine tuberculosis and brucellosis from free-ranging bison in and around WBNP.

The herd, then numbering 48, became free-ranging after portions of the fence collapsed in 1993. It remained in the vicinity of Hay-Zama Lakes. The population steadily increased from 58 animals in early winter 1994 to approximately 100 in March 1999 (Morton 1999). By winter 1999–2000, the herd was estimated at 130. Wood bison from the Hay-Zama herd occasionally wander into the Hay River drainage in northeastern British Columbia.

The Government of Alberta established a 36 000-km^2 management area in the northwestern corner of the province, within which wood bison are protected. This area has the potential to support at least 400 wood bison. However, the herd will be maintained at between 250 and 400 animals until the WBNP disease issue is resolved. Bison that occur between the designated bison management zone and WBNP are not protected from hunting, making the area a buffer zone and reducing the potential for disease transmission. With the exception of the bison management area, bison elsewhere in the province are designated as "livestock" in the *Alberta Wildlife Act.*

Nahanni population

In 1980, 28 wood bison were transported from EINP to the Nahanni Butte area, located near the Mackenzie Mountains in the southwestern Northwest Territories. These animals were not held at the site, but were released directly to the wild. The herd became fragmented, with some animals dispersing more than 250 km into British Columbia. Accidental deaths caused the herd to dwindle to 14 in 1981. The population subsequently increased by about 10% annually, reaching approximately 40 bison in 1989. In March 1989, the herd was augmented with 12 wood bison (nine females, three males) from Moose Jaw Wild Animal Park in southern Saskatchewan (EINP wood bison from Nyarling parent stock). Four calves were seen in the newly released group in July 1989. In January 1992, 18 bison were observed during an aerial survey near Nahanni Butte and 37 were observed along the Liard River as far south as La Joli Butte in northeastern British Columbia, indicating a total population of at least 55 bison. Surveys in 1995 and 1996 enumerated 65 and 70 bison, respectively, and 102 were counted in July 1997. The Nahanni herd was supplemented with 61 additional wood bison from EINP in March 1998, at least 17 of which dispersed south towards Fort Nelson, British Columbia. The remaining animals appear to have joined the resident herd. In 1998, the total population was estimated to include 160 bison.

The Nahanni population tends to occur in small and widely scattered groups. They are commonly seen in atypical winter habitat, including riparian balsam poplar forest, and mixed spruce–hardwood forests on islands in the Liard River. The group released in 1989 uses typical bison habitat near Nahanni Butte, consisting of a few small wet and mesic meadows. Encroachment by willows has reduced the size and quality of these meadows, and habitat may limit the herd to a level below the number estimated to represent the MVP. However, the Nahanni and Nordquist populations are likely to merge in the future, eventually resulting in a population of 400 or more bison.

Nordquist population

Wood bison were first reintroduced to British Columbia in March 1995. Forty-nine wood bison (four adult males, five adult females, five yearling males, 10 yearling females, 10 male calves, and 14 female calves) were transferred from EINP to Aline Lake in the Nordquist Flats area in the Upper Liard River Valley, British Columbia, to establish a free-ranging herd. The site is approximately 80 km from the southern part of the Nahanni herd's range along the Beaver River. Bison were held in a temporary facility for two months, to allow them to become habituated to the area prior to a "soft release." A habitat inventory in 1988 identified large upland areas where the biomass of graminoids was between 500 and 900 kg/ha, and a limited number of wet meadows provided approximately 6300 kg/ha of sedge biomass (Elliott 1989). Prescribed fire has been used to improve wildlife habitat in this area in the past and will likely be required in the future to maintain

and improve bison grazing habitat. Thirty-six bison were counted prior to calving in 1996, and in 1999 the Nordquist herd was estimated to include 50 animals.

The Nahanni and Nordquist herds are eventually expected to coalesce. The combined herd will be managed to reach a population objective of at least 400 wood bison. If the Nordquist herd fails to increase, the Government of British Columbia will assess whether the province's objectives for wood bison can be met through more intensive management, such as prescribed burning, augmenting the herd with additional stock, or reintroducing wood bison at alternative sites where suitable habitat has been identified. Other management issues pertain to logistic difficulties related to monitoring, predation, and egress of animals to the Alaska Highway corridor near Liard Hot Springs. Restoring access to the site to allow augmentation of the herd may increase the likelihood of egress. The Province of British Columbia has identified wood bison recovery as a high priority, and managers are seeking sufficient funding for bison conservation. The goals for wood bison in British Columbia, as stated in the management plan, are to continue to reestablish herds through translocation, to maintain their separation from plains bison, to maintain their disease-free status, and to allow the population to increase to a level sufficient to support nonconsumptive and consumptive use (Harper et al. 2000).

2. Public herds (captive breeding populations)

Elk Island National Park population

The EINP wood bison herd has played a key role in the recovery of wood bison in Canada, providing stock directly or indirectly for the establishment of six wild populations. It has also contributed stock for five co-managed captive herds and seven zoo herds. In 1971, after an intensive four-year disease eradication program, the herd was declared free of bovine brucellosis and tuberculosis. The pre-calving population in 2000 was 350. The herd is semi-wild, is fenced in a 65-km^2 area, relies on natural forage, and interacts with its environment in a largely natural manner. However, the herd is not subject to predation by wolves or other large carnivores. Wood bison were sold into the private sector from EINP for the first time in March 1999, with a second sale occurring during March 2000.

Bovine viral diarrhea (BVD) was detected in the EINP plains bison herd in 1996, prompting a serological survey of both the plains bison and wood bison herds. Forty-seven percent of 561 plains bison tested were seropositive for BVD, with one testing positive for virus antigen. None of 352 wood bison tested was seropositive for BVD, except for two possible BVD reactors. Further screening for virus antigen found no evidence of BVD in these two wood bison. Both populations are now vaccinated for BVD during annual roundups. However, calves to be used in translocations are not vaccinated in order to allow screening for BVD in the future.

Hook Lake Recovery Project

In 1991, Deninu Kue' First Nation initiated a program to restore a disease-free herd of wood bison in the Hook Lake area in the eastern SRL (Deninoo Wildlife and Resources Committee 1991). The Hook Lake Recovery Plan was implemented in 1992, in cooperation with the Department of Resources, Wildlife and Economic Development, Government of the Northwest Territories, the Government of Canada, and the Canadian Wildlife Federation.

The plan includes the following goals:

1) to restore a healthy herd of wood bison in the Hook Lake area that is free of bovine tuberculosis and brucellosis;
2) to preserve the genetic integrity of the Hook Lake wood bison herd;
3) to salvage disease-free bison from the Hook Lake area;
4) to preserve and enhance the Hook Lake ecosystem; and
5) to develop economic opportunities from the Hook Lake bison herd.

The Hook Lake management plan was updated in 1995, when measures for safeguarding genetic resources and establishing a disease-free herd were revised (Gates et al. 1998). The project involves three phases, including habitat renewal, propagation of a disease-free captive breeding herd in Fort Resolution, and eventual reestablishment of a disease-free herd in the wild.

Phase one began in May 1996 with the capture of 14 female and six male newborn bison calves from the Hook Lake area in the eastern SRL. The procedure was repeated in May 1997, when 16 females and four male calves were captured, and in May 1998, when 22 calves were removed from the wild herd. Calves were captured using either a hand-held or helicopter-mounted net gun and moved to an isolation and treatment facility at Fort Resolution. They were bottle-raised on a high-quality milk replacer and colostrum diet and were treated for exposure to tuberculosis and brucellosis with a specific antibiotic and quarantine protocol.

The calves captured in 1996 were tested for brucellosis and tuberculosis in late November 1996. All tests were negative. A second caudal fold test in February 1997 revealed a single tuberculosis test-positive calf. The calf and its pen mate were slaughtered. Histopathological study of tissues from the calf that tested positive revealed a minute granulomatous lesion in a mediastinal lymph node, which contained acid-fast bacteria consistent with *Mycobacterium bovis*. However, *M. bovis* was not cultured from sampled tissues. Subsequent repeated tests of all other stock have been negative. Bison will be maintained in small groups to minimize potential losses if additional culling is necessary (Gates et al. 1998).

Twenty-two additional calves were captured in 1998. One suffered from a neurological disorder and was euthanized shortly after it was captured. Another died from an accidental injury in April 1999, leaving a total of 58 disease-free wood bison. This number is sufficient to ensure that the genetic diversity of the Hook Lake population is adequately represented in the captive breeding herd. Seven calves were born in the captive herd in 1999, bringing the total number of animals to 65.

Bison removed from the Hook Lake area, and their progeny, will be used to reestablish a wild herd after diseases have been eradicated. However, the captured stock will not be used to augment or establish commercial herds.

Etthithun Lake population

In March 1996, 18 wood bison were released to the wild in northeastern British Columbia in the proximity of Etthithun and Kantah lakes. These animals had been maintained for two years at Northern Lights College in Dawson Creek, British Columbia. Habitat consists primarily of a mixture of domestic and native grasses occurring in natural meadows and on disturbed sites associated with road allowances, logging, seismic lines, pipelines, and well sites. The area is located near the bison management unit created in northwestern Alberta.

Fifteen bison were observed in January 1997. During the next few months, three of the 15 died in collisions with vehicles. During the summer of 1997, the herd ranged as far as 100 km to the south, occupying an area adjacent to agricultural development. They eventually joined a small group of feral plains bison that had escaped from a farm. The mixed herd, including 26 feral plains bison and wild wood bison, was captured in late 1997, placed in quarantine and tested for disease, and sold into private ownership. Funds resulting from the sale of 19 wood bison, including calves born under quarantine, were allocated to wood bison management in northeastern British Columbia.

No free-ranging wood bison occurred in the Etthithun Lake area in 1998. It is not known if feral plains bison remain in the area. A revised Etthithun Bison Area Management Plan has been developed, and an 850-ha enclosure was fenced in the winter of 1998–1999. In March 1999, 14 female calves and five yearling bulls were translocated from EINP to an enclosure in the Etthithun Bison Area. In February 2000, 24 additional wood bison were translocated to the Etthithun captive herd from EINP, bringing the total to 43.

Future plans include enlarging the enclosure to 1850 ha and allowing the herd to become free-ranging after calves have been born in the captive herd.

3. Public herds (free-ranging populations exposed to/infected with tuberculosis and brucellosis)

Disease testing indicates that all bison herds in the vicinity of WBNP and the SRL are exposed to or infected with bovine tuberculosis and brucellosis, which were transmitted by plains bison introduced from Wainwright, Alberta, in the 1920s (Tessaro 1988).

Wood Buffalo National Park

There were approximately 1500–2000 wood bison in WBNP when the park was established in 1922. Between 1925 and 1928, more than 6000 plains bison were relocated to the park from east-central Alberta. These animals dispersed from their release site near Hay Camp. The population increased to about 12 000 and remained near this level for several decades. In 1970, there were still approximately 12 000 bison in WBNP (Carbyn et al. 1993). However, the population subsequently declined to the lowest level observed in recent decades, with 2105 bison counted inside the park boundary in March 1997 and 2178 in 1998.

Five subpopulations are thought to exist in WBNP. The extent of interchange between them is variable, although it is now known to take place. Subpopulations in the Sweetgrass, SRL, and Nyarling areas were classified as wood bison by van Zyll de Jong et al. (1995). The metapopulation of bison associated with WBNP, which includes the SRL herds, is approximately 2700–2800 bison. It is infected with bovine tuberculosis and brucellosis. The long-term viability of bison

subpopulations and the effects of the diseases on population dynamics are currently being investigated (Joly et al. 1998).

Slave River Lowlands

In 1970, there were about 2500 bison in the SRL adjacent to WBNP. The Hook Lake (eastern SRL) herd declined from 1700 in 1970 to about 200 by the late 1980s. Poor calf production, infection with tuberculosis and brucellosis, wolf predation, and hunting contributed to the decline and to the continued low number of bison in the resident population. In 1994, there were 212 bison in this herd and 463 in the adjacent Little Buffalo herd, located in the western SRL. In March 1996, 454 wood bison were counted in the eastern SRL (Hook Lake herd), while only 228 remained in the Little Buffalo herd, suggesting that part of the Little Buffalo herd may have crossed the Slave River. There are currently about 600 bison in the entire SRL. These bison are classified as wood bison (van Zyll de Jong et al. 1995).

The SRL herds (both western and eastern sides) formerly played a more important role in the culture and economies of aboriginal communities. The potential for SRL herds to sustain hunting and provide economic opportunities for these communities is currently limited by their small size, instability, and the presence of two bovine diseases.

Caribou Mountains–Lower Peace Area

There is relatively little information available concerning bison populations in the region in Alberta adjacent to the southwestern corner of WBNP. Both Soper (1941) and Novakowski (1957) indicated that bison had moved into the Wabasca/Fort Vermilion area as early as 1926. Tessaro (1988) indicated that varying numbers of bison occurred in the transboundary area between Garden River and Ruis Lake in southwestern WBNP and the Wabasca River south of the Peace River. Heavy hunting in the area west of the park is a significant limiting factor (Gainer 1985; Tessaro 1988). Tessaro et al. (1990) conducted a limited survey for brucellosis and tuberculosis, examining six animals taken south of the Peace River and outside WBNP; *B. abortus* was cultured from the tissues of one animal. During an aerial survey in November 1996, the Alberta Fish and Wildlife Division counted 51 bison in two herds located between the Mikkwa and Wabasca rivers. The bison in this area are known as the Wabasca herd.

A second bison population ranges in the boundary area between WBNP and Wentzel Lake, north of the Peace River. Estimates of the number of animals residing in this area range from 25 to 110 (S. Tessaro, Canadian Food Inspection Agency, and V. Neal, Little Red River Cree Nation, pers. comm.). The movements, habitat use, and disease status of this population, known as the Wentzel Lake herd, are being investigated.

4. Privately owned herds with conservation objectives

Waterhen herd

In 1984, EINP provided founding stock for a wood bison ranch in the northern Interlake region of Manitoba. In June 1989, several wood bison from this herd were sold to private bison breeders and two bulls were slaughtered for the commercial market. This marked the first commercial use of NR (EINP) wood bison in Canada. In February 1995, the herd maintained by Waterhen Wood Bison Ranches Ltd. numbered 185 bison. Initially, the Manitoba Department of Natural Resources and the Waterhen First Nation cooperatively managed the herd. The Waterhen First Nation now manages the herd. In 1991 and 1993, 22 wood bison from the Waterhen Wood Bison Ranch herd were used to establish a free-ranging herd in the Chitek Lake area.

Syncrude Canada Ltd. herd

In cooperation with Alberta Environmental Protection and CWS, Syncrude Canada Ltd. and the Fort McKay First Nation established a breeding herd on oil sands lease property north of Fort McMurray in 1993. EINP provided wood bison stock for the experimental project. The herd occupies fenced pastures encompassing 2.6 km^2 on oil sands reclamation sites. It became the property of Syncrude Canada Ltd. in 1995, when the *Alberta Wildlife Act* no longer differentiated subspecies of bison. In 1999, the pre-calving herd approximated 150. Over the term of the Syncrude project, there is potential to convert 2000 ha of reclaimed oil sands lands to grassland and manage a wood bison population that exceeds 1200 animals.

The project was initially designed to determine experimentally whether restored soil on reclaimed areas could support forage crops and a productive bison herd. Results of the initial five-year research project (1993–1997) indicate that reclaimed landscape can support a healthy and productive herd of wood bison at a carrying capacity rate for managed grasslands of 0.67 cow–calf pairs per hectare (Pauls et al. 1999). Therefore, bison grazing would be a socially valuable land use relative to forestry, the other major commercial land use in the region (Pauls et al. 1999). In the future, possibly one or more of

the following long-term bison management objectives could be selected, in consultation with the provincial government and local and regional stakeholders:

1) removal of all fences and structures and management as a free-ranging herd, possibly within a wood bison sanctuary, pending resolution of the northern bison disease problem;
2) removal of all but perimeter fences and management similar to EINP; and/or
3) commercial production of wood bison.

If objective 1 or 2 is selected, the Syncrude Canada herd could contribute significantly to the national wood bison recovery and conservation effort. The first objective would serve the main recovery goal by creating another free-ranging population in Canada that could reach the MVP. However, this herd is located to the southeast of WBNP, approximately 105 km from populations that are infected with brucellosis and tuberculosis.

LaPrairie Ranch herd, Yukon

This herd was established in 1996, when 36 free-ranging wood bison that posed a hazard along the Alaska Highway west of Whitehorse were captured and removed. They were placed on the LaPrairie ranch, located about 70 km west of Whitehorse. An agreement with the owner stipulated that the same number and sex ratio of bison provided to the operator are to be returned to the government for conservation purposes within five years. The ranch owner will obtain ownership of the captive wood bison at the same rate and in the time frame that the bison are returned to the government. The captive herd increased and, in November 1998, numbered between 45 and 50 bison. The present herd size is unknown, as ownership of the animals is currently under dispute.

5. Privately owned commercial herds

There are 45–60 privately owned herds of wood bison in Canada, mainly in the Prairie provinces. They are widely distributed and contain about 500–700 animals. Privately owned herds are managed for commercial production and are not considered within the context of subspecies recovery, unless management plans link them directly to conservation projects. The number and size of privately owned herds are increasing rapidly, driven largely by commercial interests.

6. Privately owned herds in zoos and wildlife parks

The rapid growth of the EINP wood bison herd during the early 1970s led to a recognition of the need to broaden the geographic distribution of captive breeding herds and safeguard genetic resources against unforeseen losses of single herds. In 1976, four calves were transferred to the Calgary Zoo to establish the first captive breeding herd under a cooperative lease program. Between 1976 and 1982, wood bison were transferred to seven zoos and wildlife parks, including five in Canada, one in the United States, and one in Europe. During the late 1980s, the Recovery Team concluded that captive breeding herds in zoos were no longer required for conservation purposes. Therefore, CWS terminated the captive breeding herd lease program in 1990, relinquishing ownership of wood bison to those zoos and parks that had maintained animals. There are currently about 50 wood bison in zoos and wildlife parks.

c. Diseases, competition, and predation

1. Diseases

There are three diseases that are a major concern in the management of free-ranging wood bison populations in northern Canada. *Brucella abortus* is a coccobacillus that lives as a facultative intracellular parasite (Blood et al. 1983) and causes a disease known as brucellosis. It is transmitted in mammals primarily by oral contact with aborted fetuses, contaminated placentas, and uterine discharges. The organism may also be excreted in milk. Lesions associated with brucellosis are similar in bison and cattle (Tessaro 1988). *Brucella*-induced abortion occurs in >90% of female bison during the first pregnancy following infection, depending on the inoculum size (Davis et al. 1990, 1991). The abortion rate subsequently declines to near zero after the third pregnancy due to naturally acquired immunity. Some females may be lost as a result of acute metritis associated with retained placentas (Broughton 1987). Infected calves may be weak, with low survival rates. In males, *Brucella* causes orchitis and sterility in advanced cases. Localization in joints causes chronic suppurative arthritis and lameness (Tessaro 1989). Fuller (1962) reported that arthritis occurred in 2% of adult bison slaughtered in WBNP during the 1950s. Debility caused by arthritis may increase susceptibility to predation.

Bovine tuberculosis is a chronic infectious disease that causes death in advanced cases. The etiologic agent is the bacterium *Mycobacterium bovis* . Depending on the location of the infection in the host, the organism can be excreted in exhaled air, sputum, feces, milk, urine, and vaginal and uterine discharges (Blood et al. 1983). Inhalation and consumption of contaminated feed and water are the principal modes of transmission. Consuming infected milk may infect young animals. Intrauterine infection of the fetus occurs via the umbilical vessels. The respiratory tract is the major route of infection in bison (Tessaro 1988). The pathology, pathogenesis, and

epidemiology of bovine tuberculosis are the same in bison and cattle (Tessaro 1988; Thoen et al. 1988). The organism may spread to any part of the body after invading the blood or lymph vessels. It has been estimated that advanced tuberculosis causes annual mortality of 4–6% in bison in WBNP (Fuller 1962; Tessaro 1988). Tessaro (1988) described a strong link between tuberculosis and wolf predation on bison. As with brucellosis, advanced tuberculosis should be considered as a predisposing factor when evaluating the effects of predation on bison populations.

Tuberculosis and brucellosis also affect the meat quality of bison harvested for human consumption. Hunters in Fort Smith and Fort Resolution report that meat from infected bison has been wasted, but the extent to which carcasses are abandoned is unknown.

Anthrax is caused by the bacterium *Bacillus anthracis* and can have a significant impact on bison populations. The disease is highly contagious and is usually lethal. Anthrax persists in soil, where highly resistant spores can remain dormant for many years. Under certain environmental conditions, the spores become exposed and concentrated, sometimes leading to an outbreak of the disease (Dragon and Rennie 1995; Gates et al. 1995). The disease spreads when an animal inhales or ingests spores from contaminated soil or through contact with an infected carcass. It is thought to cause rapid death in infected bison. Anthrax is not treatable in free-ranging wildlife, but captive bison can be vaccinated. Anthrax outbreaks have occurred in the SRL, WBNP, and Mackenzie bison populations (Gates et al. 1995).

The risk of infection from bison infected with bovine tuberculosis and brucellosis in the SRL and northern Alberta, including WBNP (Northern Diseased Bison Environmental Assessment Panel 1990), threatens the productivity and health of reintroduced wood bison. It also threatens the potential for reestablishing additional herds in northern Alberta, northeastern British Columbia, and southwestern Northwest Territories. Bison are scattered at low density outside WBNP in northern Alberta and southern Northwest Territories (Gates et al. 1992). The largest numbers occur in the area between WBNP and the Wabasca River, east of Fort Vermilion, and in the vicinity of Wentzel Lake. Their status relative to tuberculosis and brucellosis is poorly known. Limited testing indicates that bovine brucellosis occurs in bison south of the Peace River, adjacent to WBNP (Tessaro 1988).

Annual examination and serological studies of bison harvested from the Mackenzie herd indicate that the herd continued to be free of tuberculosis and brucellosis through 1992 (Tessaro et al. 1992). The Mackenzie, Nahanni, and Hay-Zama herds are at particular risk of acquiring these diseases through contact with infected bison herds. Dispersing adult male bison play a major role in colonizing new habitat (Meagher 1989; Gates and Larter 1990) and may travel considerable distances. Dispersers can serve as a link between noninfected and infected populations. Tuberculosis is most likely to be spread by dispersing male bison.

In 1987, the Government of the Northwest Territories created a Bison Control Area south of the Mackenzie River as a buffer zone between WBNP, bison in northern Alberta, and the Mackenzie bison herd. It encompasses approximately 39 400 km^2. Between January and June 1992, 13 sightings of bison or their sign were reported in the Bison Control Area (Gates et al. 1992). Sightings were concentrated along the south shore of Great Slave Lake, extending from the Mackenzie River near Fort Providence to the Buffalo River north of WBNP.

Nine bison were shot in May 1992, one was killed in February 1995, and three were shot in March 1996. Sera collected from most culled bison were tested for brucellosis and were found to be negative, and necropsies revealed no evidence of tuberculosis.

2. Competition

There is little potential for competition between bison and other large herbivores in the original range of wood bison. Dietary overlap between wood bison and other herbivores, such as moose, woodland or barren-ground caribou, and deer, is minimal. Preliminary results from a study in the southern Yukon indicate that there is very little niche overlap between wood bison and woodland caribou (L. Fischer, University of Calgary, pers. comm.). In the Mackenzie sanctuary, bison are known to browse willow leaves and twigs during the spring and early summer, in addition to consuming grasses and sedges. In forested areas, terricolous lichens comprise part of the diet in late summer and fall (Larter and Gates 1991). Moose coexist with every existing free-ranging wood bison herd, sometimes at high densities. Empirical evidence from one area in Canada suggests that a large herd of bison may indirectly influence predation where moose density is chronically low (Gates and Larter 1990; Larter et al. 1994). It has been hypothesized that the relatively large number of bison in the Mackenzie population had, by the early 1980s, led to an increase in wolf numbers and increased predation on moose (Larter et al. 1994). The effects of predation on alternative prey species like moose are related to the numerical response of wolves to bison population size (Gates and Larter 1990; Larter et al. 1994). It follows that

by limiting the number of bison in a system through management, the numerical response of wolves and effects on alternative prey populations can be reduced.

3. Predation

Wolf predation is a significant limiting factor for some bison populations (Van Camp 1987; Carbyn and Trottier 1988; Carbyn et al. 1993, 1998) and may regulate diseased herds at low density (Gates 1993). The "disease–predation hypothesis," proposed by Messier (1989) and Gates (1993), suggests that tuberculosis and brucellosis reduce productivity and increase the vulnerability of some individuals to predation, resulting in population declines and chronically low densities. Disease-free bison populations may be regulated at high density by intraspecific competition for food, despite the presence of wolves.

d. Commercial, consumptive, and subsistence use

Commercial production of wood bison by the private sector began in 1989 when Waterhen Wood Bison Ranches Ltd. first sold animals to other private operators. Since then, the number of private owners has gradually increased, reflecting the limited availability of stock.

The commercial production of wood bison can provide opportunities for economic diversification and increased self-sufficiency in rural areas, particularly for aboriginal and other communities. In the last two decades, there has been renewed interest in bison ranching in western Canada, and the number of farms and ranches has dramatically increased. At present, most commercial production is based on plains bison herds. In 1996, the Canadian Bison Association listed more than 600 owners in Canada, with a ranch population of about 30 000 bison (N. Moore, Moore's Auction Ltd., pers. comm.).

A registry for wood and plains bison has been established under the national *Livestock Pedigree Act* and is maintained by the Canadian Livestock Records Corporation. The Canadian Bison Association established bylaws governing the certification of stock according to conformation standards developed in cooperation with the Recovery Team.

Hunting is currently permitted only for the Mackenzie and Yukon wood bison herds and for subpopulations in the SRL. In the Mackenzie area, bison hunting is regulated with a harvest quota (47 males in 1996). Permits for six male wood bison were issued in the Yukon in 1998, and more than 40 animals were taken in 1999. During 2000–2001, 85 permits were issued for hunting. In the future, the number of permits issued annually in the Yukon is anticipated to be from 80 to 90, based on calf production in the previous years (P. Merchant, Yukon Fish and Wildlife Branch, pers. comm.). Bison hunting in the SRL is restricted to Northwest Territories General Hunting Licence holders, but no limits are imposed. Legislation enacted in 1995 by the Deninu Kue' First Nation (Fort Resolution) restricted hunting within a Wildlife Management Area that includes the range of the Hook Lake herd. Bison are not protected from hunting in northeastern Alberta in areas external to WBNP. This serves to reduce the risk of diseases spreading beyond WBNP.

II. Habitat considerations

a. Overview of habitat requirements

Wood bison are well adapted to northern habitats. They are primarily grazers, relying on a variety of grasses and sedges found in northern meadows and successional habitats (Reynolds et al. 1978; Reynolds and Hawley 1987; Larter and Gates 1991). Wood bison show strong seasonal changes in diet, with sedges predominating during winter and a more diverse diet of grasses, sedges, and shrub foliage during summer and fall. Foraging efficiency is maximized by a selection of habitats that provide the most available crude protein (Larter and Gates 1991). Willow savannas are the most important habitat during the spring and summer in the SRL and Mackenzie areas (Reynolds and Hawley 1987; Larter and Gates 1991). Wet meadows are used heavily during winter, when sedges comprise nearly 100% of the diet. Wood bison use a variety of habitats during fall, when crude protein is most widely available. The foraging habitats most favoured by wood bison are grass and sedge meadows occurring on alkaline soils. Grassland/sedge habitat is usually interspersed among tracts of coniferous and aspen forest, bogs, fens, and shrubs. It represents 5–20% of the land area in most bison ranges.

b. Status of habitat

The total area encompassed by the original range of wood bison in Canada is approximately 1 823 000 km^2. A significant portion of the original range of the wood bison is no longer available for recovery. Agricultural and urban development has alienated large portions of the range in Alberta and British Columbia. Free-ranging plains bison populations have been established in parts of the original range of wood bison in British Columbia and Alaska, precluding the restoration of wood bison in some areas.

High-quality habitat for wood bison is widespread in WBNP and in the large meadow systems of the SRL. These areas are currently inhabited by stable low-density or declining populations of diseased bison. The reestablishment of wood bison is precluded in adjacent areas in the Northwest Territories and Alberta by policies designed to prevent the spread of bovine diseases from bison in WBNP and the SRL. The total area compromised by diseased herds is approximately 218 516 km^2, or about 12% of the original range in Canada.

If bovine diseases could be eradicated, substantial high-quality habitat would be available in WBNP and the SRL. Large areas in northern Alberta now being modified by the forest products industry and by tar sands mining would also be suitable for wood bison recovery in the future.

The habitat available to the Mackenzie bison population declined after 1988 as a result of flooding in shallow lake basins, which formerly provided extensive grazing habitat. A study of fire history suggested that many prairies and other open habitat near Fort Providence have been overgrown by aspen forest or reduced by encroaching shrubs as a result of changes in the fire regime and flooding during the last century (Chowns et al. 1998). Similar changes in bison habitat have occurred in the SRL (Quinlan 1999). Changes in the human use and management of fire during the last 50 years may be an important underlying factor, as is the historic decline or absence of grazing by bison in other areas (Campbell et al. 1994). Changes in the hydrological regime in the SRL following construction of dams on the Peace and Talston rivers may also have induced changes in meadow succession. While it is difficult to manage variations in surface water, it may be feasible to alter forest and shrub cover using prescribed fire, thereby increasing the amount of available bison habitat. However, prescribed fire may also cause negative effects on bison forage in riparian meadows (Quinlan 1999).

III. Effects of human activities/land use conflicts

Human activities and developments, some of which are incompatible with the existence of free-ranging wood bison, continue to increase within the original range of the wood bison. Continued alienation of habitat is a major factor limiting the potential for recovery of this threatened subspecies.

The W.A.C. Bennett Dam on the Peace River in British Columbia altered the hydrological regime of the Peace and Slave rivers. The effects of changes in the hydrology and vegetation of the Peace–Athabasca Delta are being studied. The dam reduced the frequency of floods in the Peace–Athabasca Delta and tributaries of the Peace River near WBNP. Meadows in the SRL downstream of the delta are also not as subject to flooding as they once were. Climate change and natural variation in annual patterns of precipitation and discharge may have also contributed to reduced flooding. Terrestrial and aquatic habitats are changing as a result. Sedges, which provide important winter forage for bison, formerly dominated large meadows in the delta. Now, grasses, forbs, and shrubs are replacing them as the land becomes drier. The effect on bison has not been studied in detail, but it appears that the available forage can still support a larger bison population than currently exists.

Land clearing and seeding associated with expanding forestry and petroleum resource development in northern Alberta and British Columbia have increased the amount of native and domestic grasslands. Bison are well adapted to a variety of meadow habitats and could benefit from some types of habitat alteration associated with resource development.

Agricultural development has reduced the amount of habitat available to wood bison. The number of bison ranches has increased rapidly, with the majority of commercial production involving plains bison. There are at least 20 000 bison on commercial ranches within the original range of wood bison, and the number is increasing by about 30% annually (D. Patten, Peace Country Bison Association, pers. comm.). The continued expansion of plains and wood bison farming could further limit the amount of land available for wild populations. It is also difficult to maintain fences where both wild and captive bison occur in the same area.

The potential for dissemination of livestock diseases continues to be a major concern. Free-ranging populations may contract diseases from translocated animals, contact through fence lines, or infected stock that escapes captivity. There is always some risk of disease transfer associated with the translocation of wildlife (Samuel 1987). Under the guidelines of the most recent Parks Canada Agency Surplus Wildlife Directive (4.4.11), EINP is required to conduct disease risk assessments in cooperation with the receiving agency prior to translocation of wood bison into new range. Genetic contamination of wood bison by escaped plains bison is also an ongoing concern. Enforcement of wildlife regulations may be compromised in areas where captive bison herds are present.

B. Role of wood bison in the ecosystem and interaction with humans

I. Ecological considerations

a. Ecological role

Wood bison have been a keystone species in a vast region within the boreal forest. They occupy a niche that is not available to other extant northern herbivores and are able to thrive on coarse grasses and sedges in northern meadows. They are a key element in the dynamic interplay among indigenous large mammals, serving as prey for wolves, indirectly influencing the abundance of carnivores and other herbivores, and playing an important role in nutrient cycling (Gates and Larter 1990; Larter et al. 1994). The role of northern grazers, including wood bison, in maintaining meadow habitat and ecological diversity is beginning to be understood (Campbell et al. 1994; Zimov et al. 1995).

b. Taxonomic status

The wood bison is recognized as a subspecies of North American bison (Cook and Muir 1984; van Zyll de Jong 1986). Some taxonomists hold the view that because of the close morphological and genetic similarity of *Bos* and *Bison*, they should be united in a single genus (Simpson 1961; Van Gelden 1977). Morphological (Groves 1981) and genetic evidence (Miyamoto et al. 1989; Wall et al. 1992; Janecek et al. 1996) support this view, as does the partial fertility of cattle × bison hybrids (Van Gelden 1977). Jones et al. (1997: 5) included bison and cattle in a single genus in their checklist of North American mammals; they continued the "somewhat unpopular decision to use the name combination of *Bos bison* for the American bison." However, the American Society of Mammalogists (http://asm.wku.edu/mammalsinfo.html) lists bison (*B. bison* and *B. bonasus*) as a genus separate from *Bos*, following the taxonomy of Wilson and Reeder (1993). Because of lack of consensus on the taxonomy of *Bos* and *Bison*, the Recovery Team continues to refer to wood bison as *Bison bison athabascae*.

Fossil evidence indicates that there was a single species of bison in Eurasia and North America during the middle and late Pleistocene (Guthrie 1990). During the last (Wisconsin) glaciation, there were two separate populations of bison in North America (Guthrie 1990; van Zyll de Jong 1993). The steppe bison (*B. priscus, sensu* McDonald 1981 and Guthrie 1990; *B. b. priscus, sensu* van Zyll de Jong 1986), a relative newcomer from Eurasia, occupied Beringia and was adapted to the rigors of the cold steppe. *Bison antiquus*, a descendant of an invasion of bison from Eurasia during the preceding Illinoian glaciation, was adapted to a temperate climate and open woodlands and persisted south of the continental ice sheet. About 14 000 years ago, Eurasia and Alaska were separated by rising sea levels resulting from climatic warming. Subsequently, bison on both sides of the Bering Isthmus appear to have undergone parallel evolution from large-horned to small-horned forms (van Zyll de Jong 1993). Three bison taxa (wood bison, plains bison, and European bison, *B. bonasus*) continue to exist. The two North American subspecies (*B. b. athabascae* and *B. b. bison*) represent the most recent variants on this continent, while the European bison, which survived only in the forests of eastern Europe, is the only extant bison on the Eurasian continent. A northern form of small-horned bison, similar to wood bison, became extinct in eastern Siberia by the late Holocene (van Zyll de Jong 1993). The taxonomy of this form is not well defined.

A corridor in the ice sheet separating Beringia from central North America began to form about 13 000 years ago, after which northern and southern forms of bison apparently dispersed and intermingled. Existing North American bison are descendants of these two Pleistocene lines. However, the contribution of *antiquus* and *priscus* in the evolution of modern North American bison is not well understood. The southern *antiquus* was more widely distributed and abundant than *priscus* and may have played a larger role in the evolution of modern North American bison (van Zyll de Jong 1993). The fusion of northern and southern forms produced the early-Holocene form, *B. b. occidentalis* (*sensu* van Zyll de Jong 1986), which underwent rapid evolutionary change, leading to the two modern North American subspecies by about 5000 years ago. Adapted to northern woodlands, the nonmigratory wood bison evolved in the northwestern section of the species' range, while the migratory plains bison evolved in the extensive grasslands of central and southern North America.

The taxonomic status of Holocene bison in eastern Siberia is less clear, but evidence suggests that they were morphologically similar, and ecologically equivalent, to wood bison. A well-preserved skull from the Kolyma River lowlands, believed to be of late-Pleistocene or early-Holocene age, is taxonomically intermediate between *B. b. occidentalis* and *B. b. athabascae*, demonstrating a close affinity with these forms (van Zyll de Jong 1986, 1993). Bison remains have also been recorded at archaeological sites dating to as late as 900 A.D. in southern Yakutia (Lazarev et al. 1998). A proposal to establish a captive wood bison herd in the Kolyma lowlands is reviewed elsewhere in the recovery plan.

Wood Bison

The two modern forms of North American bison (*B. b. athabascae* and *B. b. bison*) evolved relatively recently, resulting in minor differences between subspecies. A parallel "evolution," directed by humans, occurred over a similar period (6000 years), with the radiation of breeds of domestic cattle from the wild progenitor *Bos primigenius.*

Prior to the mass slaughters of the 19th century, wood and plains bison occupied different habitats. During winter, their movements may have overlapped in a limited area along the southern edge of wood bison range, but their different migratory habits suggest that they did not share a common range during the breeding season. Differing habitat preferences and seasonal movement patterns maintained reproductive isolation and geographic discontinuity between these forms (van Zyll de Jong 1986).

1. Morphological evidence

Wood bison are distinguished from plains bison based on a number of morphological characteristics. Skeletal material from a number of wood and plains bison populations has been analyzed in considerable detail (McDonald 1981; van Zyll de Jong 1986). These studies show that geographic variation in historical populations of North American plains bison was largely continuous (clinal) through a series of overlapping populations and was most evident along a north–south axis. Bison in the eastern and southern United States were smaller than those found in the north-central United States or on the Canadian Prairies. However, the continuous gradation of intermediate types between the extremes makes a meaningful delineation of northern and southern plains bison impossible. In contrast to the clinal variation observed in plains bison, phenotypic discontinuity was evident between wood bison and plains bison populations. This discontinuity was reflected not only in size, but also in differences in morphology, independent of size (van Zyll de Jong 1986).

Morphometric analysis of bison from the NR area of WBNP demonstrated that they are similar to the original *B. b. athabascae*, although they show evidence of interbreeding with *B. b. bison* (van Zyll de Jong 1986). Because NR bison are much closer to *athabascae* than to *bison*, they should be assigned to the former taxon as a valid subspecies.

A recent study of external morphological characteristics in 11 bison populations in North America revealed three significantly different groups: plains bison (six populations), wood bison (four populations), and an intermediate form in central WBNP (van Zyll de Jong et al. 1995). The Peace–Athabasca Delta (WBNP), SRL, Mackenzie, and EINP bison populations were classified as wood bison.

2. Karyotypes

The karyotype (chromosome morphology) of NR and plains bison is identical (Ying and Peden 1977) and is nearly identical to that of the wisent (*Bison bonasus*), which is indigenous to Europe (Orlov and Chudinovokaya 1979). All living forms of bison are completely interfertile and lack intrinsic isolating mechanisms, indicating that they are members of one species. Bhambhani and Kuspira (1969) argued that the similarity of the karyotypes of bison and cattle warrants their inclusion in a single genus. However, since bison and cattle are not completely interfertile, they must be considered as separate species. For a more detailed explanation, refer to Section I, 2. Current status, B.I.b, Taxonomic status, above.

3. Blood characteristics

Hartl and Reimoser (1988) found the genetic distance between *B. b. bison* and *B. bonasus* to be comparable to that between local populations of a species, based on 15 blood protein and enzyme systems. This finding supports the conspecific designation of American and European bison. A comparison of wood bison and plains bison, based on 13 cattle blood typing reagents and carbonic anhydrase electrophoresis, failed to differentiate between the two North American subspecies (Peden and Kraay 1979). Zamora (1983) was also unable to distinguish subspecies of bison based on analysis of erythrocyte antigens and blood proteins. However, Peden and Kraay (1979) found significant variation in blood characteristics of six herds, including four plains bison herds, a NR herd (EINP), and the WBNP herd, and distinguished plains bison in Canada from those in the United States.

4. DNA

Cronin (1986) examined mitochondrial DNA (mtDNA) restriction fragments in NR and plains bison and concluded that they could not be distinguished. With the notable exception of mule deer (*Odocoileus hemionus hemionus*) and black-tailed deer (*O. h. columbianus*), Cronin (1991) was also unable to distinguish between other subspecies within several cervid and bovid taxa. Strobeck et al. (1993) compared sequence divergence in a section of D-loop in the mtDNA of a small number of NR wood bison and plains bison. They found that differences between NR and plains bison are approximately the same or less than within plains bison. Their gene tree did not reveal monophyletic separation between wood and plains bison alleles. Separate groups are not expected to have

monophyletic mitochondrial DNA trees until 4N generations (where N represents population size) have passed, assuming constant and equal population sizes. Thus, there is no reason to expect a monophyletic tree for bison mtDNA unless N is less than 250, assuming a generation time of five years and that wood and plains bison existed separately for the last 5000 years.

MtDNA is maternally inherited and thus reflects the contribution of the maternal population that gave rise to NR bison and other bison populations in the vicinity of WBNP. Because plains bison cows greatly outnumbered wood bison cows following the introduction of plains bison in the 1920s, it is not surprising that mtDNA in extant bison populations in this area is similar to that of plains bison. Moreover, the rate of sequence divergence in mtDNA is on the order of 1–2% per million years (Wilson et al. 1985). Since the divergence of wood and plains bison occurred only during the last 5000–10 000 years, there has been little time for the development of significant differences in bison mtDNA. Incongruent relationships of mtDNA and taxonomic designations within Cervinae and Odocoilinae support the contention that gene and species trees may not be synonymous (Pamilo and Nei 1988). Cronin et al. (1991) concluded that one must proceed with caution when using mtDNA to infer species relationships and that many loci must be assessed to derive correct species trees. He also concluded that population genetics must be considered in evaluating phylogenetic relationships among closely related taxa.

Molecular studies are providing additional insight regarding the phylogeny of bison subspecies. Bork et al. (1991) found significant differences in restriction fragment length polymorphism frequencies in 2 of 28 fragments in NR and plains bison. The low number of net nucleotide substitutions in these two populations suggests recent divergence. This finding is consistent with the view that wood and plains bison existed as reproductively isolated populations during the last 5000–10 000 years, a relatively short time in evolutionary terms.

Wilson and Strobeck (1999) investigated variability in 11 microsatellite loci of genomic DNA in 11 public North American bison herds. Populations arising from stock originating in WBNP (WBNP subpopulations and EINP and Mackenzie herds) formed one group on a Nei's minimum unrooted genetic tree. There were differences in allele frequencies between some subpopulations in WBNP. In particular, allele frequencies in the Pine Lake subpopulation were significantly different from those in other subpopulations. This subpopulation was also identified by van Zyll de Jong et al. (1995) as being intermediate between wood bison and plains bison. The EINP and Mackenzie wood bison populations exhibited less genetic variability than the WBNP population, reflecting the small number of founders. Genetic distances between wood bison and plains bison populations were usually larger than within either subspecies. Wilson and Strobeck (1999) concluded that genetic clustering of wood bison populations indicates that they are functioning as a genetic entity separate from plains bison and should continue to be managed separately.

5. Subspecies designation

The classification of wood bison as a subspecies is in accord with accepted criteria. Mayr (1963: 348) defines a subspecies as "an aggregate of local populations of a species, inhabiting a geographic subdivision of the range of the species, and differing taxonomically from other populations of the species," noting that differing taxonomically means "by diagnostic morphological characters." Allen (1876), Seton (1886), and Ogilvie (1893) were among the first to recognize wood bison as distinct from plains bison. Rhoads (1897) provided the first formal taxonomic description of wood bison as a distinct subspecies. Since then, many other scientists (Raup 1933; Soper 1941; Skinner and Kaisen 1947; Banfield and Novakowski 1960; Flerov 1965; Karsten 1975; Geist and Karsten 1977) have acknowledged the subspecific status of wood bison.

Geist (1991) argued that extant North American subspecies are "ecotypes" with morphological differences reflecting local environmental influences rather than heritable traits. Mayr (1963: 354) cites a definition of an ecotype as "the product arising as a result of the genotypical response of an ecospecies to a particular habitat." Recent studies have demonstrated that phenotypic characteristics of wood and plains bison are genetically controlled and are not induced by environmental factors (van Zyll de Jong et al. 1995).

The subspecies concept applied by the Recovery Team adheres to guidelines established by Avise and Ball (1990: 59–60): "subspecies are groups of actually or potentially interbreeding populations phylogenetically distinguishable from, but reproductively compatible with, other such groups. Importantly, the evidence for phylogenetic distinction must normally come from the concordant distributions of multiple, independent, genetically-based traits."

The following conclusions regarding the status of North American bison subspecies stem from the application of recently formulated criteria (Avise and Ball 1990; O'Brien and Mayr 1991):

1) Historically, wood bison differed from other bison populations with regard to multiple morphological and genetic characteristics.
2) The intrusion of plains bison into the range of wood bison in 1925–1928 was entirely human-caused.
3) The two North American bison subspecies continue to be morphologically and genetically distinct, despite some hybridization in the 1920s.
4) Wood bison and their descendants continue to constitute populations of a subspecies of bison.

In 1991, a subcommittee of COSEWIC prepared guidelines for listing populations below the species level. It recommended the following criterion for including infraspecies groups on the COSEWIC list:

"Geographical distinctiveness as indicated by barriers, distribution gaps, behavioural isolating mechanisms, different modes of relating to the environment, or other compelling evidence."

Consistent with this definition, the proposed Species At Risk Act (SARA), Bill C-5 (First Reading, 2 February 2001), defines a wildlife species in the following manner: "*wildlife species* means a species, subspecies or biologically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and (a) is native to Canada; or (b) has extended its range into Canada without human intervention and has been present in Canada for at least 50 years."

Clearly, wood bison meet these criteria and have been a key component in the diversity of natural life forms in northern Canada, Alaska, and possibly Siberia. Free-ranging wood bison populations in northern Canada are particularly important because they are currently the only populations that exist in relatively unaltered and intact ecosystems. The Recovery Team strongly supports the position that publicly owned wood bison continue to be maintained and managed separately from plains bison as a distinct subspecies.

II. Sociopolitical considerations

a. Existence value

The wood bison represents a valuable heritage for the people of Canada and other northern regions. The bison is of cultural and spiritual significance for many aboriginal peoples in North America, and wood bison are highly valued as part of the cultural inheritance of many communities within the original range of the subspecies. There are rich oral traditions about bison among aboriginal people, which continue even in areas where bison have not been present for decades (Lotenberg 1996; Stephenson et al. 2001). The historic presence of wood bison is often reflected in toponyms such as "Buffalo Shirt Mountain" (Alaska), "Wood Bison Lake," "Buffalo Head Prairie," "Buffalo Head Hills" (northern Alberta), and "Wood Buffalo Park." The Ross River in central Yukon was known as the "Buffalo River" when translated from the Tagish language (P. Merchant, Yukon Fish and Wildlife Branch, pers. comm.). Some communities use wood bison as a symbol to promote their historic and economic value (e.g., Fort Providence and Fort Smith). On 6 April 1981, Canada Post issued a commemorative wood bison postage stamp in recognition of Canadian endangered wildlife. In 1997, the Royal Canadian Mint produced a platinum four-coin set portraying wood bison.

The Wood Bison Recovery Team recognizes the cultural significance of bison as well as the economic and other benefits to both rural and urban communities from the presence of viable and healthy wood bison populations.

b. Utilitarian value

The utilitarian value of free-ranging wood bison is currently limited by the small size of most populations. Regulated hunting was initiated in the Mackenzie area in 1988, and a hunting season was established in the Yukon in 1998. The additional hunting opportunities have provided considerable economic and social benefits locally (P. Merchant, Yukon Fish and Wildlife Branch, pers. comm.). Bison can provide food for local communities, as well as income from outfitted trophy hunting and tourism based on bison in a wilderness setting. Hides and horns can be used in handicrafts. Bison hunting may serve to reduce hunting pressure on local populations of moose and caribou.

With approximately 700 wood bison under private ownership in Canada and a policy that supports commercial sales of wood bison from the national captive breeding herd at EINP, the wood bison ranching industry will continue to expand. There is potential for further development of commercial trade in wood bison and their by-products within Canada and for the development of international markets.

c. Legal considerations

Wood bison were recognized by COSEWIC as an endangered subspecies of Canadian wildlife in 1978. This status was changed to "threatened" in June 1988, based on data presented in the status report prepared by the Wood Bison Recovery Team (1987). In addition, the Committee

for the Recovery of Nationally Endangered Wildlife in Canada (RENEW) has placed wood bison on its priority list.

Under the *Northwest Territories Act*, wood bison are designated as in danger of becoming extinct. As such, restrictions may be placed on the hunting of wood bison, and subsistence hunting by aboriginal people may be regulated. The Government of the Northwest Territories recognizes the Mackenzie, Nahanni, and Hook Lake herds as wood bison, and hunting may be regulated under quota after consideration of community interests.

The wood bison is designated as a protected species in Manitoba, British Columbia, the Yukon, and the Northwest Territories. Bison are protected in WBNP under the *National Parks Act*. Alberta has established a Wildlife Management Area to protect the Hay-Zama wood bison herd. Elsewhere in the province of Alberta, free-ranging bison are not classified as wildlife and are not protected. Manitoba established a protected area for wood bison and their habitat in the Chitek Lake area.

Among the western provinces and territories, only British Columbia, the Yukon, and the Northwest Territories classify plains bison under wildlife legislation. In these three jurisdictions, both bison subspecies are designated as "wildlife" and are property of the provincial or territorial government. Bison are considered "domestic" only when held in captivity under permit or licence for game farming purposes. If a bison escapes captivity, the provincial/territorial government acquires ownership of the animal. In Manitoba and Alberta, plains bison are classified as a domestic species and do not fall under the jurisdiction of provincial wildlife management agencies. Similarly, bison that are commercially raised in Saskatchewan are considered to be domestic animals. In the Yukon and Northwest Territories, existing policies do not permit the establishment of plains bison ranches or their introduction to the wild.

Alaska currently supports four free-ranging herds of plains bison, which are classified as wildlife. They are managed for a sustained yield, and hunting is allowed by permit only. Privately owned bison are classified as "domestic mammals." If they are not confined (except when held under a grazing lease), they are defined as "feral" and become property of the state.

In 1977, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) placed wood bison on Appendix I. The subspecies was downlisted to Appendix II in June 1997. The proposal to downlist in CITES was based on 1) the absence of a threat from international trade; 2) progress towards recovery in the wild; 3) the rapidly growing wood bison ranching industry; and 4) problems inherent in effectively regulating exports and imports of wood bison and their products produced on commercial ranches if wood bison remained on Appendix I.

The sale of wood bison within Canada is not regulated by federal wildlife legislation. International commercial trade of wood bison or wood bison products between signatory parties is regulated through CITES export permits. In 1993, the European Economic Community CITES Working Group authorized the import of wood bison trophies from the Mackenzie population. The U.S. *Endangered Species Act* lists wood bison as endangered in Canada. Regulations associated with the *Endangered Species Act* create a significant obstacle to the import of wood bison and wood bison products into the United States.

d. Proportion of breeding populations in Canada

As of 2000, all free-ranging, breeding populations of wood bison existed exclusively in Canada.

III. Potential for recovery of wood bison

a. Review of major threats and outlook for the future

The existence of diseased bison herds in and around WBNP is the greatest single factor affecting the availability of original range and the potential for further recovery of wood bison in northern Alberta, the Northwest Territories, and British Columbia.

Uncontrolled translocation or the escape of domestic bison of either subspecies also poses a threat to the recovery and genetic integrity of wood bison. The existence of free-ranging plains bison in the Pink Mountain area of British Columbia and of plains bison at four locations in Alaska constrains the recovery of wood bison in a significant portion of their original range. Some wildlife management agencies have relinquished regulatory responsibility for plains bison to agricultural agencies. The proliferation of plains bison ranches in parts of the original range of wood bison and the potential for escapes threaten the genetic integrity of free-ranging wood bison. There would be less concern if confinement of captive bison could be guaranteed. Ranching of either subspecies in areas where wild herds exist, or could exist, can result in conflicts when habitat is alienated from use for wild herds, when bison break through fences, or when there is contact between captive and free-ranging animals through fences.

b. Current protection efforts

Current recovery efforts include maintaining captive herds to provide stock for reintroductions, protecting free-ranging populations, and promoting growth of small populations. Efforts also include managing hunting for populations that can sustain consumptive use, maintaining habitat, and preventing transmission of bovine tuberculosis and brucellosis to disease-free herds.

c. Degree of habitat management required

Habitat management may be required where alteration of the natural fire regime has caused encroachment of trees and shrubs into meadows. Prescribed fire may be used to restore natural vegetation patterns that favour bison. However, other processes may also influence habitat succession and renewal, and prescribed fire may result in negative effects on some forage species (Quinlan 1999).

Climate change and hydroelectric development may have altered the hydrological regime on the Peace River, resulting in a progressive loss of meadow habitat in the Caribou–Lower Peace region in Alberta. Experiments have been conducted to determine if original spring flood regimes can be re-created with the use of artificial ice dams.

Intensive forestry and petroleum development are expanding in the original range of the wood bison. There is an opportunity to integrate bison habitat management with the objectives of these industries. Ongoing negotiations between wildlife management, forest management, and resource development agencies and other stakeholders, including First Nations, will play a key role in determining the amount of habitat available for wood bison.

d. Biological considerations affecting recovery

1. Scope for growth of existing herds

The Mackenzie wood bison herd was the first population to contribute to the minimum recovery objective of reestablishing four stable or increasing wild herds of at least 400 disease-free wood bison. The population declined somewhat in recent years, after bison had occupied most of the suitable habitat west of Great Slave Lake. Increased wolf trapping by local trappers in 1995 may have influenced an increase from 1300 in 1996 to 1900 in 1998. The prospects for maintaining the population are also being improved with a habitat enhancement program. Factors such as predation, drowning, and anthrax have also affected herd growth. The herd is lightly hunted at present.

Maintaining or increasing the Mackenzie population will require effective management of a number of limiting factors.

The Yukon herd is being managed to exceed a population of 400, the estimated MVP. The population exceeded this number following the 1998 calving season. Similarly, the Chitek Lake herd will be managed to attain a population objective of 400 or more bison. The Hay-Zama herd also has the potential to exceed 400 animals.

The Nahanni herd is unlikely to contribute independently to the goal of reestablishing four free-ranging wood bison herds at the MVP. Wood bison in this region use habitats that were not evaluated in initial forecasts of range capability (Reynolds et al. 1980) and have dispersed from the intended range. However, only a short distance separates the Nahanni and Nordquist herds at present. Eventually, they are likely to coalesce into a single population that will exceed 400 bison and thereby contribute to the recovery goal. There was a combined total of at least 190 bison in these herds during 1998.

The interest in eliminating bovine tuberculosis and brucellosis reservoirs in northern Canada has grown as both wild and captive disease-free bison herds have increased in size and number. The future of diseased bison populations is uncertain, and the extent to which they may contribute to the survival of wood bison in the long term are unknown. A recovery and disease management program for the Hook Lake wood bison herd is now in the final stages of phase two and about to commence phase three.

Continued efforts are required to achieve the minimum recovery goal of four geographically separate, free-ranging, disease-free, and viable wood bison populations.

2. Potential for reintroductions and introductions

Eliminating bovine tuberculosis and brucellosis from bison herds in the vicinity of WBNP would remove the largest single obstacle to the recovery of wood bison in Canada (Northern Diseased Bison Environmental Assessment Panel 1990; Gates et al. 1992). This vast area includes what may be the highest quality habitat for the subspecies and comprises the core of original range in Canada. Other parts of northern Alberta could potentially support 4000 wood bison (Alberta Forestry, Lands and Wildlife 1989).

In the absence of the threat of disease, bison herds could be maintained in the Hay River drainage in British Columbia and Alberta, at several locations along the Peace

River, in the Wabasca and Mikkwa river areas, at Wentzel Lake in the Caribou Hills, south of the Birch Mountains, in the Buffalo Head Hills, and along the Athabasca River near Fort McKay. Wood bison in the SRL could be expected to reach or exceed the level of 2500 that existed in 1970 (Van Camp and Calef 1987). Based on current abundance, restored subpopulations in WBNP would include more than 2000 wood bison, while recovery to the 1972 level (Carbyn et al. 1989, 1998) would result in a population of about 9000 bison.

The Alaska Department of Fish and Game developed a proposal to restore wood bison to the Upper Yukon Basin in Alaska (Alaska Department of Fish and Game 1994). The Yukon Flats area lies within the original range of wood bison (Alaska Department of Fish and Game 1994; Lotenberg 1996; Stephenson et al. 2001) and continues to offer a substantial amount of high-quality habitat, with a carrying capacity conservatively estimated at 2000 bison (Gates 1992; Berger et al. 1995). The restoration of a viable wood bison population in this area would make a significant contribution to their conservation. The Beaver and Dendu tribal councils have resolved to support the restoration of wood bison and have authorized the use of their lands for this purpose. Other communities on the Yukon Flats support these initiatives.

The Recovery Team recommends reestablishing one or more populations in Alaska in areas capable of supporting the MVP of 400 wood bison. The opportunity to restore wood bison in Alaska is especially important to their conservation and long-term survival in North America. This is because of the limited availability of habitat for recovery of wood bison in their original range in Canada and the risk of infection of some Canadian herds with bovine tuberculosis and brucellosis.

A wood bison recovery project in Alaska would be consistent with the international agreement "Framework for Cooperation between Environment Canada and the U.S. Department of the Interior in the Protection and Recovery of Wild Species at Risk," signed in April 1997. The goal of the framework is to prevent populations of wild species in both Canada and the United States from becoming extinct as a consequence of human activity, through the conservation of wildlife populations and the ecosystems on which they depend. In addition to facilitating the reestablishment of wood bison in Alaska, the framework agreement could provide for cooperative and coordinated action to establish and manage a shared, transboundary population in Alaska and the Yukon.

The Government of the Republic of Sakha (Yakutia), Russia, has developed a program to restore and enrich biodiversity in the republic. As part of this effort, it have set aside land near Cherskii (Pleistocene Park), where grazing mammals are being restored to a fenced area. Pleistocene Park will contain an assemblage of large herbivores and predators resembling, as nearly as possible, those present 10 000 years ago. Wood bison are the closest living relatives of steppe bison and closely resemble bison that occurred in Siberia as recently as 5000–6000 years ago (van Zyll de Jong 1993). The Government of the Republic of Sakha (Yakutia) supports the establishment of a wood bison herd in Pleistocene Park.

The current initiative to reestablish bison reflects a long-standing interest in restoring large mammal fauna to northern Asia. A Russian nonprofit group called the Pleistocene Park Association, an international group of scientists (Chapin et al. 1997), and the Department of Biology Resources of the Ministry of Nature, Republic of Sakha (Yakutia), Russia, are organizing the current project. The Recovery Team supports this effort because it represents another potential opportunity to secure the survival of the subspecies in geographically separate populations.

The governments of Canada and the Republic of Sakha (Yakutia) are developing a protocol to complete this research project and have agreed to implement the transfer of wood bison to Pleistocene Park, pending the availability of funding. The Recovery Team recommends that the protocol agreement include a condition stating that wood bison will not be released to the wild unless a taxonomic evaluation concludes that Holocene forms in Siberia are related to those in Alaska and northwestern Canada. This evaluation should consider evidence from skeletal morphology, and an attempt should be made to determine phylogenetic relationships based on DNA.

Supplementing existing herds of wood bison in Canada, where further growth is desirable, is also a priority use of wood bison stock from captive breeding herds.

Section II
Wood Bison Recovery

1. Recovery goals and objectives

Although wood bison are no longer in imminent danger of extinction, additional efforts are required to secure their survival. The recovery plan outlines goals and specific objectives to achieve recovery of wood bison, first downlisting them from "threatened" status on the COSEWIC list and eventually delisting them altogether.

> GOAL #1:
> To reestablish at least four discrete, free-ranging, disease-free, and viable populations of 400 or more wood bison in Canada, emphasizing recovery in their original range, thereby enhancing the prospects for survival of the subspecies and contributing to the maintenance of ecological processes and biological diversity.

Although it is not possible to restore wood bison to their original abundance and distribution in Canada, further recovery of the subspecies is possible. Achieving the following objectives will contribute to fulfilling this goal:

1. Establish four or more free-ranging herds of wood bison in Canada. Each herd should be managed to meet or exceed the minimum viable population size (MVP) of 400 recommended for the subspecies and to maintain a stable or increasing population trend.
2. Augment existing wild herds as required, allowing them to reach or remain at the MVP.

A viable population is "a population in a state that maintains its vigor and its potential for evolutionary adaptation" (Soule 1987: 1). This requires that the population be free-ranging and subject to selective pressures.

The interaction of many factors and the probabilistic nature of viability estimates make it difficult to accurately determine the MVP. The MVP for bison has been inferred from a study of 24 western North American national parks and park assemblages (Newmark 1987) in which the median size of artiodactyl populations that became extinct was 241. The median size of thriving populations (N = 88) was 792. We infer that the population size of 200 previously proposed as the MVP for wood bison (Wood Bison Recovery Team 1987) may be too low. Bison are susceptible to periodic mortality in some areas, caused, for example, by drowning or anthrax. Substantial mortality from drowning was observed in the Mackenzie population in 1989, when 177 bison were killed (Larter et al. 1993), and in WBNP in 1974, when several thousand bison drowned in a spring flood (Carbyn et al. 1993). These losses indicate that catastrophic mortality can jeopardize small populations.

Therefore, the Recovery Team recommends that a free-ranging population of 400 or more bison be regarded as a realistic guideline for the MVP for wood bison. This does not contradict the establishment of smaller populations in limited habitat to contribute to the overall recovery of the subspecies.

3. Base reintroduction and management projects on knowledge of ecology, behaviour, and demography of wood bison. Conduct research on environmental and anthropogenic factors that affect bison populations.

> GOAL #2:
> To foster the restoration of wood bison in other parts of their original range and in suitable habitat elsewhere, thereby ensuring their long-term survival.

There is a substantial amount of high-quality habitat in parts of the original wood bison range in Alaska. Habitat also exists in eastern Siberia, where bison occurred for millennia during the Pleistocene and much of the Holocene, but where information concerning the history of late-Holocene bison is currently limited. Additional habitat exists in parts of Canada that lie outside the original range

of the subspecies. The Recovery Team supports the following initiatives because they will contribute to the global recovery and long-term survival of wood bison and to the restoration of ecological processes and diversity, and because the prospects for further recovery within the original range in Canada are limited.

1. Enhance wood bison conservation and recovery by providing technical assistance and disease-free wood bison from EINP for reintroduction to the Yukon Flats or other areas in Alaska. The Yukon Flats area is capable of supporting a viable population of wood bison that would contribute significantly to the restoration of the subspecies in its original range and enhance the global security of wood bison.
2. Support the establishment of a captive population of wood bison in Pleistocene Park, Siberia. Free-ranging populations may be established if additional taxonomic research confirms that a form resembling wood bison existed in Siberia during the mid to late Holocene.
3. Manage the Chitek Lake population so that it will reach or exceed 400 animals and contribute to the national objective of four populations in Canada that are each greater than the MVP. Although the Chitek Lake herd is outside the original distribution of wood bison, it serves goal #2.

GOAL #3:
To ensure that the genetic integrity of wood bison is maintained without further loss as a consequence of human intervention.

1. Minimize the risk of further hybridization between bison subspecies in the wild.
2. Broaden the genetic base of wood bison by encouraging the salvage of additional stock from herds infected with tuberculosis and brucellosis, where taxonomic evaluation indicates that they are morphologically representative of wood bison.
3. Reestablish wood bison in areas where they will be subject to natural selection.

GOAL #4:
To restore disease-free wood bison herds, thereby contributing to the aesthetic, cultural, economic, and social well-being of local communities and society in general.

1. Control or eliminate alien or exotic diseases of parasitic, viral, or bacterial origin (e.g., tuberculosis and brucellosis) in both free-ranging and captive wood bison herds under public ownership.
2. Reestablish or augment disease-free wood bison herds in suitable habitat, particularly where northern communities and aboriginal people will benefit from consumptive and/or nonconsumptive uses of bison.
3. Establish or augment captive herds that provide stock for conservation and recovery in the wild and support research and other purposes.
4. Encourage the establishment of long-term cooperative management programs to reestablish free-ranging, disease-free wood bison populations in which local communities, aboriginal people, and public agencies play an integral role.

2. General strategies

There are five strategies for realizing the plan's goals and objectives. Details are provided in the stepdown narrative and outline of tasks.

1. Continue to work towards resolution of the northern diseased bison issue. Explore new technologies and approaches that will lead to publicly acceptable disease management within the context of wood bison recovery.
2. Undertake background studies and research to provide information needed to manage extant herds and reestablish additional free-ranging populations.
3. Maintain the genetic integrity of free-ranging populations, augmenting genetic diversity where possible through salvage of disease-free bison from herds in and around WBNP and through exchange of individuals between populations.
4. Complete reintroduction projects where feasible. Northern Yukon and Alaska may well provide the last remote habitat in North America where the restoration of additional free-ranging populations is feasible. Suitable bison habitat also exists in eastern Siberia.
5. Develop public support for wood bison recovery through educational programs, and develop cooperative management projects with aboriginal people, other conservation groups, and resource development industries.

3. Stepdown outline

A. Undertake studies to fill information gaps pertinent to recovery

I. Disease

a. Evaluate the potential to salvage genetic resources from wood bison herds infected with brucellosis and tuberculosis

b. Evaluate the risk of disease-free herds becoming infected with tuberculosis and brucellosis
c. Evaluate the social, economic, and human health implications of bison populations infected with brucellosis and tuberculosis
d. Evaluate the epizootiology of anthrax with a view towards its control in free-ranging bison

II. Habitat
a. Evaluate integration of bison habitat management with forestry, oil and gas development, reclamation of industrial sites, and other land uses
b. Evaluate the use of prescribed fire for habitat management
c. Evaluate the rate of alienation or withdrawal of bison habitat associated with agricultural development

III. Predation and competition
a. Continue to assess the role of predation in limiting bison populations and ecological effects on other species

IV. Genetics
a. Evaluate approaches to maintain or enhance genetic diversity in wood bison populations

B. Implement actions in support of recovery

I. Ecological actions
a. Manage habitat with techniques such as prescribed fire, integrated land management plans, and reclamation of industrial development sites, to meet population objectives
b. Plan for disease management in the event of an outbreak of anthrax, tuberculosis, brucellosis, or other diseases in a disease-free herd

II. Intensive management techniques
a. Augment free-ranging populations where necessary and feasible
b. Establish new populations
1. Reestablish an additional wood bison herd in northeastern British Columbia
2. Reintroduce wood bison to Alaska
3. Transfer wood bison to Pleistocene Park, Sakha Republic (Yakutia), Russia
4. Reestablish populations in unoccupied areas of original range in Canada

c. Maintain disease-free breeding herds as sources of stock to establish or augment wild herds
d. Establish policies for use of wood bison from breeding herds
e. Protect disease-free populations from infection by tuberculosis and brucellosis
1. Maintain a buffer zone for Northwest Territories herds
2. Protect the Hay-Zama population
3. Monitor disease status of herds

f. Establish captive breeding herds using bison salvaged from herds infected with brucellosis and tuberculosis
g. Reestablish disease-free populations in areas occupied by herds infected with brucellosis and tuberculosis
h. Prevent further hybridization between plains bison and wood bison in the wild
1. Monitor and manage the Pink Mountain herd in northeastern British Columbia
2. Disallow the introduction of plains bison to the Yukon and Northwest Territories.
3. Establish designated wood bison management areas that exclude conflicting land uses
4. Regulate bison ranching where it conflicts with recovery of free-ranging wood bison herds

i. Enhance the genetic diversity of the Yukon herd by translocating wood bison from the Mackenzie population

III. Sociopolitical actions
a. Encourage development of a long-range plan to resolve problems associated with brucellosis and tuberculosis
b. Develop population management plans that integrate conservation and recovery values with the needs of rural communities
c. Foster recovery of disease-free wood bison in the Caribou–Lower Peace river area in Alberta

C. Evaluate the effectiveness of recovery actions

I. Monitor population status and trend
II. Monitor the habitat and land base available for wood bison
III. Evaluate management alternatives for populations infected with tuberculosis and brucellosis, including inaction, interim containment, and efforts to eradicate disease
IV. Arrange periodic meetings of the Recovery Team

4. Narrative for stepdown outline

The history of the North American bison is fraught with examples of habitat destruction, land use conflicts, intentional and inadvertent destruction of populations, commercial exploitation, and excessive hunting. While the restoration of bison to original levels of abundance is no longer feasible, the recovery and continued evolution of both North American subspecies of bison are possible. This will require the cooperation of conservation agencies,

aboriginal organizations, communities, commercial bison producers, and other nongovernment organizations. The following narrative identifies the information needed to support recovery actions. It also describes management activities required to reach recovery goals and outlines a program to evaluate recovery actions and make adjustments to improve the effectiveness of the wood bison recovery program.

A. Undertake studies to fill information gaps pertinent to recovery

Information is required to guide the management of existing herds and to support additional recovery projects.

I. Disease

a. Evaluate the potential to salvage genetic resources from wood bison herds infected with brucellosis and tuberculosis

Conservation biologists are concerned about the potential loss of genetic diversity that could accompany efforts to eradicate tuberculosis or brucellosis from northern bison populations. The Hook Lake wood bison recovery project includes an effort to assess the genetic diversity in a wild herd and methods to maintain those genetic resources, including rare alleles, in a captive breeding herd. These studies involve a cooperative effort between the Government of the Northwest Territories and the Deninu Kue' First Nation. The initiative of the Little Red River Cree First Nation and the Tall Cree First Nation to salvage bison from the Caribou–Lower Peace river area is similarly encouraged.

b. Evaluate the risk of disease-free herds becoming infected with tuberculosis and brucellosis

The Animal and Plant Health Risk Assessment group of the Canadian Food Inspection Agency has completed a risk assessment. However, the Canadian Bison Association Disease Risk Management Committee has asked that additional information be included in the assessment and supports the development of guidelines for bison and livestock producers in areas at risk. The governments of the Northwest Territories, British Columbia, and Alberta support this initiative because of their interest in the health of both wild and captive ungulates.

c. Evaluate the social, economic, and human health implications of bison populations infected with brucellosis and tuberculosis

Social, economic, and human health considerations have a bearing on the reestablishment of wood bison in a large portion of their original range. The term "economic" is used in the broad sense and includes both subsistence and commercial values of bison. A large area in northern Alberta is currently unsuitable for free-ranging populations of wood bison because of the presence of diseased bison in the region. There continues to be the potential for infection of the Hay-Zama herd, commercial bison herds, and domestic livestock. A large bison-free zone is required in the Northwest Territories to maintain the disease-free status of the Mackenzie and Nahanni populations and to protect conservation and economic values. The Deninu Kue' First Nation has undertaken a long-term program to eradicate the two bovine diseases from the Hook Lake herd and enhance its value to the community. There is a need to evaluate lost economic opportunities and other costs associated with land withdrawal, maintaining buffer zones, and management efforts to contain and/or eradicate the diseases.

There has not been an adequate assessment of the risk of infection to people who handle or eat infected bison. The risk of humans becoming infected with either disease will depend on a number of factors, one of which is the extent of contact with infected bison. The Little Red River Cree and the Tall Cree First Nations have expressed an interest in evaluating socioeconomic and human health issues related to bison diseases. This task was identified as a possible component of WBNP's Bison Research and Containment Program, but funding has not been allocated to conduct the study.

d. Evaluate the epizootiology of anthrax with a view towards its control in free-ranging bison

The current approach to controlling anthrax is to detect and dispose of carcasses using methods that reduce environmental contamination with infectious endospores. Advances in immunology may lead to new techniques that will allow for detection and decontamination of spore concentration sites. The Department of Microbiology and Public Health of the University of Alberta Hospitals is conducting research to develop a field assay to detect areas where anthrax is concentrated.

II. Habitat

a. Evaluate integration of bison habitat management with forestry, oil and gas development, reclamation of industrial sites, and other land uses

Much of Canada's original wood bison range is undergoing development of natural resources. There is potential to create and improve habitat associated with forestry, oil and gas development, and reclamation. The potential for modifying the amount and quality of wood bison habitat should be examined.

There are several opportunities to test the feasibility of using industrial land use development to benefit bison, including the following:

1) Small forest clearcuts are being seeded with grass to provide forage for the Nahanni wood bison herd in the Liard Valley in the Northwest Territories. An oil and gas exploration company operating west of the Liard River and north of Fort Liard, Northwest Territories, will be seeding seismic lines, road allowances, and drilling sites with a forage mixture suitable for bison.
2) Similar reclamation activities on well sites and linear corridors resulted in the establishment of meadow vegetation in the Etthithun Lake area in northeastern British Columbia. These meadows were considered in appraising the capability of the area for wood bison. Any future reintroductions in northeastern British Columbia will likely utilize similar habitats to some degree.
3) The Little Red River Cree and the Tall Cree First Nations have expressed a desire to work with forestry companies to improve habitat for bison near WBNP.
4) Syncrude Canada Ltd. is proposing to include up to 9% meadow habitat for bison in a restored landscape mosaic including forest, grasslands, and wetlands in an area of about 250 km^2 near Fort McMurray. At the request of the Government of Alberta, Syncrude reduced the proposed grassland area of the reclaimed landscape from 20% to 9%. A Conservation and Reclamation Plan has been submitted for approval.
5) The Recovery Team recommends that oil sands reclamation sites be restored in ways that will increase the amount of available wood bison habitat. At present, bison habitat is fenced and the wood bison are privately owned. However, continuing participation of project managers in the recovery program could lead to establishment of a wild herd that would benefit conservation and recovery of wood bison, should the northern diseased bison issue be resolved.

b. Evaluate the use of prescribed fire for habitat management

Habitat management practices that could maintain or improve the northern meadow complex, the key habitat for bison, could be better understood. Many meadows have been grazed only lightly or not at all in the recent past, and accumulated plant litter and encroachment by woody plants have reduced forage production. Evaluation of the potential for using prescribed burning to create or improve bison habitat is an important area for study. However, factors other than fire may play a role in habitat renewal, particularly in low-lying meadows where periodic flooding may maintain graminoid communities. Therefore, studies on the hydrology of the Lower Peace River in Alberta, the Peace–Athabasca Delta, and the SRL are seen as important research initiatives.

c. Evaluate the rate of alienation or withdrawal of bison habitat associated with agricultural development

The commercial bison industry is expanding, particularly in northeastern British Columbia and northern Alberta. There has been no formal assessment of its effects on availability of habitat for free-ranging wood bison. However, potential problems and solutions are being discussed with the agricultural community in British Columbia.

III. Predation and competition

a. Continue to assess the role of predation in limiting bison populations and ecological effects on other species

Empirical evidence from one area in Canada suggests that large numbers of bison may indirectly affect populations of other large herbivores. Larter et al. (1994) hypothesized that the large number of bison in the Mackenzie population supported an increase in wolf numbers, resulting in increased predation on moose. However, bison coexist with high densities of moose and/or other ungulates in several areas, and there appears to be relatively little interaction between wolf and bison populations when the number of bison is near the MVP. The interrelationships between predators and prey in systems where multiple species are present are variable and complex (Gasaway et al. 1983; Seip 1992). Interactions among bison, moose, caribou, and predator populations deserve further research. Potentially important research topics include niche partitioning and overlap between herbivore species, numerical and functional responses of predators to bison populations, and effects of predation on alternative prey species in relation to wood bison population size.

IV. Genetics

a. Evaluate approaches to maintain or enhance genetic diversity in wood bison populations

Both plains bison and wood bison survived a period of extremely low numbers, or genetic "bottlenecks." Evaluation of effects on genetic variation within and between populations will contribute towards improving genetic management of both wild and captive breeding herds.

B. Implement actions in support of recovery

I. Ecological actions

Recommended management actions address limiting factors while respecting conservation of biodiversity and human needs. Individual populations should be maintained at or above 400 wood bison where habitat will support this number.

a. Manage habitat with techniques such as prescribed fire, integrated land management plans, and reclamation of industrial development sites, to meet population objectives

Meadows provide important habitat for wood bison. When hunting or other mortality factors are appropriately managed, bison can thrive where natural resource development has created meadow habitat. Several examples exist where habitat management has occurred in conjunction with natural resource development.

Prescribed fire is being applied in the Northwest Territories to improve and expand bison habitat for the Mackenzie and the SRL populations. Prescribed fire and habitat improvement by logging have been carried out in the Liard River Valley in British Columbia and the Northwest Territories. These initiatives are consistent with the goals and objectives of the recovery plan.

The Recovery Team recommends that wood bison conservation objectives be incorporated in Syncrude's reclamation efforts, allowing for the establishment of populations on reclaimed oil sands lands. This would contribute to the national conservation and recovery program for wood bison.

b. Plan for disease management in the event of an outbreak of anthrax, tuberculosis, brucellosis, or other diseases in a disease-free herd

Contingency plans are needed to deal with the possible outbreak of diseases in a disease-free herd. The Northwest Territories has developed an emergency response plan for anthrax. The objectives are to minimize the extent of contamination of bison range and reduce the risk of human exposure to anthrax spores. Contingency plans for outbreaks of diseases other than anthrax are strongly recommended.

II. Intensive management techniques

a. Augment free-ranging populations where necessary and feasible

Supplementation of existing herds in Canada is seen as a priority for the allocation of animals from captive breeding herds. Surplus wood bison from EINP can be used to augment disease-free wild populations or for other conservation initiatives as requested by conservation agencies. Consideration should be given to augmenting the Nordquist herd and the Chitek Lake herd. Periodic censuses are necessary to monitor the status of each population.

b. Establish new populations

1. Reestablish an additional wood bison herd in northeastern British Columbia

A renewed effort is being made to establish a wood bison herd in the Etthithun Lake area in British Columbia. The herd will initially be maintained in a fenced area. A free-ranging population is to be established once conditions are suitable.

2. Reintroduce wood bison to Alaska

An additional herd exceeding the MVP could result from a reintroduction of wood bison to the Yukon Flats or other areas in Alaska. The Recovery Team recommends that Canada support the Alaskan proposal by providing technical assistance and disease-free wood bison from EINP. The Yukon Flats area is capable of supporting a population that would contribute significantly to the restoration of the subspecies within its original range, thereby enhancing the global security of wood bison. Some policy issues still need to be resolved before this project can be implemented.

3. Transfer wood bison to Pleistocene Park, Sakha Republic (Yakutia), Russia

The Pleistocene Park proposal is supported because it will contribute to the global security of wood bison. This international research project will require planning and cooperation by Canada and the Republic of Sakha (Yakutia), Russia. Funding for the project is being sought.

4. Reestablish populations in unoccupied areas of original range in Canada

The original range of wood bison in the Yukon and Northwest Territories extended nearly to the Arctic Ocean (Figure 1). Additional bison habitat appears to exist in the Lower Mackenzie Valley, near Wha Ti (Lac la Martre) in the Northwest Territories, and as far north as the Old Crow Flats in the Yukon. Studies are required to confirm the availability and quality of additional sites in the Yukon and Northwest Territories. In Alberta, there may be additional suitable habitat south of WBNP that could support wood bison. Reestablishing wood bison populations in these areas would contribute to the security of the subspecies in the wild. The continued presence of populations infected with tuberculosis and brucellosis in Alberta presents an obstacle to reestablishing additional wood bison herds in some areas. The support and participation of local communities are important prerequisites for successful reintroduction projects in these jurisdictions.

c. Maintain disease-free breeding herds as sources of stock to establish or augment wild herds

Although there has been steady progress towards the recovery goal of at least four wild herds of 400 wood bison each, there is a continuing need to propagate wood bison for conservation and recovery projects. The EINP herd serves as the national breeding herd for recovery projects. Wild populations that have exceeded the MVP should also be considered as a source of stock for recovery projects and for increasing genetic diversity in other herds. The Mackenzie herd is the largest free-ranging, disease-free wood bison population. It represents a significant gene pool that could be used to augment or reestablish other populations. The management plan developed by the Government of the Northwest Territories in 1987 states that wood bison could be made available for translocation (Government of the Northwest Territories 1987). Public agencies wishing to establish herds should be aware of this policy.

d. Establish policies for use of wood bison from breeding herds

The Recovery Team recommends the following priorities for the transfer of wood bison from source herds:

1) Establish wild herds in original range within Canada.
2) Augment existing wild, disease-free herds in original range within Canada.
3) Establish or augment wild herds outside of original range within Canada.
4) Establish or augment wild herds in original range outside of Canada.
5) Establish or augment wild herds outside original range outside of Canada.
6) Contribute to captive operations that have conservation objectives (priority is given to projects undertaken by First Nations).
7) Contribute to scientific research institutions.
8) Contribute to zoos for display and captive breeding.
9) If there is no further opportunity to contribute to projects falling under the above eight priorities, sell surplus bison to the commercial industry. Revenue from the sale of animals from public herds should be dedicated to wood bison conservation.

e. Protect disease-free populations from infection by tuberculosis and brucellosis

1. Maintain a buffer zone for Northwest Territories herds

A comprehensive solution to the management issues posed by diseased populations will not be developed until current disease research is completed. Interim risk management measures should be continued or put into place to reduce the risk of infection of disease-free bison herds in the region. The Government of the Northwest Territories and Heritage Canada should continue to guard against interchange between disease-free herds and infected populations in WBNP.

2. Protect the Hay-Zama population

The Hay-Zama herd is currently free-ranging in the northwestern corner of Alberta. It was established with disease-free stock from EINP and is protected in a designated Wildlife Management Area. Bison can be hunted without restriction in the area between the Wildlife Management Area and WBNP. Maintaining low numbers of bison adjacent to WBNP reduces the risk of diseases being transferred to the disease-free Hay-Zama herd and to captive bison and livestock in the region. Alberta will maintain this policy until the disease reservoir is no longer a threat. The Recovery Team recognizes that although this interim approach to disease management is necessary, the recovery of disease-free wood bison herds would be more beneficial to the ecosystem, would better serve the interests of local communities, and should continue to be the ultimate goal.

3. Monitor disease status of herds

Periodic testing of disease-free herds should be carried out to determine and confirm disease-free status. Serological and histopathological monitoring of disease status, especially brucellosis and tuberculosis, should be conducted, particularly where there is the risk of contact with infected herds.

f. Establish captive breeding herds using bison salvaged from herds infected with brucellosis and tuberculosis

The successful establishment of an additional disease-free captive breeding herd using a large number of wood bison captured in the wild will make a major contribution to the national recovery program. This is being attempted with bison removed from the Hook Lake herd in the SLR. The Little Red River Cree First Nation and the Tall Cree First Nation are considering a similar project involving the Wentzel Lake herd.

g. Reestablish disease-free populations in areas occupied by herds infected with brucellosis and tuberculosis

Although WBNP comprises only a small percentage of wood bison range in Canada, the presence of diseased bison in and adjacent to the park effectively precludes the establishment of disease-free wood bison herds in a much larger area. Eradication of these diseases is necessary if the area is to support disease-free populations in the future. A pilot study would be an effective means of assessing techniques for disease eradication. The Government of the Northwest Territories and the Deninu Kue' First Nation have undertaken a program to reestablish a disease-free wood bison population in the eastern SRL. They implemented a conservative approach involving habitat management, capture and antibiotic treatment of bison calves, periodic disease testing, and establishment of a captive breeding herd. Methods to eliminate the infected parent population and reestablish a disease-free herd in the wild are being developed.

h. Prevent further hybridization between plains bison and wood bison in the wild

1. Monitor and manage the Pink Mountain herd in northeastern British Columbia

Two wood bison herds were recently reestablished in northeastern British Columbia. However, the size and range of the Pink Mountain plains bison herd have increased. Separation between plains bison and wood bison must be maintained to prevent hybridization. A primary goal of the 2000 BC Bison Management Plan is to prevent interbreeding between plains and wood bison (Harper et al. 2000). Recommended actions include the designation of separate wood bison and plains bison management areas as well as limiting the number of plains bison to approximately 1800 adults. If plains bison move beyond designated boundaries, the Government of British Columbia will limit distribution using hunting by licensed hunters, aboriginal hunters, or Ministry staff. Similarly, if plains bison escape from ranches in northeastern British Columbia, actions authorized in statute and policy will be used to remove the animals from the wild.

2. Disallow the introduction of plains bison to the Yukon and Northwest Territories

The Yukon and Northwest Territories have established policies that prevent importation of plains bison for the purpose of establishing captive or free-ranging herds. Participating jurisdictions should maintain such policies.

3. Establish designated wood bison management areas that exclude conflicting land uses

Agricultural development is expanding in northern Alberta and northeastern British Columbia. Free-ranging bison populations are generally not compatible with large-scale livestock and crop production. Therefore, habitat designated for free-ranging wood bison should be protected from extensive agricultural development.

4. Regulate bison ranching where it conflicts with recovery of free-ranging wood bison herds

Commercial bison ranches are expanding in parts of original wood bison range, particularly in the agricultural corridor along the Peace River. This is creating a potential problem for wood bison recovery. Existing legislation and policies are inadequate to ensure containment of captive commercial bison. Wildlife management agencies should regulate bison ranching and other wildlife ranching to safeguard wild herds and their habitat. Alberta does not currently have legal authority to address this issue. However, British Columbia, the Northwest Territories, Yukon, and Alaska have legislative authority to regulate bison as wildlife.

The cooperative development of improved regulations governing confinement will benefit commercial bison producers as well as agricultural and wildlife agencies. Contact between commercial bison of known disease-free status and free-ranging bison of unknown disease status may result in a change in federal disease-free health status of commercial herds. Existing legislation addresses stray livestock, including bison, but improvements might include more stringent fencing standards and a requirement

to mark/brand captive stock and to report escapes within a specified time. Inclusion of stipulations on recapture methods and time constraints would also be beneficial.

i. Enhance the genetic diversity of the Yukon herd by translocating wood bison from the Mackenzie population

The Government of Yukon has made a request to obtain up to six young bulls from the Mackenzie population to enhance the genetic diversity of the wild herd in the Nisling River Valley. The exact number to be translocated should be sufficient to provide a meaningful contribution to the genetic diversity of the wild population. The published management plan for the Yukon herd proposes that a translocation should occur after the year 2000 (Government of Yukon 1998).

III. Sociopolitical actions

a. Encourage development of a long-range plan to resolve problems associated with brucellosis and tuberculosis

The governments of British Columbia, Alberta, the Northwest Territories, and Canada should collaborate with the Canadian Bison Association and environmental and conservation organizations in managing and eradicating bovine tuberculosis and brucellosis from free-ranging herds. It is recognized that this difficult issue cannot be resolved within the context of the recovery plan. However, the eradication of brucellosis and tuberculosis from free-ranging bison, accompanied by genetic conservation and recovery of disease-free wild herds, is a desirable long-range goal. The Recovery Team can enhance prospects for the long-term survival of wood bison by facilitating the reestablishment of additional disease-free populations in northern Canada and Alaska and by encouraging research on the epidemiology of brucellosis and tuberculosis and related conservation issues.

b. Develop population management plans that integrate conservation and recovery values with the needs of rural communities

Free-ranging, disease-free wood bison populations have the potential to contribute significantly to the economic well-being of rural communities through ecotourism, subsistence and trophy hunting, and the sale of value-added products, such as heads, hides, meat, and possibly live animals. Many of these uses are consistent with rural lifestyles, including aboriginal cultures, in the boreal forest region. Where appropriate, population recovery and management plans should reflect the utilitarian value of wood bison to local communities. Wildlife management agencies should recognize the interests of First Nations in the recovery of wood bison in the boreal forest region. Efforts should be made to ensure that local communities and First Nations are involved in shaping the management of wood bison populations in local areas. However, public consultation should be broad and include other interest groups as well.

Bison management plans have been developed for wood bison in British Columbia (Harper et al. 2000) and for the Mackenzie (Government of the Northwest Territories 1987), Hook Lake (Deninoo Wildlife and Resources Committee 1991), and Yukon herds (Government of Yukon 1998).

c. Foster recovery of disease-free wood bison in the Caribou–Lower Peace river area in Alberta

The Little Red River Cree First Nation and the Tall Cree First Nation have developed a long-term vision for the recovery of disease-free wood bison in the Caribou–Lower Peace river area. These two First Nations communities are proposing to undertake biological studies and the salvage of bison from the Wentzel Lake herd as part of the Caribou–Lower Peace Aboriginal Model Forest program. The Recovery Team supports the following initiatives in the area:

1) establishing an interim (five-year) protection area for bison north of the Peace River in the range of the Wentzel Lake herd, after which the area would be opened to hunting if brucellosis and/or tuberculosis are still present in the population;
2) assessing the disease status of the Wentzel Lake population;
3) capturing animals to salvage wood bison genetics from the Wentzel Lake herd;
4) establishing a disease-free captive breeding herd with animals captured from the Wentzel Lake area;
5) establishing a captive breeding herd south of the Peace River using disease-free wood bison from EINP and/or other sources; and
6) the eventual recovery of a free-ranging, disease-free wood bison population in the Caribou–Lower Peace river area.

C. Evaluate the effectiveness of recovery actions

I. Monitor population status and trend

The status and trend of each population of wood bison should be regularly monitored.

II. Monitor the habitat and land base available for wood bison

Management agencies should evaluate the effects of agricultural or industrial development, forestry, and habitat enhancement projects on habitat available for wood bison.

III. Evaluate management alternatives for populations infected with tuberculosis and brucellosis, including inaction, interim containment, and efforts to eradicate disease

The effectiveness of efforts to control or eradicate tuberculosis and brucellosis and their effect on genetic resources, ecological processes, and other conservation values should be evaluated.

IV. Arrange periodic meetings of the Recovery Team

The Wood Bison Recovery Team should meet annually, or as required, to review the status and management of wood bison relative to recovery objectives identified in this recovery plan.

Section III
Implementation schedule

The implementation schedule outlines recovery tasks for the entire recovery period and ranks them in order of priority. It will be used in the regular monitoring of activities and as a basis for funding recovery measures. The various tasks are grouped together under general categories, and their description is taken from the outline of tasks. The schedule sets out objectives and tasks in most cases, identifies the responsible agencies, and provides estimates of funding and person-years required. Tasks will be revised regularly based on results and new information and opportunities.

Recovery priorities are defined as follows:

Priority 1: An action required to reestablish a population or to prevent its extirpation or irreversible decline in the foreseeable future.

Priority 2: An action required to prevent a significant decline in population or habitat quality or other significant negative trends short of extirpation.

Priority 3: Other actions necessary to achieve recovery and reclassification of the subspecies in Canada.

Acronyms used in the implementation schedule are as follows:

ADFG	Alaska Department of Fish and Game
AE	Alberta Environment
BCME	British Columbia Ministry of Environment, Lands and Parks
CBA	Canadian Bison Association
CFIA	Canadian Food Inspection Agency
CWS	Canadian Wildlife Service
DCH	Department of Canadian Heritage, Bison Research and Containment Program
DG	Deh Gah Gotie Council (includes the Fort Providence Resources Management Board)
DKFN	Deninu Kue' First Nation (includes the Fort Resolution Aboriginal Wildlife Harvesters' Committee)
DRWED	Department of Resources, Wildlife and Economic Development, Government of the Northwest Territories
EINP	Elk Island National Park
MDNR	Manitoba Department of Natural Resources
tbd	to be determined
UAH	University of Alberta Hospitals, Department of Microbiology and Public Health
UC	University of Calgary
WBRT	Wood Bison Recovery Team
YTG	Yukon Territorial Government

Action	Priority	Responsibility: Lead	Responsibility: Coop.[a]	Target date	Estimated costs ($K/PY[b]): 1999/2000	2000/2001	2001/2002	2002/2003	2003/0204
1. Studies to fill gaps									
I. Disease									
a. Genetic salvage of diseased herds	1	DRWED[c]	DKFN	2001/02	165.0/2.0	165.0/2.0	165.0/2.0	165.0/2.0	–
b. Evaluate risk of healthy herds becoming infected	1	UC	CBA CFIA AE DRWED	2000/01	53.0/1.5	33.0/1.5	–	–	–
c. Implications of infected herds	2	tbd							
d. Epizootiology of anthrax	3	DRWED	UAH DG	Ongoing	10.0/0.2	7.5/0.2	7.5/0.2	7.5/0.2	7.5/0.2
II. Habitat									
a. Integration with resource and land use	2	YTG	UC	2000/01	35.0/0.3	15.0/0.3	–	–	–
b. Evaluate prescribed fire	2	tbd							
c. Agricultural development and habitat loss	3	tbd							
III. Predation and competition									
a. Predation	3	DRWED		2000/01	7.0/0.4	7.0/0.4	–	–	–
IV. Genetics									
a. Genetic diversity	2	tbd		2001/02	–	–	3.0/0.2	–	–
2. Implement actions									
I. Ecological actions									
a. Manage habitat (prescribed fire, integrated plans, reclamation)	1	EINP MDNR DRWED BCME	CWS	Ongoing Ongoing Ongoing Ongoing	15.0/0.2 3.5/0.1 100.0/3.0 5.0/0.1 –	15.0/0.2 3.5/0.1 100.0/3.0 50.0/0.5 –	15.0/0.2 3.5/0.1 100.0/3.0 50.0/0.5 2.0/0.2	15.0/0.2 3.5/0.1 100.0/3.0 50.0/0.5 2.0/0.2	15.0/0.2 3.5/0.1 100.0/3.0 50.0/0.5 2.0/0.2
b. Plan for disease management	1	EINP			– / 0.1	– / 0.1	–	–	–
II. Intensive management									
a. Augment populations with surplus bison	1	EINP	BCME		40.0/0.4 20.0/0.4	40.0/0.4 70.0/0.5	40.0/0.4	40.0/0.4	40.0/0.4
b. Establish new populations	1	ADFG[d] BCME CWS			– Ongoing/0.5	– 1.0/0.1	– 2.0/0.1	– 2.0/0.1	– 2.0/0.1
c. Maintain disease-free breeding herds	1	tbd							
d. Policies for use of breeding herds	3	tbd							
e. Protect disease-free populations	1	DRWED[e]	DCH	Ongoing	69.0/0.5	69.0/0.5	69.0/0.5	69.0/0.5	69.0/0.5
f. Establish captive breeding herds	1	tbd							
g. Reestablish disease-free populations	1	tbd							
h. Prevent further hybridization	1	EINP BCME		Ongoing	50.0/0.4 10.0/0.2	50.0/0.4 10.0/0.2	10.0/0.2 10.0/0.2	10.0/0.2 10.0/0.2	10.0/0.2 10.0/0.2
i. Exchange of animals to enhance genetic diversity	2	YTG		2003	–	–	5.0/–	5.0/–	5.0/–
III. Sociopolitical									
a. Long-term plan to resolve disease issue	1	tbd							
b. Management plans and needs of local communities	2	DRWED YTG BCME		Ongoing Ongoing Ongoing	5.0/0.1 5.0/– 10.0/0.2	5.0/0.1 5.0/– 5.0/0.1	5.0/0.1 5.0/– 5.0/0.1	5.0/0.1 5.0/– 5.0/0.1	5.0/0.1 5.0/– 5.0/0.1
c. Foster recovery of bison in Caribou–Lower Peace river area	2	tbd							

Continued on next page

Action	Priority	Responsibility: Lead	Responsibility: Coop.[a]	Target date	Estimated costs ($K/PY[b]): 1999/2000	2000/2001	2001/2002	2002/2003	2003/0204
3. Evaluation									
I. Population status and trend	1	EINP		Ongoing	5.0/0.1	5.0/0.1	5.0/0.1	5.0/0.1	5.0/0.1
		DRWED[f]			30.0/0.3	5.0/0.1	5.0/0.1	5.0/ 0.1	5.0/0.1
		MDNR			6.0/0.1	6.0/0.1	6.0/0.1	6.0/0.1	6.0/0.1
		YTG			25.0/0.3	25.0/0.3	25.0/0.3	25.0/0.3	25.0/0.3
		BCME			8.0/0.2	8.0/0.2	20.0/0.3	20.0/0.3	20.0/0.3
II. Monitor habitat and land base	1	YTG		Ongoing	3.0/–	3.0/–	3.0/–	3.0/–	3.0/–
		BCME			30.0/0.5	10.0/0.2	5.0/0.2	5.0/0.2	5.0/0.2
III. Evaluate disease management alternatives	2	EINP			7.0/0.2	7.0/0.2	7.0/0.2	7.0/0.2	7.0/0.2
IV. Periodic meetings of WBRT	3	WBRT	CWS	Ongoing	2.0/0.2	2.0/0.2	2.0/0.2	2.0/0.2	2.0/0.2
			DRWED		1.0/0.1	1.0/0.1	1.0/0.1	1.0/0.1	1.0/0.1
			YTG		1.0/–	1.0/–	1.0/–	1.0/–	1.0/–
			BCME		1.0/0.1	1.0/0.1	1.0/0.1	1.0/0.1	1.0/0.1
TOTALS					721.5/12.7	725.0/12.2	578.0/9.7	575.0/9.5	410.0/7.5

Five-year grand to tal = $3 009 500 and 51.6 per son-years

[a] Cooperators.
[b] Es ti mated costs in thou sands of dol lars and per son-years com mit ted by an agency.
[c] Sub ject to an nual bud get pro cess.
[d] Im ple men ta tion of the Yu kon Flats pro ject is un cer tain at pres ent due to pol icy ques tions within the U.S. Fish and Wild life Ser vice. Fi nan cial com mit-ments can not be made un til these is sues are re solved.
[e] An nual mon i tor ing of the Bi son Con trol Area Pro gram is funded co op er a tively (50:50 cost share) by the Gov ern ment of the North west Ter ri tories, De-part ment of Re sources, Wild life and Eco nomic De vel op ment, and the Gov ern ment of Can ada, Department of Ca na dian Her i tage.
[f] Fre quency of sur veys for bi son herds in the North west Ter ri tories is un der re view.

Section IV
Literature cited

Alaska Department of Fish and Game. 1994. Reintroducing wood bison to the Upper Yukon Valley, Alaska: A feasibility assessment. Unpublished report (Fairbanks, AK). 94 pp.

Alberta Forestry, Lands and Wildlife. 1989. Alberta's Fish and Wildlife reply to Northern Diseased Bison Assessment Panel information requirements. Pages 110–126 *in* Northern Diseased Bison Environmental Assessment Panel: Compendium of government submissions and technical specialist reports in response to the Panel information requirements document. Federal Environmental Assessment Review Office (Ottawa, ON).

Allen, J.A. 1876. The American bisons, living and extinct. *Memoirs of the Museum of Comparative Zoology* 4: 1–246. Cambridge University Press (Cambridge, UK).

Archipov, N.D. 1989. Drevnye Kul'tury Iakutii. Izdatel'stvo, Yakutsk.

Avise, J.C. and R.M. Ball, Jr. 1990. Principles of genealogical concordance in species concepts and biological taxonomy. Pages 45–67 *in* D. Futuyma and J. Autonovics (Editors): *Oxford surveys in evolutionary biology*. Oxford University Press (Cambridge, UK).

Banfield, A.W.F. and N.S. Novakowski. 1960. The survival of the wood bison (*Bison bison athabascae* Rhoads) in the Northwest Territories. *Natural History Papers No. 8*. Natural Museum of Man, August 30, 1960. 6 pp.

Berger, M., R.O. Stephenson, P. Karczmarczyk, and C.C. Gates. 1995. Habitat inventory of the Yukon Flats as potential wood bison range. Unpublished report. Alaska Department of Fish and Game (Fairbanks, AK). 38 pp.

Bhambhani, R. and J. Kuspira. 1969. The somatic karyotypes of American bison and domestic cattle. *Canadian Journal of Genetics and Cytology* 11: 243–249.

Blood, D.C., O.M. Radostits, J.A. Henderson, J.H. Arundel, and C.C. Gay. 1983. *Veterinary medicine — A textbook of disease in cattle, sheep, goats and horses.* 6th edition. Baillere, Tindall (London, UK). 1310 pp.

Bork, A.M., C.M. Strobeck, F.C. Yeh, R.J. Hudson, and R.K. Salmon. 1991. Genetic relationship of wood and plains bison based on restriction fragment length polymorphisms. *Canadian Journal of Zoology* 69: 43–48.

Broughton, S. 1987. Diseases affecting bison. Pages 34–38 *in* H.W. Reynolds and A.W.L. Hawley (Editors): *Bison ecology in relation to agricultural development in the Slave River lowlands, NWT*. Occasional Paper No. 63. Canadian Wildlife Service (Ottawa, ON).

Campbell, C., I.D. Campbell, C.B. Blyth, and J.H. McAndrews. 1994. Bison extirpation may have caused aspen expansion in western Canada. *Ecography* 17: 360–362.

Carbyn, L.N. and T. Trottier. 1988. Description of wolf attacks on bison calves in Wood Buffalo National Park. *Arctic* 41: 297–302.

Carbyn, L.N., D. Huisman, E. Street, and D. Anions. 1989. An analysis of the decline of bison in Wood Buffalo National Park from 1971 to 1981 and a review of the status to 1989. Unpublished report. Canadian Wildlife Service (Edmonton, AB). 268 pp.

Carbyn, L.N., S.M. Oosenbrug, and D.W. Anions. 1993. Wolves, bison and the dynamics related to the Peace–Athabasca Delta in Canada's Wood Buffalo National Park. *Canadian Circumpolar Research Series No. 4.* Canadian Circumpolar Institute, University of Alberta (Edmonton, AB). 270 pp.

Carbyn, L.N., N. Lunn, and K. Timoney. 1998. Trends in the distribution and abundance of bison in Wood Buffalo National Park. *Wildlife Society Bulletin* 26: 463–470.

Chapin III, F.S., M.C. Chapin, and S.A. Zimov. 1997. Preliminary proposal for a bison reintroduction to northeast Siberia. Unpublished report. Department of Integrative Biology, University of California (Berkeley, CA). 41 pp.

Chowns, T., C. Gates, and F. Lepine. 1998. Large scale free burning to improve wood bison habitat in northern Canada. Pages 205–210 *in* L. Irby and J. Knight (Editors): *International symposium on bison ecology and management in North America.* Bozeman, MT, 4–7 June 1997. Montana State University (Bozeman, MT).

Clarke, C.H.D. c. 1945. Biological reconnaissance of the lands adjacent to the Alaska Highway in northern British Columbia and the Yukon Territory. Unpublished report in the National Archives of Canada, RG 85 collection, Vol. 1191, file 400-2, Parts 1–2.

Cook, F.R. and D. Muir. 1984. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC): history and progress. *The Canadian Field-Naturalist* 98: 63–70.

Cronin, M.A. 1986. Genetic relationships between white-tailed deer, mule deer, and other large mammals inferred from mitochondrial DNA analysis. M.Sc. thesis. Montana State University (Bozeman, MT). 49 pp.

Cronin, M.A. 1991. Mitochondrial-DNA phylogeny of deer (Cervidae). *Journal of Mammalogy* 72: 533–566.

Cronin, M.A., D.A. Palmisciano, E.R. Vyse, and D.G. Cameron. 1991. Mitochondrial DNA in wildlife forensic science: species identification of tissues. *Wildlife Society Bulletin* 19: 94–105.

Davis, D.S., J.W. Templeton, T.A. Ficht, J.D. Williams, J.D. Kopek, and L.G. Adams. 1990. *Brucella abortus* in captive bison. I. Serology, bacteriology, pathogeneses and transmission to cattle. *Journal of Wildlife Disease* 26: 360–371.

Davis, D.S., J.W. Templeton, T.A. Ficht, J.D. Huber, R.D. Angus, and L.G. Adams. 1991. *Brucella abortus* in bison. II. Evaluation of strain 19 vaccination of pregnant cows. *Journal of Wildlife Disease* 27: 258–264.

Deninoo Wildlife and Resources Committee. 1991. Hook Lake wood bison management plan. Report prepared by the Deninoo Wildlife and Resources Committee, July 1991. Deninoo Kue First Nation (Fort Resolution, NT). 27 pp.

Dragon, D. and B. Rennie. 1995. The ecology of anthrax spores: Tough but not invincible. *Canadian Veterinary Journal* 36: 295–301.

Elliott, J.P. 1989. A proposal for the reintroduction of wood bison to British Columbia. Unpublished report. British Columbia Ministry of Environment, Lands and Parks (Victoria, BC). 15 pp.

Environment Canada. 1990. *A Wildlife Policy for Canada*. Canadian Wildlife Service for Wildlife Ministers' Council of Canada (Ottawa, ON). 29 pp.

Flerov, C.C. 1965. Comparative craniology of recent representatives of the genus *Bison. Bulletin of the Moscow Nature Society* LXX(1). Department of Biology. 17 pp.

Flerov, K.K. 1979. Systematics and evolution. Pages 9–127 *in* V.E. Sokolov (Editor): *European bison. Morphology, systematics, evolution, ecology.* Nauka Publishers (Moscow).

Fuller, W.A. 1962. The biology and management of the bison of Wood Buffalo National Park. *Wildlife Management Bulletin Series 1*, 16: 1–52. Canadian Wildlife Service.

Gainer, R. 1985. Free-roaming bison in northern Alberta. *Alberta Naturalist* 15: 86–87.

Gasaway, W.C., R.O. Stephenson, J.L. Davis, P.E.K. Shepherd, and O.E. Burris. 1983. Interrelationships of wolves, prey and man in interior Alaska. *Wildlife Monographs 84*. 50 pp.

Gates, C.C. 1992. Cursory evaluation of the habitat potential of the Yukon River Flats, Alaska, for a reintroduction of wood bison. Unpublished report for the Alaska Department of Fish and Game (Fairbanks, AK). 42 pp.

Gates, C.C. 1993. Biopolitics and pathobiology: Diseased bison in northern Canada. Pages 271–288 *in* R.E. Walker (Symposium organizer and compiler): *Proceedings of the North American public bison herds symposium*. Lacrosse, WI, 27–29 July 1993. Custer State Park (Custer, SD).

Gates, C.C. and N.C. Larter. 1990. Growth and dispersal of an erupting large herbivore population in northern Canada: The Mackenzie wood bison (*Bison bison athabascae*). *Arctic* 43: 231–238.

Gates, C.C., N.C. Larter, and P.E. Komers. 1991. Size and composition of the Mackenzie wood bison population in 1989. File Report No. 93. Northwest Territories Department of Renewable Resources. 24 pp.

Gates, C., T. Chowns, and H. Reynolds. 1992. Wood Buffalo at the crossroads. *Alberta: Studies in the Arts and Sciences* 3: 139–165. University of Alberta Press (Edmonton, AB).

Gates, C.C., B. Elkin, and D. Dragon. 1995. Investigation, control and epizootiology of anthrax in an isolated, free-roaming bison population in northern Canada. *Canadian Journal of Veterinary Research* 59: 256–264.

Gates, C.C., B.T. Elkin, and D.C. Beaulieu. 1998. Initial results of an attempt to eradicate bovine tuberculosis and brucellosis from a wood bison herd in northern Canada. Pages 221–228 *in* L. Irby and J. Knight (Editors): *International symposium on bison ecology and management in North America*. Bozeman, MT, 4–7 June 1997. Montana State University (Bozeman, MT).

Geist, V. 1991. Phantom subspecies: the wood bison *Bison bison athabascae* Rhoads 1897 is not a valid taxon, but an ecotype. *Arctic* 44: 283–300.

Geist, V. and P. Karsten. 1977. The wood bison (*Bison bison athabascae* Rhoads 1989) in relation to hypotheses on the origin of the American bison (*Bison bison* Linnaeus). *Zeitschrift für Saugetierkunde* 42: 119–127.

Government of the Northwest Territories. 1987. Mackenzie wood bison management plan. Department of Renewable Resources, Government of the Northwest Territories (Yellowknife, NT). 20 pp.

Government of Yukon. 1998. Yukon bison management plan 1998–2003. Unpublished report. Department of Renewable Resources, Government of Yukon (Whitehorse, YK). 20 pp.

Graham, M. 1924. Finding range for Canada's buffalo. *The Canadian Field-Naturalist* 38: 189.

Groves, C.P. 1981. Systematic relationships in the Bovini (Artiodactyla, Bovidae). *Zeitschrift für zoologischen Systematik und Evolutionsforschung* 19: 264–278.

Guthrie, R.D. 1990. *Frozen fauna of the Mammoth Steppe. The Story of Blue Babe*. University of Chicago Press (Chicago, IL). 323 pp.

Harington, C.R. 1977. Pleistocene mammals of the Yukon Territory. Ph.D. dissertation. University of Alberta (Edmonton, AB). 1060 pp.

Harington, C.R. 1990. Arctic bison. *Biome* 10(2): 4. Canadian Museum of Nature (Ottawa, ON).

Harper, F. 1925. Letter to the editor of the Canadian Field-Naturalist. *The Canadian Field- Naturalist* 39: 45.

Harper, W.L., J.P. Elliott, I. Hatter, and H. Schwantje. 2000. Management plan for wood bison in British Columbia. British Columbia Ministry of Environment, Lands and Parks (Victoria, BC). 43 pp.

Hartl, G.B. and F. Reimoser. 1988. Biochemical variation in Roe deer (*Capreolus capreolus L.*): Are r-strategists among deer genetically less variable than k-strategists? *Heredity* 6: 221–227.

Hewitt, C.G. 1921. The buffalo or bison: Its present, past, and future. Pages 113–142 *in* C.G. Hewitt: *The conservation of the wildlife of Canada*. Charles Scribner's Sons (New York, NY).

Howell, A.B. 1925. Letter to the editor of the Canadian Field-Naturalist from the Corresponding Secretary of the American Society of Mammalogists, 13 April 1925. *The Canadian Field-Naturalist* 39: 118.

IUCN. 1980. *World conservation strategy: Living resource conservation for sustainable development.* With support from the United Nations Environment Programme and the World Wildlife Fund. International Union for Conservation of Nature and Natural Resources, Gland, Switzerland.

IUCN. 1987. Translocation of living organisms: IUCN position statement, 4 September 1987. International Union for Conservation of Nature and Natural Resources, Gland, Switzerland. 20 pp.

Janecek, L.L., R.L. Honeycutt, R.M. Adkins, and S.K. Davis. 1996. Mitochondrial gene sequences and the molecular systematics of the Artiodactyl subfamily Bovinae. *Molecular Phylogenetics Evolution* 6: 107–119.

Joly, D., F.A. Leighton, and F. Messier. 1998. Tuberculosis and brucellosis infection of bison in Wood Buffalo National Park, Canada: preliminary results. Pages 23–31 *in* L. Irby and J. Knight (Editors): *International symposium on bison ecology and management in North America.* Bozeman, MT, 4–7 June 1997. Montana State University (Bozeman, MT).

Jones, C., R.S. Hoffmann, D.W. Rice, R.J. Baker, M.D. Engstrom, R.D. Bradley, D.J. Schmidly, and C.A. Jones. 1997. Revised checklist of North American mammals north of Mexico, 1997. *Occasional Papers No. 173.* Museum of Texas Tech University. 24 pp.

Karsten, P. 1975. Don't be buffaloed...by a bison: history of Alberta herds. *Dinny's Digest, Calgary Zoological Society* 2: 3–13.

Larter, N.C. and C.C. Gates. 1991. Diet and habitat selection of wood bison in relation to seasonal change in forage quantity and quality. *Canadian Journal of Zoology* 69: 2677–2685.

Larter, N.C., A.R.E. Sinclair, and C.C. Gates. 1993. Dynamics of the Mackenzie wood bison population. Pages 260–270 *in* R.E. Walker (Symposium organizer and compiler): *Proceedings of the North American public bison herds symposium.* Lacrosse, WI, 27–29 July 1993. Custer State Park (Custer, SD).

Larter, N.C., A.R.E. Sinclair, and C.C. Gates. 1994. The response of predators to an erupting bison, *Bison bison athabascae*, population. *The Canadian Field-Naturalist* 108: 318–327.

Lazarev, P.A., G.G. Boeskorov, and A.I. Tomskaya. 1998. Mlekopitauschie Antropogena Yakutii. Yu.V. Labutin (Editor), Sibirskoe otdelenie Rossiiskoi Akademii Nauk. Yakutskii Nauchnyi Centr, Yakutsk.

Lotenberg, G. 1996. History of wood bison in the Yukon; a reevaluation based on traditional knowledge and written records. Unpublished report for Yukon's Renewable Resources Department. Boreal Research Associates (Whitehorse, YK). 23 pp. + appendices.

Lothian, W.F. 1979. *A history of Canada's national parks. Vol. III.* Parks Canada, Supply and Service Canada (Ottawa, ON). 118 pp.

Lothian, W.F. 1981. *A history of Canada's national parks. Vol. IV.* Parks Canada, Supply and Service Canada (Ottawa, ON). 154 pp.

MacGregor, J.G. 1952. *The land of twelve foot Davis. (A history of the Peace River Country.)* The Institute of Applied Art Ltd. (Edmonton, AB). 394 pp.

Mayr, E. 1963. *Animal species and evolution.* Harvard University Press. 797 pp.

McDonald, J.N. 1981. *North American bison, their classification and evolution.* University of California Press (Berkeley, CA). 316 pp.

Meagher, M. 1989. Range expansion by bison of Yellowstone National Park. *Journal of Mammalogy* 70: 670–675.

Messier, F. 1989. Effects of bison population changes on wolf–prey dynamics in and around Wood Buffalo National Park. Pages 229–262 *in* Northern Diseased Bison Environmental Assessment Panel: Compendium of government submissions and technical specialists reports in response to the Panel information requirements document. Federal Environmental Assessment Review Office (Ottawa, ON). 295 pp.

Miyamoto, M.M., S.M. Tanhauser, and P.J. Laipis. 1989. Systematic relationships in the artiodactyl tribe Bovini (Family Bovidae), as determined from mitochondrial DNA sequences. *Systematic Zoology* 38: 342–349.

Morton, K. 1999. Wood bison re-introduction Hay/Zama herd progress report — April 1999. Unpublished report. Natural Resources Service, Alberta Environmental Protection (High Level, AB). 21 pp.

Newmark, W.D. 1987. A land-bridge island perspective on mammalian extinctions in western North American parks. *Nature* 325: 430–432.

Northern Diseased Bison Environmental Assessment Panel. 1990. Northern diseased bison. *Report No. 35 of the Environmental Assessment Panel.* August 1990. Federal Environmental Assessment Review Office (Hull, QC). 47 pp.

Novakowski, N.S. 1957. Aerial re-survey of bison in Wood Buffalo National Park and surrounding areas, 1957. Unpublished report CWSC-216. Canadian Wildlife Service (Edmonton, AB). 12 pp.

O'Brien, S.J. and E. Mayr. 1991. Bureaucratic mischief: recognizing endangered species and subspecies. *Science* 231: 1187–1188.

Ogilvie, W. 1893. Report on the Peace River and tributaries in 1891. Annual report. Department of Interior Canada for 1892, part 7. 144 pp.

Orlov, V.N. and Chudinovokaya [initials unknown]. 1979. Chromosome set of European bison and other bovini. Pages 435–441 *in* V.E. Sokolov (Editor): *European bison. Morphology, systematics, evolution, ecology*. Nauka Publishers (Moscow).

Pamilo, P. and M. Nei. 1988. Relationships between gene trees and species trees. *Molecular Biology and Evolution* 5: 568–583.

Pauls, R.W., J. Peden, and G.M. Wagner. 1999. Syncrude/Fort McKay wood bison project: 1993–1997. Unpublished report prepared for Syncrude Canada Ltd. (Fort McMurray, AB). Sections 1–8 and 21 appendices.

Peden, D.G. and G.J. Kraay. 1979. Comparison of blood characteristics in plains bison, wood bison, and their hybrids. *Canadian Journal of Zoology* 57: 1778–1784.

Pollard, D.F. and M.R. McKechnie. 1986. *World conservation strategy — Canada. A report on achievements in conservation*. Conservation and Protection, Environment Canada (Ottawa, ON). 61 pp.

Quinlan, A.E. 1999. Prescribed fire and vegetation dynamics in northern boreal sedge-grass meadows of the Slave River Lowlands, Northwest Territories. M.Sc. thesis. University of Alberta (Edmonton, AB). 111 pp.

Raup, H.M. 1933. Range conditions in the Wood Buffalo Park of western Canada with notes on the history of the wood bison. *Special Publication of the American Committee for International Wild Life Protection. Vol. I, No. 2.* 52 pp. + map.

Reynolds, H.W. 1982. Range assessment of the Nisling River valley, Yukon Territory, as habitat for wood bison. Unpublished report. Canadian Wildlife Service (Edmonton, AB). 64 pp.

Reynolds, H.W. and A.W.L. Hawley (Editors). 1987. *Bison ecology in relation to agricultural development in the Slave River Lowlands, NWT*. Occasional Paper No. 63. Canadian Wildlife Service (Ottawa, ON). 74 pp.

Reynolds, H.W., R.M. Hansen, and D.G. Peden. 1978. Diets of the Slave River Lowlands bison herd, Northwest Territories, Canada. *Journal of Wildlife Management* 42: 581–590.

Reynolds, H.W., J.R. McGillis, and R. Glaholt. 1980. Range assessment of the Liard–South Nahanni Rivers Region, Northwest Territories, as habitat for wood bison. Unpublished report. Canadian Wildlife Service (Edmonton, AB). 39 pp.

Rhoads, S.N. 1897. Notes on living and extinct species of North American Bovidae. *Proceedings of the Academy of Natural Sciences* 49: 483–502.

Rusanov, B.S. 1975. Iskapaemye bizony Iakutii. Iakutskoe Knizhnoe Izdatel'stvo, Yakutsk.

Samuel, W.M. 1987. Moving the zoo or the potential introduction of a dangerous parasite into Alberta with its translocated host. Pages 85–92 *in* L. Renecker (Editor): *Focus on a new industry*. Proceedings of the Alberta Game Growers' Association Conference 1, 1987.

Saunders, W.E. 1925. Letter to the editor of the Canadian Field-Naturalist. *The Canadian Field-Naturalist* 39: 118.

Schultz, J. 1888. *The Great Mackenzie Basin*. Report of the Select Committee of the Senate Appointed to Enquire into the Resources of the Great Mackenzie Basin. Session 1888. Ottawa (ON). Taken from *The Senate Debates*, Ottawa, 27 March 1888, pages 218–244 [cited in Raup 1933].

Seip, D.R. 1992. Factors limiting woodland caribou populations and their interrelationships with wolves and moose in southeastern British Columbia. *Canadian Journal of Zoology* 70: 1494–1503.

Seton, E.T. 1886. The wood buffalo. *Proceedings of the Royal Canadian Institute, Series 3*, Vol. 3, No. 31: 114–117.

Siebert, V.F. 1925. Some notes on Canada's so-called wood buffalo. *The Canadian Field-Naturalist* 39: 204–206.

Simpson, G.G. 1961. Principles of animal taxonomy. Columbia University Press (New York, NY). 247 pp.

Skinner, M.F. and O.C. Kaisen. 1947. The fossil *Bison* of Alaska and preliminary revision of the genus. *Bulletin of the American Museum of Natural History* 89: 123–256 + Plates 8–26.

Soper, J.D. 1941. History, range and home life of the northern bison. *Ecological Monographs* 11: 347–412.

Soule, M.E. 1987. *Viable populations for conservation.* Cambridge University Press (Cambridge, UK). 189 pp.

Stephenson, R.O., S.C. Gerlach, R.D. Guthrie, C.R. Harington, R.O. Mills, and G. Hare. 2001. Wood bison in late Holocene Alaska and adjacent Canada: Paleontological, archaeological and historical records. Pages 125–159 *in* S.C. Gerlach and M.S. Murray (Editors): *People and wildlife in northern North America: Essays in honor of R. Dale Guthrie*. British Archaeological Reports, International Series 994.

Strobeck, C., R.O. Polziehn, and R. Beech. 1993. Genetic relationship between wood and plains bison assayed using mitochondrial DNA sequence. Pages 209–227 *in* R.E. Walker (Symposium organizer and compiler): *Proceedings of the North American public bison herds symposium*. Lacrosse, WI, 27–29 July 1993. Custer State Park (Custer, SD). 444 pp.

Tessaro, S.V. 1988. A descriptive and epizootiologic study of brucellosis and tuberculosis in bison in northern Canada. Ph.D. thesis. University of Saskatchewan (Saskatoon, SK). 320 pp.

Tessaro, S.V. 1989. Review of the diseases, parasites and miscellaneous pathological conditions of North American bison. *Canadian Veterinary Journal* 30: 416–422.

Tessaro, S.V., L.B. Forbes, and C. Turcotte. 1990. A survey of brucellosis and tuberculosis in bison in and around Wood Buffalo National Park, Canada. *Canadian Veterinary Journal* 31: 174–180.

Tessaro, S.V., C.C. Gates, and L.B. Forbes. 1992. The brucellosis and tuberculosis status of wood bison in the Mackenzie Bison Sanctuary, Northwest Territories, Canada. *Canadian Journal of Veterinary Research* 57: 231–235.

Thoen, C.O., K.J. Throlson, L.D. Miller, E.M. Hines, and R.L. Morgan. 1988. Pathogenesis of *Mycobacterium bovis* infection in American bison. *American Journal of Veterinary Research* 49: 1861–1865.

Van Camp, J. 1987. Predation on bison. Pages 25–33 *in* H.W. Reynolds and A.W.L. Hawley (Editors): *Bison ecology in relation to agriculture development in the Slave River lowlands, NWT*. Occasional Paper No. 63. Canadian Wildlife Service (Ottawa, ON). 74 pp.

Van Camp, J. and G.W. Calef. 1987. Population dynamics of bison. Pages 21–23 *in* H.W. Reynolds and A.W.L. Hawley (Editors): *Bison ecology in relation to agriculture development in the Slave River lowlands, NWT*. Occasional Paper No. 63. Canadian Wildlife Service (Ottawa, ON). 74 pp.

Van Gelden, R.G. 1977. Mammalian hybrids and generic limits. *American Museum Noviates*, No. 2635. American Museum of Natural History. 25 pp.

van Zyll de Jong, C.G. 1986. A systematic study of recent bison, with particular consideration of the wood bison. *National Museum of Natural Sciences Publication in Natural Science No. 6.* 69 pp.

van Zyll de Jong, C.G. 1993. Origin and geographic variation of recent North American bison. *Alberta: Studies in the Arts and Sciences* 3(2): 21–35. University of Alberta Press (Edmonton, AB).

van Zyll de Jong, C.G., C. Gates, H. Reynolds, and W. Olson. 1995. Phenotypic variation in remnant populations of North American bison. *Journal of Mammalogy* 76: 391–405.

Wall, A.D., S.K. Davis, and B.M. Reed. 1992. Phylogenetic relationships in the subfamily bovinae (Mammalia – Artiodactyla) based on ribosomal DNA. *Journal of Mammalogy* 73: 262–275.

Wilson, A.C., R.L. Cann, S.M. Carr, M. George, U.B. Gyllensten, K.M. Helm-Gychowski, R.G. Higuchi, S.R. Palumbi, E.M. Prager, R.D. Sage, and M. Stoneking. 1985. Mitochondrial DNA and two perspectives on evolutionary genetics. *Biological Journal of the Linnean Society* 26: 375–400.

Wilson, D.E. and D.M. Reeder (Editors). 1993. *Mammal species of the World.* Smithsonian Institution Press (Washington, DC). 1206 pp.

Wilson, G. and C. Strobeck. 1999. Genetic variation within and relatedness among wood and plains bison populations. *Genome* 42: 483–496.

Wood Bison Recovery Team. 1987. Status report on endangered wildlife in Canada 1987: Wood bison. Canadian Wildlife Service (Ottawa, ON). 87 pp.

Ying, K.L. and D.G. Peden. 1977. Chromosomal homology of wood bison and plains bison. *Canadian Journal of Zoology* 55: 1759–1762.

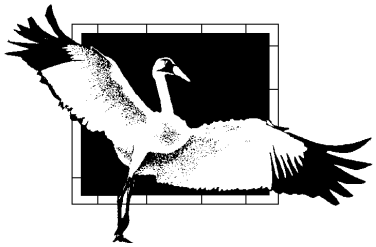
Zamora, L.E. 1983. An analysis of bison erythrocyte antigens and blood proteins. M.Sc. thesis. Texas A and M University (College Station, TX). 94 pp.

Zimov, S.A., V.I. Chuprynin, A.P. Oreshko, F.S. Chapin III, J.F. Reynolds, and M.C. Chapin. 1995. Steppe–tundra transition: A herbivore-driven biome shift at the end of the Pleistocene. *The American Naturalist* 146: 765–794.

Previous National Recovery Plans

1. Canadian Whooping Crane Recovery Plan	December 1987
2. *Anatum* Peregrine Falcon Recovery Plan	October 1988
3. National Recovery Plan for the Baird's Sparrow	April 1993
4. National Recovery Plan for the Roseate Tern	June 1993
5. National Recovery Plan for the Greater Prairie-Chicken	October 1993
6. National Recovery Plan for the Whooping Crane (1994 update)	January 1994
7. National Recovery Plan for the Loggerhead Shrike	March 1994
8. National Recovery Plan for the Marbled Murrelet	May 1994
9. National Recovery Plan for the Gaspésie Caribou	November 1994
10. National Recovery Plan for the Vancouver Island Marmot	December 1994
11. National Recovery Plan for the Ferruginous Hawk	December 1994
12. National Recovery Plan for the Harlequin Duck in Eastern North America	March 1995
13. National Recovery Plan for the Burrowing Owl	April 1995
14. National Recovery Plan for the Newfoundland Marten	August 1995
15. National Recovery Plan for the Swift Fox	April 1996
16. National Recovery Plan for the Blanchard's Cricket Frog	March 1997
17. National Recovery Plan for the Henslow's Sparrow	August 1997
18. National Recovery Plan for Blandings Turtle (*Emydoidea blandingii*) Nova Scotia population	January 1999
19. National Recovery Plan for the Vancouver Island Marmot (*Marmota vancouverensis*) 2000 Update	May 2000
20. National Recovery Plan for Acadian Flycatcher (*Empidonax virescens*) and Hooded Warbler (*Wilsonia citrina*)	November 2000

Recovery of Nationally Endangered Wildlife



In 1988, the Wildlife Ministers' Council of Canada endorsed a new strategy to rescue wildlife species at risk of extinction and to prevent other species from becoming at risk. Called RENEW (the acronym for Recovery of Nationally Endangered Wildlife), the strategy brings together all responsible agencies and interested organizations and individuals to work as a team for the recovery of wildlife at risk. RENEW focuses on those species or populations that have been designated as extirpated, endangered, or threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The responsible jurisdictions establish a National Recovery Team of experts for each species to produce a recovery plan, which becomes the basis for a recovery program carried out by the responsible governments in cooperation with aboriginal groups, universities, nongovernment organizations, businesses, and private citizens.

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