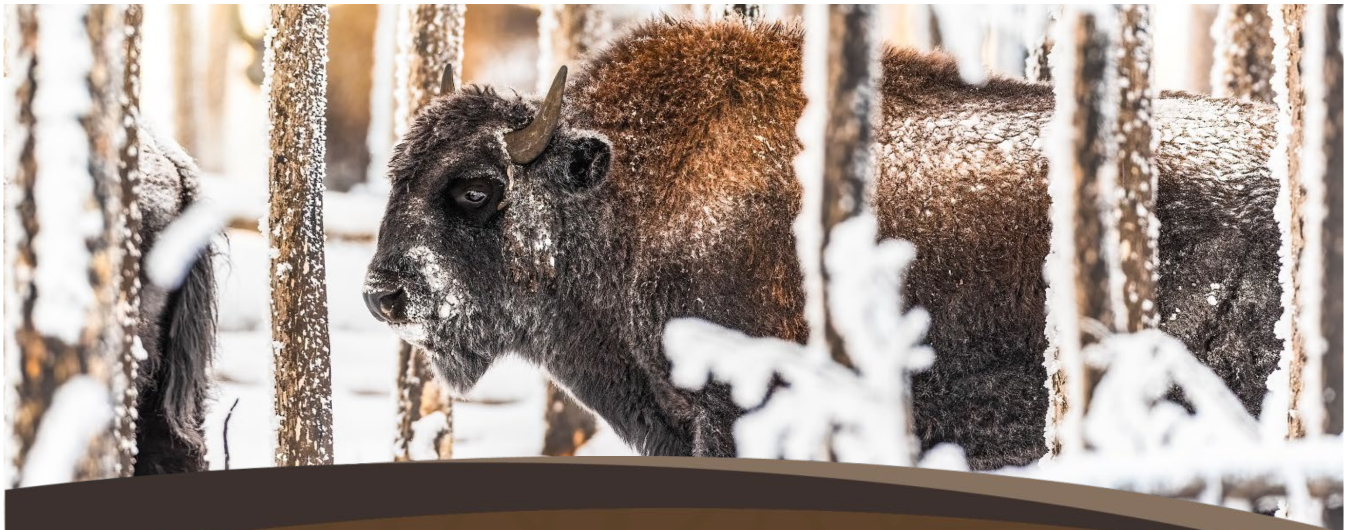

Species Status Report

Wood bison

Bison bison athabascae

Sakāwmostos (Cree)
Ejuda (Dene Kədə́)
Dechįtah goegié (Dene Zhatıé)
Dechen yághe ejere, thachin ya n'jere, ʔejëre (Dené sųłiné/Chipewyan)
Aak'ii, Dachan tat gwa'aak'įį (Gwichya Gwich'in)
Dachan tat gwi'aak'ii (Teetł'it Gwich'in)
Dechįta gojıe, Enareh gojıe, Hozìı gojìè, Ejıe, Ejıezaa (Tłįchǫ)

IN THE NORTHWEST TERRITORIES

NORTHWEST TERRITORIES SPECIES AT RISK COMMITTEE

DRAFT

REASSESSMENT – TO BE DETERMINED

MAY 2025

Species at Risk Committee status reports are working documents used in assigning the status of species suspected of being at risk in the Northwest Territories (NWT).

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This report is an update of the Species Status Report for Wood Bison (*Bison bison athabascae*) in the Northwest Territories (2016).

For additional copies contact:

Species at Risk Secretariat
c/o Department of Environment and Climate Change
P.O. Box 1320
Yellowknife, NT X1A 2L9
Tel: (855) 783-4301 (toll free)
Fax: (867) 873-0221
E-mail: SARA@gov.nt.ca
www.nwtspeciesatrisk.ca

ABOUT THE SPECIES AT RISK COMMITTEE

The Species at Risk Committee was established under the *Species at Risk (NWT) Act*. It is an independent committee of experts responsible for assessing the biological status of species at risk in the NWT. The Committee uses the assessments to make recommendations on the listing of species at risk. The Committee uses objective biological criteria in its assessments and does not consider socio-economic factors. Assessments are based on species status reports that include the best available Indigenous knowledge, community knowledge, and scientific knowledge of the species. The status report is approved by the Committee before a species is assessed.

ABOUT THIS REPORT

This species status report is a comprehensive report that compiles and analyzes the best available information on the biological status of wood bison in the NWT, as well as existing and potential threats and positive influences. Full guidelines for the preparation of species status reports, including a description of the review process, may be found at www.nwtspeciesatrisk.ca.

Environment and Climate Change, Government of the Northwest Territories, provides full administrative and financial support to the Species at Risk Committee.

Cover illustration photo credit: Pierre-Emmanuel Chaillon

Executive Summary

Indigenous and Community Knowledge
About the Species
Wood bison hold profound spiritual and cultural significance for many Indigenous communities — symbolizing strength, resilience, and a deep connection to the land. Historically abundant, wood bison populations have declined due to habitat loss and disease. This has impacted food security and disrupted cultural practices, making it challenging for younger generations to connect with their heritage. Reintroduction efforts aim to restore wood bison to their historic ranges and revitalize cultural practices. However, reintroductions may also create conflicts, including property damage and vehicle collisions. Wood bison prefer grass and sedge meadows, which provide high-quality forage. They avoid muskeg, steep terrain, and dense forest and favour areas with less snow or recent burns with newer vegetation. Wood bison calve in late spring or early summer after an early fall rut, although young calves can occasionally be seen year-round. Herd size is variable and can change throughout the year. Wood bison are often seen in small groups. Caribou and wood bison tend to avoid each other, and wood bison are sometimes seen as competitors to both boreal caribou and moose. Wolves are the main predator of wood bison. In the North Slave region, increasing wood bison populations are believed to be responsible for an increase in wolf numbers. This is considered a threat to other ungulates such as boreal caribou.
Place
Wood bison occur in the southern NWT (around the Liard River and northwest of Great Slave Lake), in and around Wood Buffalo National Park and northern Alberta, northern British Columbia, and the Yukon. In the NWT, they are found in four populations: Mackenzie, Nahanni, Wood Buffalo National Park, and Slave River Lowlands. Wood bison exhibit distinct movement behaviours that vary between bulls and cows. Bulls are more likely to travel alone and disperse great distances from their herd, while cows and calves disperse in summer into smaller groups and congregate again in wintering areas. Wood bison establish trails between favoured places, including along linear disturbances and crossing water bodies. Rivers can impede wood bison movement if the banks are steep or the river is too wide

Wood bison have extended their range in recent decades, although there is likely good habitat in the NWT that is not currently supporting a wood bison population.
Population
Wood bison population trends were not well documented in available Indigenous and community knowledge sources.
Threats and Limiting Factors
The most important threats to wood bison include disease, vehicle collisions, increased predation and loss of habitat. Historically, hunting was considered to be the largest threat to wood bison. This appears to no longer be the case from the perspective of Indigenous and community knowledge. In the late 1980s, disease eradication efforts were considered to be a larger threat to wood bison than the diseases themselves. It is unclear to what extent this perspective remains. Other threats and limiting factors include ranching, intense wildfires, and efforts to preserve genetic/subspecies purity. Wood bison are also known to die off in large numbers in extreme events, such as anthrax outbreaks, winter starvation, and drowning due to both flooding and falling through the ice.
Positive Influences
Indigenous knowledge and cross-cultural approaches are supporting wood bison stewardship in the NWT. Co-management systems have evolved, shifting local knowledge holders from informers to active managers. Land users, governments and resource boards have collaboratively developed management plans for each of the NWT's wood bison populations, which include harvest quotas that reflect current herd status and support the collection of harvest information. Land use and conservation planning initiatives, such as the establishment of Edéhzhíe Dehcho Protected Area and National Wildlife Area, protect important wood bison habitat and enhance the role of Indigenous guardians in managing for wood bison on the landscape. Recent wildfires may improve habitat quality, benefiting wood bison populations. The bison-free buffer zone between Wood Buffalo National Park and the Mackenzie Wood Bison Sanctuary to reduce disease transmission is also seen as a positive influence on wood bison.

Scientific Knowledge

About the Species

The wood bison is a subspecies of North American bison that is, among other differences, larger than plains bison. All bison in the NWT are considered to be wood bison, regardless of any hybridization that occurred when plains bison were released into Wood Buffalo National Park in the 1920s. Mature bulls measure over 1.8 metres at the shoulder and average 910 kilograms by 13 years of age, while mature cows average 567 kilograms by 12 years.

Although some animals become sexually mature as yearlings, it is not until females are three years old that most become pregnant, and males generally do not have opportunities to breed until they are five or six years old. Average longevity of bison has never been determined, but it is unlikely that many animals in the wild live past 20 years.

Variation in age structure of females in the population affects generation time. The average generation time for wood bison has been calculated at approximately seven years. Female bison likely have only one or two ovulations per year with a gestation period of about 285 days or 9.5 months. The ability to produce offspring is greatly affected by nutrition and the average conception rate of an adult female has been estimated to be 67% during her lifetime.

Wood bison are large generalist herbivores that specialize in grazing sedges and grasses, especially in winter. They also supplement their diet by browsing on shrubs and saplings.

Bison are gregarious animals and mixing of herds is quite common. Cows, calves and young bulls may form large mixed herds. Except for the breeding season, mature bulls roam alone or in small temporary groups.

The only documented source of predation for bison is wolves which focus primarily on herds containing calves. Although blood-feeding insects are primarily a source of torment, injury, and blood loss, other adverse effects on bison may also include behavioural changes and immunological impacts from insect attacks.

When not being harassed, bison easily become habituated to human presence and infrastructure. They often congregate along roads and have become a traffic hazard in many areas.

Place

Free-roaming populations of wood bison in the NWT presently occur south of Great Slave Lake in Wood Buffalo National Park and the Slave River Lowlands, north of the Mackenzie

River, and in the Nahanni-Liard watershed, which is shared by the NWT, British Columbia and the Yukon. These bison form three populations in the NWT, known as the Greater Wood Buffalo metapopulation, the Mackenzie population, and the Nahanni population. Within the Greater Wood Buffalo metapopulation, only the following three subpopulations occur within the NWT. The Nyarling River is entirely within Wood Buffalo National Park, while the Grand Detour (also known as Little Buffalo) and Hook Lake subpopulations are collectively referred to as the Slave River Lowlands. Wood bison continue to expand into former historic range.

Habitat components of wood bison range are floodplains, marl lake basins, fens, bogs, salt plains, karst terrain, and uplands. Inherently unstable, bison habitat is constantly changing through vegetation succession and retrogression. High quality habitat characterized by early seral vegetation stages must be revitalized and maintained by frequent disturbances such as flood/drawdowns and fires. Habitat fragmentation occurs through land conversion by humans, natural discontinuities such as steep mountains, dense forest, or extensive muskegs, and disease control measures, i.e. the Bison Control Area.

Population

The total NWT population of wood bison is approximately 3,079, which is about 36% of the global population of free-roaming animals. The most recent figures for individual populations indicate that the Nahanni numbers 544 ± 173 (2021) and the Mackenzie numbers 1,945 ± 761 (2023). Within the NWT subpopulations of the Greater Wood Buffalo metapopulation, the Nyarling River numbers 282 ± 223 (2024), Little Buffalo 101 ± 88 (2024), and Hook Lake 207 ± 69 (2024). Population densities based on area of occupation range from 0.03 bison/km^2 (Little Buffalo) to 0.07 bison/km^2 (Mackenzie).

The birth rate of NWT wood bison tends to range between 40-60 calves/100 cows, but may decline as low as 10 calves/100 cows in poor years. The percentage of juveniles entering the reproductive segment of the population is mostly dependent on the overwinter survival of calves and can vary from less than 10 to more than 50 yearlings/100 cows. Annual survival of adult bison is much more stable and usually exceeds 80%.

No evidence of immigration or emigration has been reported between populations other than among the subpopulations of the Greater Wood Buffalo metapopulation. While the likelihood of rescue from other subpopulations in the Greater Wood Buffalo metapopulation is high for the Nyarling River, Grand Detour/Little Buffalo and Hook Lake subpopulations, the Mackenzie population is too remote for natural rescue from other sources, and for the Nahanni population, the Nordquist population in northern British Columbia is near, but too low in numbers for rescue.

The change in abundance of NWT wood bison during the last three generations (approximately 2003 to 2024) has been a 17.5% decline.

Threats and Limiting Factors

Human-caused mortality, including overhunting and culls for disease control and vaccination round-ups, represents an important historical threat to wood bison. Slave River Lowlands and Nyarling bison that wander beyond the boundaries of Wood Buffalo National Park are hunted with few restrictions. Vehicle collisions are also a common cause of mortality for wood bison in the NWT.

Anthrax and bovine tuberculosis are considered to have the most serious disease implications for bison restoration. Bovine brucellosis is also considered a significant impediment to recovery and Johne's disease is considered a medium impediment. Diseases may interact where one enhances the pathological effects of the other, overwhelming the immune response for the host.

Frequent fire is necessary for maintaining wood bison habitat, and fire suppression since the middle of the 20th century reduces the number of bison that habitat can support. Although the ecological role of fire is now better understood, the threat of wildfire to other values at risk must be considered alongside impacts to bison habitat.

Low genetic diversity may lead to decreased fitness (inbreeding depression), often revealed by under-weight births, low survival, and poor reproduction, as well as reduced resistance to disease, predation and environmental stress. Genetic drift is the loss of genetic diversity by chance and is intensified when populations remain small and isolated for many generations. As a population becomes more homogenous, it has fewer individuals with unique resistance traits to certain pathogens. All current wood bison populations have been derived from remnants of much larger populations whose original gene pools may be poorly represented. Further loss of genetic diversity is exacerbated if new parent populations are already genetically impoverished.

Drownings from attempts to swim across rivers or falling through ice are unpredictable events that can cause sudden mass mortalities, potentially devastating to small wood bison populations.

Adverse snow conditions, especially early winter freeze-thaw events that create an icy barrier to grazing, can cause substantial bison losses through the winter.

Wolf predation affects bison populations mainly in winter when bison are in relatively poor condition. Generally, the very young or the very old are targeted, and vulnerability may be worsened by habitat structure, disease, and alternate prey that support high wolf numbers.

Positive Influences
Most wood bison populations in the NWT are protected from overharvesting by quotas. Advances in habitat conservation and enhancement include the establishment of the Edéhzhíe Dehcho Protected Area and National Wildlife Area, modified water release from the Bennett Dam to maintain wetland habitat, and a better understanding of the natural role and use of fire in the ecosystem. The Bison Integrated Genomics (BIG) project was launched with a goal to ensure and restore the existence of genetically diverse bison populations by producing disease-free germplasm from genetically isolated herds. The *Recovery Strategy for Wood Bison in the Northwest Territories* aims to avoid hybridization of wood bison with plains bison, domestic bison and cattle by preventing domestic bison and plains bison from entering wood bison range in the NWT. Monitoring and removal of bison in the Bison Control Area between Wood Buffalo National Park and the Mackenzie River has been ongoing since 1987 to reduce the risk of contact between infected and non-infected wild bison populations. The BIG Project's other main goal is to reduce the prevalence of tuberculosis and brucellosis and protect bison that are disease-free by developing new strategies to rapidly diagnose these diseases and develop a combined tuberculosis and brucellosis vaccine that could be delivered orally to wild bison populations. Routine aerial anthrax surveillance flights are conducted each summer, followed by an enhanced surveillance program if an outbreak is suspected. An Anthrax Emergency Response Plan is implemented when an anthrax outbreak is confirmed, which includes surveillance, testing, scavenger prevention, disposal of carcasses, decontamination of sites, and human health protection. Although the Greater Wood Buffalo metapopulation has essentially reached its limits of distribution, the Nahanni and Mackenzie populations are still undergoing range expansion. As this proceeds, the risk of a significant portion of the population falling victim to a local catastrophe (such as disease outbreak or major drowning event) diminishes. Subpopulations inside Wood Buffalo National Park are managed cooperatively with those subpopulations ranging outside of the park (either in Alberta or the NWT). As of November 2021, wild disease-free wood bison in Alberta were designated as Threatened wildlife and offered protection from overharvesting. The Nahanni population also extends across several jurisdictions and is managed collaboratively by the governments of Canada, the NWT, Yukon and British Columbia.

The Conference of Management Authorities on Species at Risk (CMA) provides a forum under the *Species at Risk (NWT) Act* to make collaborative decisions about species at risk in the NWT, including wood bison. Three bison working groups were also established to develop population-specific management plans for Mackenzie, Nahanni and Slave River Lowlands bison (part of the Greater Wood Buffalo metapopulation), and they continue to meet regularly. These working groups play a crucial role in implementing management actions, as well as bringing their organizations' perspectives into decision-making about wood bison. Indigenous governments, Indigenous organizations and communities in the range of wood bison are also involved in carrying out conservation and recovery actions for wood bison.

Technical Summary

Question	Indigenous and Community Knowledge
Population	
How often is the species observed compared to the past (less, more, same)? Include an estimate of how much of the species range these observations represent (percentage).	Information not available in sources.
Have there been changes observed in the sizes of groups?	Information not available in sources.
If the species is observed less frequently, what is the level of concern (high, moderate, low)?	Information not available in sources.
If concerns being expressed about the future of the species, are these concerns expressed in the short-, medium-, or long-term? (e.g. disappearance or decline within their grandchildren's lifetimes)	Information not available in sources.
Distribution	
Is the species still observed in all the places it was in the past? Or is the species now unavailable, or less available, in areas where it was historically abundant?	Historically, wood bison may have been abundant throughout the boreal forest, including areas in the Gwich'in and Inuvialuit regions. In the southern part of the NWT, introduced herds are now found in the Liard River valley and west of Great Slave Lake in areas where wood bison had been previously extirpated. Wood bison have been present in Wood Buffalo National Park and adjacent areas throughout the decline and recovery.
Have declines or changes to movements of the species been	Wood bison have been observed along the newly-constructed Tłı̨chǫ Highway (Highway 9) as far as the

observed? If so, are these changes to movements or distribution considered normal or unusual for the species?	community of Whatì. This represents an expansion of their range into areas where knowledge holders have no memory of them visiting. Similar movements have been observed in the past in other regions. Populations may move hundreds of kilometres over a short period and then reside in that area permanently.
How often do people talk about the disappearance of the species from its historic range? What is the level of concern (high, moderate, low)?	Information not available in sources.
Is there any indication the species has moved elsewhere?	Information not available in sources.
What is the amount and quality of habitat available to the species? How does this compare to the past?	There is likely wood bison habitat in the NWT that is not currently populated with wood bison. Wood bison habitat and habitat quality is declining with increasing forestry and development in northern Alberta, and encroaching willow/brush growth in open grassland meadows in the Slave River Lowlands and northern Alberta; however, wood bison distribution in the NWT has been observed to have increased in the last half-century.
Does the species have specific habitat requirements? (e.g. salt licks, ice patches, sea ice, karst, hot spring or specific food requirements)	Wood bison use salt licks. However, there is no indication that their movements are defined by the presence or absence of this feature.
Biocultural linkages	
Have declines resulted in significant adverse impacts to Indigenous cultures and traditional ways of life tied to the species or its habitat?	The disappearance of wood bison from large portions of their historic range has resulted in significant and ongoing impacts to Indigenous cultures and traditional ways of life. In areas where wood bison have been absent from the landscape for a number of generations, they may be perceived as a 'novel' or nuisance wildlife species.

Are continued cultural connections and practices related to the species now impossible or extremely impaired?	As wood bison have vanished from most of their historic range, many of the communities that would have formerly had contact with them have not encountered them for multiple generations. It would appear that most of the cultural awareness of this species in these regions has been lost. Harvest is restricted in areas where wood bison have been reintroduced (Nahanni and Mackenzie ranges).
Are people affected across the species range or only certain parts of the range?	Across the NWT wood bison range, communities have vastly different experiences and impacts depending on when wood bison disappeared from their traditional territories and when or whether they were reintroduced. Communities in the northern portion of the historic range may no longer have any contact with wood bison while some communities the South Slave, Dehcho and Tłįchǫ regions have either maintained their biocultural linkages to wood bison or are redeveloping them as wood bison return to parts of their historic ranges.
Threats and limiting factors	
Is the species being adversely impacted by one or more natural or human-caused threats?	Disease and overhunting are reported as the most significant current threats to wood bison populations in the NWT. Diseases such as bovine brucellosis, tuberculosis, and anthrax are important threats for wood bison. The threat of excessive harvest primarily affects Slave River Lowlands bison populations (Grand Detour and Hook Lake), as harvest is regulated for the Nahanni and Mackenzie populations. Disease eradication efforts such as herding animals to vaccinate, vaccinations or treatments, and allowing unmitigated hunting of diseased herds in the last half-century have threatened wood bison in the past. Efforts to preserve the genetic distinctiveness of wood bison from plains bison imported to the Wood Buffalo National Park area during the 20th century was considered a threat, such as the exclusion of wood

	bison from hunting laws (as 'hybrids') by the government of Alberta. Imminence and degree are not discussed in Indigenous and community knowledge sources.
What level of concern is expressed about threats impacting the species (high, moderate, low)? How often are these concerns expressed?	Information not available in sources.
How sensitive is this species to natural or human-caused threats?	Information not available in sources.
To what extent are these threats being managed?	Information not available in sources.
Does the species have characteristics that are likely to negatively affect their response to declines? (e.g. reproduces late in life, has few offspring, unable to go elsewhere if habitat becomes unsuitable)	Information not available in sources.
Positive influences	
Briefly summarize positive influences and indicate the magnitude and imminence for each.	Co-management and Indigenous ecological stewardship ('only taking what you need') appear to have a positive influence though the magnitude of influence is not available in the sources reviewed. Land use planning initiatives, such as protection of wood bison habitat near Wood Buffalo National Park and the establishment of Edéhzhíe Dehcho Protected Area and National Wildlife Area are expected to be a positive influence. Forestry remediation, including tree planting of forestry cutblocks, is a positive influence. Forest fires of moderate intensity can be a positive influence by creating bison habitat and encouraging

	forage. However, the impacts from the severe 2023 fire season have yet to be assessed. The bison-free buffer zone between Wood Buffalo National Park and the Mackenzie Wood Bison Sanctuary is a positive influence on wood bison in preventing disease transmission. Imminence and degree are not discussed in Indigenous and community knowledge sources

Question	Scientific Knowledge
Population Trends	
Generation time (average age of parents in the population)	7 years
Number of mature individuals in the NWT	**2,371** (see p. 159 for more information on how this number was derived)
Percent change in total number of mature individuals over the **last** 3 generations (2003-2024)	17.5% decline
Percent change in total number of mature individuals over the **next** 3 generations (2024-2045)	Unknown
Percent change in total number of mature individuals over any 10 year or 3 generation period that includes **both the past and the future**.	Unknown
If there is a decline in the number of mature individuals, is the decline likely to continue if nothing is done?	The cause of the decline must be determined before concluding whether it is likely to continue and if remedial actions will be effective.
If there is a decline, are the causes of the decline reversible?	Some causes are reversible (overhunting and road mortality); others may not be reversible (diseases, habitat change).

If there is a decline, are the causes of decline clearly understood?	No
If there is a decline, have the causes of the decline been removed?	No
If there are fluctuations or declines, are they within, or outside of, natural cycles?	The natural demographic history is too short to be certain whether they are within or outside of natural cycles.
Are there 'extreme fluctuations' (>1 order of magnitude) in the number of mature individuals?	No
Distribution	
Estimated extent of occurrence in the NWT.	150,717 km^2
Index of area of occupancy (IAO) in the NWT (in km^2; based on 2 x 2 grid).	50,352 km^2
Number of extant locations[1] in the NWT.	3
Is there a **continuing decline** in area, extent, and/or quality of habitat?	Yes

[1] Extant location - The term 'location' defines a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the species present. The size of the location depends on the area covered by the threatening event and may include part of one or many subpopulations. Where a species is affected by more than one threatening event, location should be defined by considering the most serious plausible threat.

Is there a **continuing decline** in number of locations, number of populations, extent of occupancy, and/or IAO?	No
Are there 'extreme fluctuations' (>1 order of magnitude) in number of locations, extent of occupancy, and/or IAO?	No
Is the total population 'severely fragmented' (most individuals found within small and isolated populations)?	Yes 63% of the total NWT population is in one herd and 37% of NWT bison are in 2 distinct or 4 partially isolated herds.
Immigration from Populations Elsewhere	
Does the species exist elsewhere?	Yes
Status of the outside population(s)?	Threatened – Yukon, B.C., Alberta
Is immigration known or possible?	Yes, but only within the transboundary Greater Wood Buffalo metapopulation
Would immigrants be adapted to survive and reproduce in the NWT?	Yes
Is there enough good habitat for immigrants in the NWT?	Yes
Is the NWT population self-sustaining or does it depend	Self-sustaining

on immigration for long-term survival?	
Threats and Limiting Factors	
Briefly summarize negative influences and indicate the magnitude and imminence for each.	Human-caused mortality, including harvesting and management activities like culls for disease control and vaccination round-ups, represents an important historical threat to wood bison. Currently, the Mackenzie, Nahanni and Slave River Lowlands populations in the NWT are harvested. A relatively small number of bison are removed because of bison-human conflicts and to prevent the spread of diseases. Vehicle collisions are an important cause of mortality for wood bison in the NWT, especially in the Mackenzie population. Four infectious bacterial diseases are currently of concern to the conservation of wood bison. Anthrax (*Bacillus anthracis*) and bovine tuberculosis (*Mycobacterium bovis*) are considered to have the most serious disease implications for bison restoration. Bovine brucellosis (*Brucella abortus*) is also considered a significant impediment to recovery. Johne's disease (*Mycobacterium avium* subspecies *paratuberculosis*) is also considered a medium impediment. Loss and deterioration of habitat in bison ranges can be threatened by agriculture. Forest expansion and destabilization of vegetation communities due to fire control after the mid-1900s is detrimental to habitat maintenance. Low genetic diversity has resulted from wood bison herds having been derived from remnants of much larger populations, such that the original gene pools may be poorly represented. Further loss of genetic diversity is exacerbated if new parent populations are already genetically impoverished. Inbreeding among closely related individuals causes a higher probability of recessive deleterious alleles being expressed in the progeny. The resulting decreased fitness, known as inbreeding depression, is often manifested by under-weight births, low survival, and poor reproduction,

	as well as reduced resistance to disease, predation and environmental stress. Genetic drift is the loss of alleles by chance and is intensified when populations remain small and isolated for many generations. Outbreeding depression is a genetic condition manifested by interbreeding of two genetically distant populations, resulting in a loss of fitness of the progeny from the disruption of selective advantage of adapted gene complexes in the parental forms. Interbreeding of wood bison with cattle and plains bison (either of pure lineage or carrying some cattle heritage from past breeding experiments) potentially threaten the genetic integrity, fitness and evolutionary pathway of wood bison. Drowning of large herds of wood bison occasionally occur. When bison break through thin ice on lakes or rivers, they are generally unable to climb out. For example, in 1989, 177 bison perished through spring ice on Falaise Lake in the Mackenzie Bison Sanctuary. Adverse snow conditions may lead to mass mortality of wood bison, particularly if heavy snowfall is followed by rain and refreezing. A thick frozen crust impairs foraging and mobility of bison, and increases vulnerability to wolves and hunters. Predation was identified as the prominent causal factor when the Greater Wood Buffalo metapopulation was in decline after the mid-1970s. More specifically, it was attributed to excessive predation on calves resulting in low recruitment. Bison calves are smaller and usually easier to kill than adults. Advanced diseases may also predispose bison to predation.
Positive Influences	
Briefly summarize positive influences and indicate the magnitude and imminence for each.	Efforts to manage human-caused mortality include the most effective management intervention which was the introduction of hunting restrictions. Harvest is prohibited inside Wood Buffalo National Park. The reintroduced Mackenzie and Nahanni populations have special protection

	and are managed through adaptable harvest quotas. Harvest of the Slave River Lowlands subpopulations outside of Wood Buffalo National Park (Hook Lake and Grand Detour) is not regulated by quotas for General Hunting Licence holders, and other NWT residents may purchase one bison tag per year for hunting. The current co-management approach with renewable resource boards shares the commitment for appropriate conservation measures. Habitat conservation and enhancement progressed when the Mills Lake-Horn River Delta agricultural threat was removed by the establishment of the Edéhzhíe Dehcho Protected Area and National Wildlife Area. The Northern River Basins Study was initiated to determine the effects of the Bennett Dam on the Peace River, Slave River and Great Slave Lake ecosystems. A major recommendation was modification of water release from the dam in an attempt to maintain wetlands, including bison habitat, in a more natural state. As resource managers and the public develop a better understanding of the natural role of fire in the ecosystem, and how to use it safely for resource management, there may be greater confidence in using fire as a bison habitat improvement tool. The Wildlife Conservation Society set a vision for the ecological future of the North American bison articulated in the release of the *Vermejo Statement*. Managing genetic diversity is important for the viability of wood bison populations. All wild and reintroduced bison in northern Canada are now considered to be wood bison. Minimum standards pertaining to effective population size, have now become established for starting new wood bison populations. Recommendations for reintroductions address genetic salvage, number of founding individuals, using the most genetically important disease-free populations as the primary source, and minimum viable population sizes, and optimal gene flow among herds. Advances in reproductive technology are continuing to find ways to salvage valuable genetic material from diseased populations. The Bison Integrated Genomics (BIG) project aims to ensure the

	existence of healthy, genetically diverse bison populations that includes long-term sustainability. Safeguarding genetic integrity is being strengthened by federal and territorial actions recognizing that wood bison and plains bison are on different evolutionary pathways. To prevent hybridization of the two subspecies, the Recovery Strategy for Wood Bison in the NWT discourages domestic bison or plains bison from entering wood bison. Managing disease by reducing the risk of tuberculosis and brucellosis transmission between infected and healthy bison populations and implementing the Anthrax Emergency Response Plan for anthrax outbreaks continue. The Bison Control Area between Wood Buffalo National Park and the Mackenzie River has been in place since 1987, and anthrax surveillance flights are routine each summer. The Bison Integrated Genomics (BIG) Project also aims to reduce the prevalence of tuberculosis and brucellosis and protect bison that are disease-free by developing new strategies to rapidly diagnose these two diseases. Range expansion still has potential for the Nahanni and Mackenzie populations and as this proceeds, the risk of a significant proportion of the population falling victim to a local catastrophe or adverse climate diminishes. Interagency cooperation and co-management partnerships are in place to manage cooperatively wood bison populations ranging across multiple jurisdictions. The Conference of Management Authorities on Species at Risk was established to partner the Government of the Northwest Territories and the Government of Canada with wildlife co-management boards and Indigenous governments in the NWT. These Management Authorities share responsibility for the listing, conservation, and recovery of wood bison. In addition, working groups have been established to provide direction

	and perspectives for managing populations. Through collaborative efforts, the Mackenzie Bison Management Plan, Nahanni Bison Management Plan, and the Slave River Lowlands Bison Management Plan have been completed and implementation is underway.

Acronyms

Acronym	Term
ADKFN	Acho Dene Koe First Nation
CMA	Conference of Management Authorities
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DFN	Dehcho First Nations
DLUPC	Dehcho Land Use Planning Committee
EC	Environment Canada
ECC (or GNWT-ECC)	Department of Environment and Climate Change, GNWT (formerly Environment and Natural Resources)
ECCC	Environment and Climate Change Canada
EMB	Edéhzhıe Management Board
ENR	Environment and Natural Resources (now ECC)
FCMN	Fort Chipewyan Métis Local 125
FNFN	Fort Nelson First Nation
GHL	General Hunting Licence
GNWT	Government of the Northwest Territories
GRRB	Gwich'in Renewable Resources Board
GSA	Gwich'in Settlement Area
IUCN	International Union for Conservation of Nature
MBWG	Mackenzie Bison Working group
RWED	Resources, Wildlife and Economic Development (now ECC)
SARC	Northwest Territories (NWT) Species at Risk Committee
SRLBWG	Slave River Lowlands Bison Working Group
SRRB	Sahtú Renewable Resources Board
SSDEC	South Slave Divisional Education Council
TG	Tłįchǫ Government
WBNP	Wood Buffalo National Park
WRRB	Wek'èezhìı Renewable Resources Board

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PLACE NAMES

Within the region containing wood bison in NWT and adjacent jurisdictions, Figure 1 shows communities, major water bodies, protected areas, settled land claims, First Nation reserves, and special management areas, as well as major rivers, lakes and landmarks named in this report. Regional maps (Figures 2a-c) provide further detail.

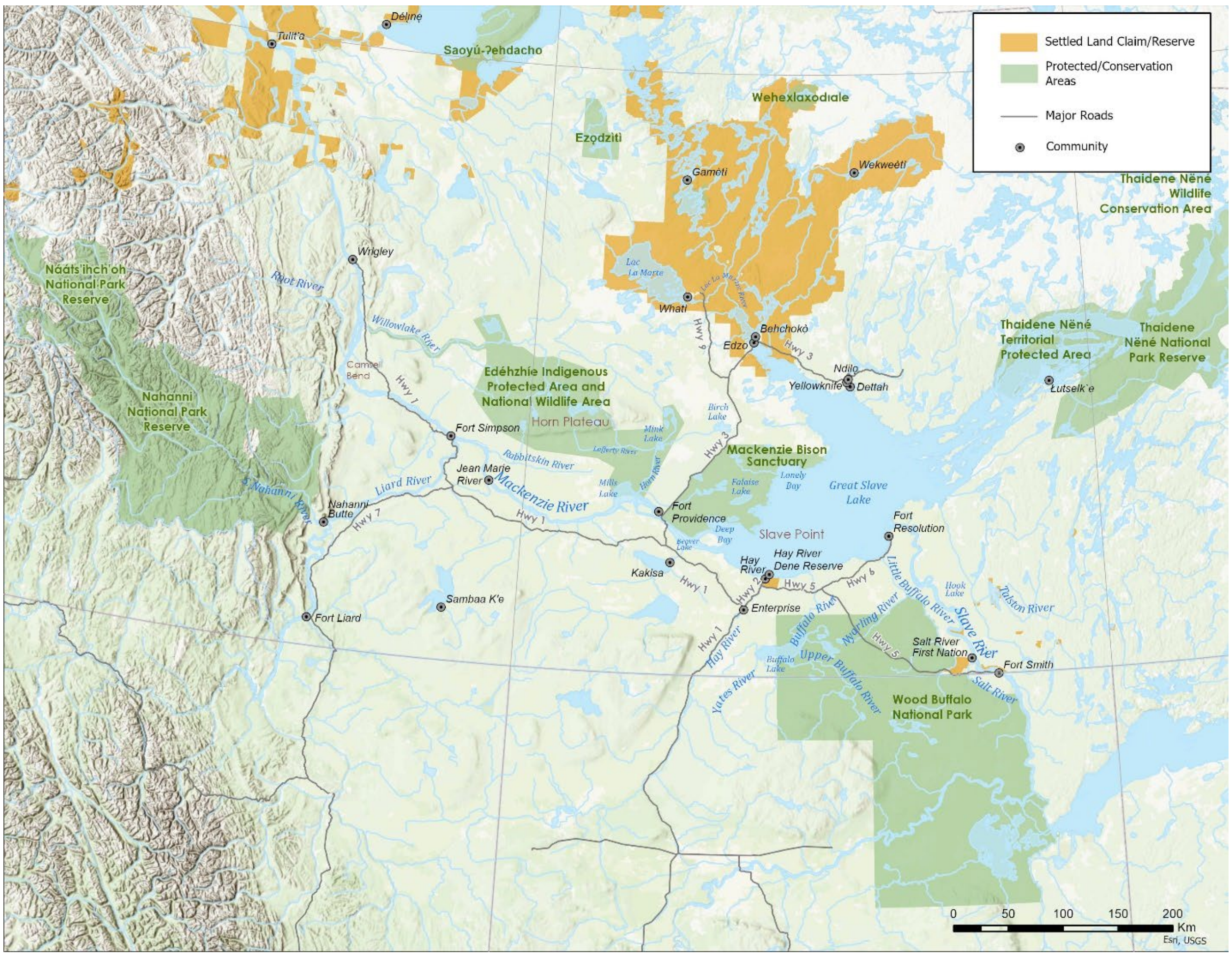

Figure 1. Map of Northwest Territories showing the places mentioned in this report. Map by B. Fournier.

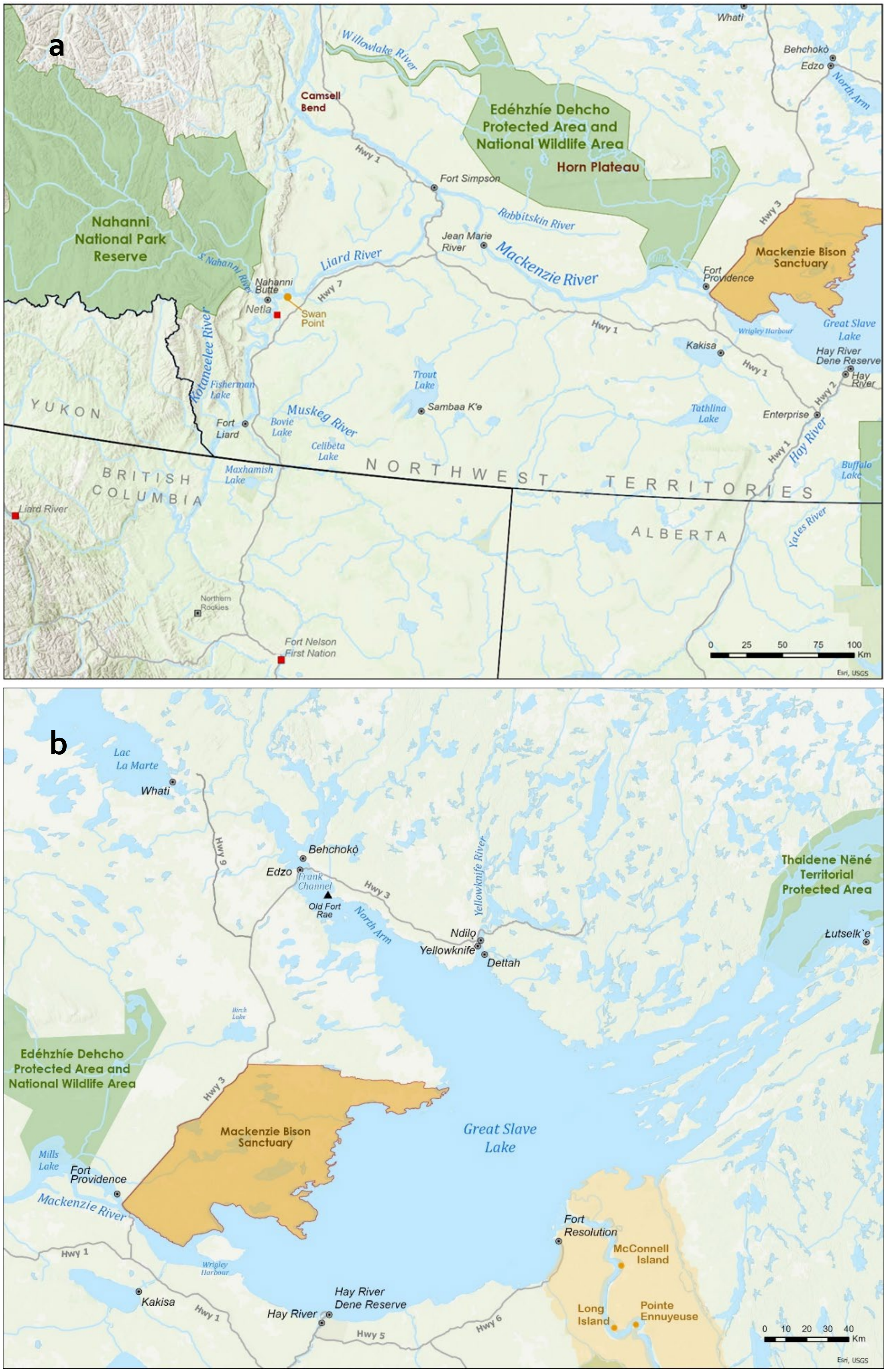
a
Willowlake River
Whatì
Behchokǫ̀
Edzo
North Arm
Camsell Bend
Edéhzhíe Dehcho Protected Area and National Wildlife Area
Horn Plateau
Hwy 1
Fort Simpson
Rabbitskin River
Hwy 3
Nahanni National Park Reserve
Jean Marie River
Mackenzie River
Mackenzie Bison Sanctuary
Liard River
S Nahanni River
Nahanni Butte
Hwy 7
Fort Providence
Netla
Swan Point
Hwy 1
Wrigley Harbour
Great Slave Lake
Kakisa
Hay River Dene Reserve
Trout Lake
Hay River
Rabbitskin River
Kotaneelee River
Fisherman Lake
Sambaa K'e
Tathlina Lake
Hwy 2
YUKON
Muskeg River
Bovie Lake
Enterprise
Fort Liard
Celibeta Lake
Hay River
Maxhamish Lake
NORTHWEST TERRITORIES
Buffalo Lake
BRITISH COLUMBIA
Liard River
ALBERTA
Yates River
Northern Rockies
Fort Nelson First Nation
0 25 50 75 100 Km
Esri, USGS
b
Lac La Marte
Whatì
Hwy 9
Behchokǫ̀
Edzo
Frank Channel
Hwy 3
Old Fort Rae
North Arm
Yellowknife River
Thaidene Nëné Territorial Protected Area
Ndilǫ
Yellowknife
Dettah
Łutselk'e
Birch Lake
Edéhzhíe Dehcho Protected Area and National Wildlife Area
Hwy 3
Mackenzie Bison Sanctuary
Great Slave Lake
Mills Lake
Fort Providence
Mackenzie River
Fort Resolution
McConnell Island
Hwy 1
Wrigley Harbour
Kakisa
Hwy 1
Hay River Dene Reserve
Hay River
Hwy 5
Hwy 6
Long Island
Pointe Ennuyeuse
0 10 20 30 40 Km
Esri, USGS

Figure 2. Regional maps of (a) the Liard and South Nahanni River valleys; (b) Great Slave Lake; and (c) Wood Buffalo National Park and the Slave River Lowlands, showing communities, protected and conserved areas, and other features mentioned in this report. Maps by B. Fournier.

INDIGENOUS AND COMMUNITY KNOWLEDGE COMPONENT

Preface

"You can't really teach someone on a piece of paper, like theoretical. For that, you have to be more practical; you have to go out there and show them. They have to physically see what you are talking about, compared to reading it from a piece of paper. That's the teaching that I do. I bring them out there. I let them feel the ice. They can see the... different ice colours. Which is safe, which is good to go on, which is not safe, [where] it could be unstable. So, there are all these things about the ice. And you've got the currents, you've got the moon, you've got the wind direction. You can't teach a person in one week about all these changes that are happening, that you're aware of, that you could see, you could hear and feel. But giving that knowledge takes time; say, two, three years just to absorb this information and keep seeing." (PIN 158 [Paulatuk] in Joint Secretariat 2015)

The consideration of Indigenous peoples' cultural histories, identities, languages, social organizations, and interactions with their environment is of vital importance for the accurate assessment of species status. While all reasonably available Indigenous and community knowledge was solicited for inclusion in this status report, limitations are acknowledged. First, in the completion of these reports, the Species at Risk Committee (SARC) is not able to conduct any primary research or information gathering activities (e.g., interviews). The transcription and verification of Indigenous and community knowledge is often complex and resource-intensive, not to mention sometimes controversial (Bayha 2012). It is often the case that only a small portion of the Indigenous and community knowledge that exists has actually been transcribed. This limits the completeness, and perhaps also the accuracy, of a status report. Second, it is important to recognize that the Indigenous knowledge transcribed and available for inclusion in this status report has been, in many respects, removed from the cultural, spiritual, linguistic, and ecological context in which it was intended to be heard (Berkes *et al.* 2000; Thorpe 2004; SENES Consultants Ltd. 2010; Tłı̨chǫ Research and Training Institute 2016). Translation, in particular, can result in generalizations and the loss of sometimes subtle descriptions of inter- and intra-specific variation, interactions, and patterns (Tłı̨chǫ Research and Training Institute 2016; Polfus *et al.* 2017). As noted by Polfus et al. (2017: 17), "words are used in context and convey different meaning depending on who is speaking, what dialect is being used, what questions are being addressed, where on the land the speaker is located, and the dialect or background of the audience." Although Indigenous knowledge and its transmission is ultimately grounded in practice, language is integral to its interpretation (Bayha 2012; Polfus *et al.* 2016). Ultimately, understanding the environment (animals, plants, land, water, air, etc.)—that is, practicing one's culture—is essential to understanding the stories and legends.

Preamble

Wood bison historically roamed across a large part of northwestern North America, including much of the Northwest Territories (NWT). They were hunted to near-extinction in the late 1800s. Wood bison persisted in Wood Buffalo National Park and adjacent areas throughout the decline, and re-introduced herds in the NWT now exist around the Liard and South Nahanni rivers (Nahanni population) and west of Great Slave Lake (Mackenzie population).

As noted in the 2016 Species Status Report for Wood Bison in the NWT (SARC 2016), there are few sources of recorded traditional, Indigenous or community knowledge about wood bison populations in the NWT where bison were absent from the landscape for two or more generations. There is a greater amount of recorded traditional and community knowledge of wood bison in areas where the herds have had an uninterrupted presence – in the South Slave area and into northern Alberta, in particular. For this reason, some of the information included in this report about wood bison biology and behaviour, state and trends, and threats, was collected from sources referring to wood bison in northern Alberta, including a portion of the information in Gates *et al.* (2001a) and Mitchell (2002), and all the information in Schramm (2005) and Schramm *et al.* (2002).

In the past, Indigenous and community knowledge on bison has been shared and documented as part of hearings or through academic research. Knowledge holders may have been consulted as part of the management process, but they may not have been actively empowered as a decision-making authority. As co-management systems have evolved, local and community knowledge holders' roles have changed from informers to managers. This evolution has led to change in how conversations about wildlife occur during consultation and management processes. As a result, local knowledge may not be collected or reported in the same way, though the knowledge holders are at the forefront of the decision-making process.

Schramm *et al.* (2002) note that traditional knowledge studies "provide a 'snapshot' in time and should not be used as final and ultimate results. The reason lies in the dynamic nature of the data, which changes as the knowledge keepers and the environment change." Many of the sources used for this report are over a decade old. While they are the best available data, it should be emphasized that that this data represents a historical snapshot that is being provided in lieu of the wealth of undocumented knowledge that would better reflect the current context and status of wood bison in the NWT.

ABOUT THE SPECIES

Names and Classification

Common Name (English):	Wood bison (also commonly known as buffalo)
Cree:	Sakāwmostos (bush bison) (Napier pers. comm. 2024)
Dené sų̨łiné/Athabasca Chipewyan First Nation:	Dechen yághe ejere (Beaver pers. comm. 2024), Thachin ya n'jere (Marcel *et al.* 2012)
Denínu Kụ́ę́ Yatié:	Ɂejëre (SSDEC, 2012)
Teetł'it Gwich'in:	Dachan tat gwi'aak'ii (Mitchell-Firth pers. comm. 2025)
Gwichya Gwich'in:	Aak'ii (to be fat or hefty), Dachan tat gwa'aak'ı̨̀ı̨ (cow of the forest) (Benson 2014)
Kaska Dene:	Łek'aye, łuk'aye, kedä-cho', ejedi (Lotenberg 1996)
Dene Kədə́ (North Slavey):	Ejuda (Lotenberg 1996)
Dene Zhatıé (South Slavey):	Dechı̨tah goegié (ECCC 2018), Dechı̨tah goejıdé (SSDEC 2009)
Tłı̨chǫ:	Dechı̨ta gojıe, Enareh gojıe, Hozìı gojıè (buffalo), Ejıe (cow; bison; buffalo), Ejıezaa (calf of cow; goat; bison; buffalo; muskox) (Tłı̨chǫ Online Dictionary 2025)
Common Name (French):	Bison des bois
Scientific Name:	*Bison bison athabascae*

Description

Figure 3. Adult male wood bison near Fort Smith, NWT. Photo courtesy A. Bathe.

Wood bison are large animals that have been referenced in many oral histories and legends (Benson 2014). Bison are described as being "hefty" or "meaty" (see Figure 3) and, although they are large, they can run through very deep snow (Lotenberg 1996; Benson 2014). Some terms for bison are also applied to muskox; both of these animals have horns and are shaggy with a large hump on their back (Stephenson *et al.* 2001; Benson 2014). Bison and muskox are distinguished based on the distinctive shape of their horns – muskox horns are downswept and cover their heads whereas bison horns curve upwards (Stephenson *et al. 2001*). In some Gwich'in dialects, the same word is used for both muskoxen and bison, with a hand signal accompanying the name to distinguish between them. This hand signal was known across the Gwich'in territory into the NWT (Stephenson *et al.* 2001).

Information about differences between two northern Alberta herds is included under *Adaptations to Northern Regions*.

Relationship with People

Wood bison hold significant spiritual and cultural importance for many Indigenous communities, symbolizing strength, resilience, and connection to the land. Indigenous and community knowledge emphasizes the role of bison in Indigenous cosmologies, where they are often associated with sacred teachings and practices that guide a respect for nature (Christianson *et al.* 2022). This relationship is not only symbolic; it is also practical, as bison have historically been a source of food and materials (Larter *et al.* 2000; Van Kessel 2002; Heuer *et al.* 2023).

Figure 4. Wood bison in Nahanni Butte. Photo courtesy A. Bathe.

Harvest

Wood bison are hunted throughout their range in the NWT, except where prohibited; however, harvest rates and approaches to harvest may differ based on regional attitudes towards wood bison (ENR 2010b; CMA 2019; APTN News 2023). The degree of harvesting is also influenced by population dynamics and health management strategies, particularly in the context of diseases such as tuberculosis and brucellosis, which have affected wood bison populations in Alberta and south of Great Slave Lake in the NWT (Schramm *et al.* 2002; Crosscurrents Associates Ltd. and Maskwa Environmental Services Ltd. 2007; Shury *et al.* 2015; Will 2015).

Interactions with wood bison have changed over time; historically, bison were more prevalent and accessible in many areas where they are no longer found. Some people no longer see bison as part of their heritage, particularly where the species has been absent from the local landscape for a number of generations (ENR 2010b; CMA 2019). For example, Tłı̨chǫ have not traditionally hunted these animals because they occupied a more southern range, which did not extend into the Tłı̨chǫ region. Even as wood bison become more common closer to Whatì, Tłı̨chǫ harvesters have not been harvesting these animals (TG and Firelight 2025b). Wood bison may even be considered an invasive species by some communities where the animals have begun to reoccupy their historic range (Huntington *et al.* 2005).

Today, some communities organize specific hunting trips for wood bison, while others rely on regulated harvests (Doney *et al.* 2019; APTN News 2023). The Salt River First Nation considers wood bison to be sacred and an essential component of their livelihood (Environment Canada 2015e). In contrast, members of the Kátł'odeeche First Nation have indicated that they do not have a strong relationship with bison, although this is perhaps because they have been barred from hunting them in Wood Buffalo National Park since the early 1920s. A lot of the Indigenous and community knowledge about this species has therefore been lost over time (Environment Canada 2015d).

Similarly, in a limited study (Fanni 2014), some members of the Acho Dene Koe First Nation (ADKFN) indicated that wood bison are never harvested by their members because they are thought to feed on garbage along Highway #77 and because their hides are too tough to be useful for traditional materials. However, this attitude may not be prevalent as some members, both young and old, have actively hunted bison (Larter pers. comm. 2016 *in* SARC 2016). Younger members of the ADKFN indicated less opposition to harvesting and eating bison (Fanni 2014). Reynolds *et al.* (1980), who, in studying the suitability of the Liard-South Nahanni rivers region for the establishment of a herd of reintroduced wood bison, indicated that the transfer of wood bison to this region ought to be carried out, in part because the local people supported the re-establishment of wood bison as an alternate meat source.

In the Tłı̨chǫ region, where wood bison are moving closer to Whatì, it is recognized that local hunters need to develop skills to harvest and butcher bison to take advantage of increasing numbers of bison along the highway. Training sessions could provide instruction to Tłı̨chǫ harvesters about how to effectively harvest and clean a wood bison (TG 2025b).

Hunting is discussed in more detail in *Threats and Limiting Factors*.

Reintroduction

The reintroduction and expansion of wood bison into their historic ranges (Figures 4 and 5; more on reintroduction in *NWT Distribution*) has been a significant conservation effort, with Indigenous communities actively involved in these initiatives, reflecting a commitment to restoring traditional practices and ecological integrity (Clark *et al.* 2016; Doney *et al.* 2018; ECCC 2018; Jung 2020; Bath *et al.* 2022; Christianson *et al.* 2022). Clark *et al.* (2016) highlight how the resurgence of bison populations can revitalize cultural practices, including hunting, storytelling, and community gatherings, thereby strengthening cultural identity and continuity.

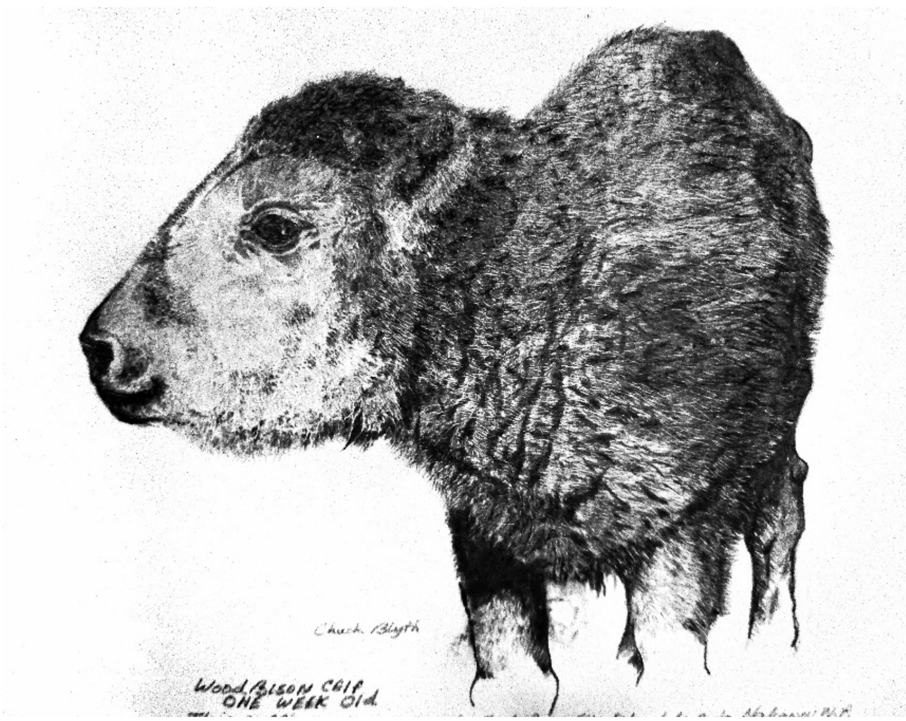

Figure 5: Drawing of a one-week-old calf at Elk Island National Park. The calf was shipped to the NWT as part of the reintroduction of the Nahanni population. Image courtesy C. Blyth.

Reintroduction is regularly presented as both a potential win for conservation and an economic opportunity for nearby communities, as sustainable wood bison management can lead to new economic ventures, such as eco-tourism and meat production (ENR 2010b). Clark *et al.* (2016) discussed the importance of developing frameworks that allow Indigenous communities to benefit economically while ensuring that traditional ecological knowledge is respected and integrated into management practices. To date, there have been significant challenges to developing a legal market-based and sustainably managed trade in wild meat in the NWT and surrounding regions (Judge *et al.* 2022; Natcher *et al.* 2022).

Communities within the range of reintroduced wood bison populations have been advocating for continued collaboration among all stakeholders to ensure that the reintroduction of bison is beneficial for both the ecosystem and the Indigenous communities (Clark *et al.* 2016).

Conflict with People

Wood bison are often perceived to be a nuisance in Dehcho and Tłı̨chǫ communities (ENR 2008, 2010a, 2012; Environment Canada 2015a; TG and Firelight 2025a and b). During winters with deep snow, bison frequently use roads, creating common roadside hazards, particularly on highways between Hay River and Fort Smith and between Fort Providence and Behchokǫ̀ (MBWG 2018; Cabin Radio 2019). People in Whatì have complained about an increase in bison since the Tłı̨chǫ Highway opened in 2021 (TG and Firelight 2025b).

"There's too much buffalo on the road now. … Lots of buffalo on that road. … We didn't see them before. … Now there's lots of buffalo on the road now." (Bobby Migwi in TG and Firelight 2025b: 34)

Residents of Fort Liard have raised concerns for decades about bison wandering into public spaces, such as schoolyards and airport runways (CBC News 2021). Conflicts also arise due to property damage, safety concerns, impacts on other wildlife and habitat, disruptions to traditional livelihoods, and potential spread of disease (Clark *et al.* 2016; Doney *et al.* 2018; CBC News 2021). There are concerns that wood bison may adversely impact traditional pursuits by competing with boreal caribou and moose (Dehcho First Nations and Resources, Wildlife and Economic Development 2002, 2004; Cluff *et al.* 2006; ENR 2006, 2008, 2012; Fanni 2014; Environment Canada 2015a), by making it difficult to set small mammal snares, and by trampling or eating plants and berries that would normally be harvested by communities (Fanni 2014).

"When I go rabbit snaring I always think… now, what will I do if I meet a buffalo? Never did yet though. think they're scared of people now since they started hunting them." (Anonymous Champagne and Aishihik First Nations member in Clark et al. 2016: 5)

"So when you see desecration happening to gravesites of your family members that really bothers you… Well, think it hurts them spiritually and creates a lot of stress for them because in our traditions and in our culture when people were put away they were put away with respect, because the whole community puts a person away." (Anonymous Champagne and Aishihik First Nations member in Clark et al. 2016: 5)

It has also been noted that bison may be blamed for unsuccessful harvests simply because they are visibly present, rather than due to any actual measurable adverse effect they may have on other harvestable species (Allaire pers. comm. 2015 *in* SARC 2016). Further, although wood bison were present in the NWT historically (early 1900s) (ENR 2012), there is the feeling that wood bison are a 'novel' wildlife species and should be prevented from expanding their range into communities (TG and Firelight 2025a). This is likely the result of wood bison being absent from the landscape for a number of generations (ENR 2008, 2012; Environment Canada 2015a). Dehcho First Nations delegates at the 6th Biennial Regional Wildlife Workshop (ENR 2012) noted that more education for communities regarding the use of bison as a meat resource was needed.

"If we were culturally connected to bison we wouldn't have a problem" (Priscilla Canadian in ENR 2012: 2).

Fanni (2014) raises another point:

"Unfortunately, the negative effects of the presence of bison disproportionately affect ADK Elders, a fact which, because of the high social standing of the latter, magnifies the already hostile attitudes of ADK members towards the animals." (Fanni 2014: 15)

Wildlife officers have taken steps to manage the impacts of wood bison, including working with hunters to drive the animals out of the community, culling problem animals and using prescribed burns to create favourable habitat outside of communities (ENR 2010b; CBC News 2021; ECC 2023; CMA 2025). Bison hunting helps control populations but has also introduced additional issues such as interference with fur trapping, trespassing, and environmental damage from trail creation (Clark *et al.* 2016; APTN News 2023).

There is, however, some indication that attitudes, at least in Fort Liard and Fort Providence, are changing. Danny Allaire (pers. comm. 2015 *in* SARC 2016) has observed increasing harvest and consumption of bison meat by locals following efforts by territorial government representatives to distribute meat harvested from problem bison kills. Stories about bison also certainly still exist. ADKFN members have discussed how they used to travel from communities to their traditional camps using old bison trails, before the reintroduction of bison. Members of the Tthets'éhk'edélî First Nation (Jean Marie River) used to travel to the Slave River in the summer to trade for bison hides because there were no more bison in their region. Hunters that lived on the Liard River historically hunted bison by scaring them into the river, drowning them by paddling up to them and splashing water into their noses, and then dragging them to shore to be butchered (Allaire pers. comm. 2015 *in* SARC 2016).

Biology and Behaviour

Breeding is known to take place in August (Gates *et al.* 2001a; Mitchell 2002; Schramm 2005; ECCC 2015 *in* SARC 2016: 43). Bison in the Slave River Lowlands are known to seek high areas between the Little Buffalo River and adjacent large wet meadows to calve (Gates *et al.* 2001a; Mitchell 2002). Wood bison in northern Alberta are known to seek out spruce bluffs for calving, where the trees offer shade and cover (Schramm 2005).

Wood bison in southern Wood Buffalo National Park are known to calve between May and early-June, although young calves have been seen year-round. One Garden River resident saw calves born in the fall during the anthrax vaccinations; many others saw calves being aborted during vaccination round-ups that were carried out by Wood Buffalo National Park between 1965-1977 (Northern Diseased Bison Environmental Assessment Panel 1990a; Schramm and Krogman 2001; Schramm 2005).

Diet and Feeding Behaviour

Wood bison primarily feed on grasses and sedges, with their foraging behaviour varying by season (Mitchell 2002). In summer, they prefer grass and sedge meadows, often moving into coniferous and mixed forests later in the season. Willow leaves also make up a notable portion of their summer diet. In winter, bison concentrate in areas where high-quality forage remains accessible, such as wetlands, shrublands, and certain grasslands. Deep snow influences their feeding patterns, encouraging them to form larger groups to facilitate movement and foraging (Schramm *et al.* 2002; Van Kessel 2002; Christianson *et al.* 2020). Wood bison frequently graze in recently burned areas and cut blocks, where regrowing vegetation provides fresh forage (Mitchell 2002).

Foraging behaviour of three wood bison herds in northern Alberta are detailed in Schramm *et al.* (2002) (Wentzel Lake, Wabasca and Garden River[2] herds; see Figure 7). The Wabasca herd prefers open areas, whereas the Wentzel Lake herd primarily inhabits forested regions. These wood bison supplement their diet with caribou lichen and willows, with their foraging behaviour resembling that of moose. In summer, the Wentzel Lake herd and the Garden River herd favour higher ground, including prairie patches, meadows, and cut blocks, where they feed on green grass. During winter, the Wentzel Lake herd remains near small lakes, dry creeks, and old beaver dams, where naturally dried grassy forage is abundant. In the southwestern part of Wood Buffalo National Park, wood bison shift from jack pine, tamarack, and poplar ridges in summer to the hay meadows along the Peace River in winter. Indigenous and community knowledge holders also observed that these wood bison consume caribou lichen during the winter when heavy snow limits access to hay, as the softer snow in spruce habitats makes lichen more accessible. Additionally, bison in the Garden River herd have been observed breaking open muskrat houses to feed on the hay used in their construction (Schramm *et al.* 2002).

An abundance of coarse thistle in Wood Buffalo National Park has pushed bison south to more suitable feeding grounds on the west side of the Athabasca River in the Ronald Lake area:

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[2] Referred to as the south-western Parks herd in Schramm *et al.* (2002).

"We do have a large number now, over the last few years. They have grown because there's a lot of that thistle in the Wood Buffalo National Park. You know that little thistle? Well, it's a plant. It's a weed or whatever, but it grows in the grass and if the buffalo, they can't eat the grass because it get stuck in their mouth. So they can't eat there. So with that thistle expanding in the park. They're being pushed south out of the park because it's good feeding ground in this—like, this whole—the whole area on the west side of the Athabasca River is, like—it's like Africa in Alberta, you know what I mean?" (Anonymous [Métis Local 1909] in O'Connor and MNAA 2015: 68)

Salt licks are also used by bison. Bison in the Wentzel Lake herd were observed using salt licks along Garden River Road (Highway 58) in northern Alberta before hunting pressure caused them to retreat (Schramm *et al.* 2002; Schramm 2005).

Adaptations to Northern Regions

Bison use their heads to dig through the snow to reach their food, or they may blow snow away (van Kessel 2002; Schramm 2005); however, according to Yukon oral history, the wood bison's short legs make it difficult for them to move in deep snow, and as such they seek out snow-free areas in the winter (see *Habitat Requirements*; Lotenberg 1996). However, a Tsiigehtchic Elder indicated that wood bison were large and capable of running through even very deep snow (Stephenson *et al.* 2001).

In the past, wood bison in the Yukon were considered difficult to kill with arrows, as they are 'fast runners.' Although some groups did harvest them with arrows, others relied upon a snare system. They were considered a dangerous animal to hunt, as they are aggressive or 'put up a fight' (Lotenberg 1996; Stephenson et al. 2001).

Bison in the Wentzel Lake herd stay in small family groups of 6-15 individuals. They are not known to coalesce into a large herd or large groups, although the small groups may come together to form slightly larger groups. The formation of these slightly larger groups is based on seasonal conditions. Heavy snow cover encourages the formation of larger groups as it is easier on individuals, in particular calves, when the work required to break through the snow crust is shared more widely. Bison in the Wentzel Lake herd are known to stay in smaller groups if the snow cover is light, as well as in the summer (Schramm 2005).

Wood bison in southwest Wood Buffalo National Park are generally encountered in smaller groups as well, although they have occasionally been seen in groups as large as 100 during the trapping season (winter) (Schramm 2005). As noted in *Movement and Dispersal*, some traditional knowledge sources suggest cows and calves will separate into smaller groups in the summer and coalesce in the winter at feeding areas (Gates *et al.* 2001a; Mitchell 2002). However, some knowledge holders indicate that Wood Buffalo National Park herds stay in larger herds in the summer and smaller herds in the winter (Schramm 2005).

Wood bison in the Wentzel Lake herd shed in spring, and use tree trunks, uprooted trees, and wallows during that time. They prefer the rough bark of spruce trees to rub on (Schramm 2005). The smell of the spruce trees helps to mask the bison's odour and protect it from wolves. Wallowing and rubbing continue throughout the insect season in the summer (Schramm 2005). Oral history from Alaska indicates that wood bison are not bothered by mosquitoes like other ungulates, due to their hair coat. However, they do harbour parasites in their coats (Stephenson *et al.* 2001).

Relationship Within and Among Species

Interactions with predators

Wolves are considered the main predator of wood bison. Black bears (Figure 6) and cougars may also kill wood bison, especially calves in the spring, but the available literature provides no direct observations of these interactions though bison have been observed with scars that could have been caused by either of these predators (Evans pers. comm. 2012 *in* Fanni 2014: 15).

Figure 6: A wood bison watches as a black bear passes by. Photo courtesy P.-E. Chaillon.

Wolves are known to follow wood bison herds around. Wolf population numbers may be linked with wood bison and moose population numbers – wolf numbers may decrease as ungulate numbers decrease (Schramm 2005). Wolf predation may also impact wood bison in other ways;

the Northern Diseased Bison Environmental Assessment Panel noted that wolf predation may be causing wood bison to be smaller in size physically (1990b).

Wolves are considered by some to have a valuable role in the ecosystem and an important relationship with bison and other wildlife (Will 2015). Wolves are known to take mainly calves, although they will occasionally take an old or diseased animal or target a healthy 'fat' animal (Schramm 2005). Wolves are known to not 'touch the boss' of the herd (Schramm 2005); however, trappers have reported single wolves tracking and killing lone bulls (Dragon pers. comm. *in* Carbyn *et al*. 1993: 150).

Hunters have seen small herds with very few calves remaining (Schramm 2005):

"I see their tracks, wolf tracks... following the buffalo. But they kept their distance; they don't want to go right up. Unless there's a few calves in a small herd, that's easy prey for them. Well, a big herd, maybe ten, twelve, they won't go. They'll stay away. But they will just circle a few times and then leave... But if there's about maybe five and there's a couple of calves, oh yeah, they go after them, right now." (Malcolm Auger in Schramm 2005: 133)

One hunter has seen three adult cows taken by wolves at around the same time. They could not escape the wolves due to snow conditions (Evans pers. comm. 2012 *in* SARC 2016).

Wood bison face wolves head on and chase them away. When approached by wolves, wood bison stay together as a group, circling the calves, making them very hard to kill. Wolves have the best chance to kill a wood bison if they can cause the group to 'open up.' If they decide to flee, the animals will go single file, led by a bull or bulls and with several large cows in the back, with the calves in the centre. In this formation, a bull at the rear is particularly vulnerable to attack, as wolves attack the genital region and will bite their testicles and rip them open (Schramm 2005).

Wood bison use seismic lines and open meadows for their improved ability to see approaching wolves. They are particularly vulnerable to predation by wolves during the summer when the soft, moist ground forces the heavy bison to sink, slowing them down (Schramm 2005).

The communities of Fort Chipewyan and Fort Smith have urged government to control wolf predation on wood bison through predator control programs since the 1930s. Wolf populations were controlled in the 1940s and 1950s and wolf numbers did decrease, although they increased again in the 1960s. A change in policy at Wood Buffalo National Park precluded further predator control programs (Carbyn and Trottier 1988). Hunters felt that any of the various proposed eradication plans suggested over the years to completely remove diseased wood bison from the Wood Buffalo National Park area would cause large changes to the relationships between wood bison predators and other prey animals (Ferguson 1989) (refer to *Threats and Limiting Factors - Disease eradication efforts*).

More recently, community members have indicated the wolf population in Wood Buffalo National Park is on the rise and expressed concerns that low calf survival among bison may be due to wolf predation. Will (2015) noted that some community members supported controlling the wolf population through hunting or culling.

"I think the large number of wolves. They are a real threat on the herds. Especially the little brownies. You don't see too many of them." (Anonymous [Fort Chipewyan Métis Local 125] in Will 2015: 78)

In the North Slave region, increasing wood bison populations are believed to be responsible for an increase in wolf numbers. This is considered a threat to other ungulates such as boreal caribou (Cluff *et al.* 2006). Likewise, in the Dehcho region, it has been noted that there are too many wolves around the Mackenzie Bison Sanctuary and that predator management could be incorporated into management plans for wood bison and caribou (ENR 2008).

Interactions with competitors

Community members have expressed concerns about the possible negative interactions and competition between wood bison and species such as boreal caribou. For example, Dehcho First Nations indicated in a 2011 report that slow declines and reduced season movements in boreal caribou populations near Fort Providence were likely due, in part, to an expanding wood bison population (DCFN 2011). Jung *et al.* (2015) cite community concerns about potential competition in the range of the reintroduced Yukon wood bison herd impacting moose, caribou and sheep. Tłı̨chǫ harvesters have expressed concerns about the northward movement of bison towards Whatì, as they worry the increased wood bison presence may cause boreal caribou to avoid the area (TG and Firelight 2025b).

Wood bison are also seen as competitors for slow-growing lichens consumed by boreal caribou in the Caribou Mountains, although the bison tend to stay in the western portion and the caribou in the east. This point was also made by some members of the Acho Dene Koe First Nation (ADKFN) in Fort Liard, who noted that competition for resources was particularly concerning during harsh winters or dry summers (Fanni 2014). Interviewees in this limited study (Fanni 2014) explain the mutual avoidance (caribou avoiding wood bison and wood bison avoiding caribou) in several ways, including the caribou avoiding the wolves near the bison, but also that the bison forage heavily on the caribou's preferred food. Schramm and Krogman (2001) also note that caribou are known to avoid areas adjacent to wood bison range despite the presence of good caribou forage.

An explanation for the avoidance of the caribou range by bison, however, is still lacking. While some knowledge holders describe a difference in habitat preferences ("a buffalo wouldn't go in the muskeg. A muskeg is too soft for a buffalo" [John James Antoine *in* Gunn 2009: 91]), others suggest they mutually agree or cooperate to remain apart (Schramm 2005).

"When I discussed the issue with Malcolm Auger he replied, "They don't bother each other". I asked Mr. Auger if the two species communicate, and he replied that they did. This is an aboriginal explanation of the phenomenon where an agreement exists between both ungulate species to stay out of each other's ranges." (Schramm 2005: 176)

Increasing wood bison range and populations are seen as a threat to boreal caribou and moose by NWT communities (DFN and RWED 2002; RWED 2004; Cluff *et al.* 2006; ENR 2006; Larter and Allaire 2007; ENR 2008, 2012; Fanni 2014; Environment Canada 2015a, b, and d). Residents of Nahanni Butte and Fort Liard have expressed concern that the increasing population of the Nahanni wood bison may compete with moose – a preferred country food source (Larter and Allaire 2007). ADKFN members noted that moose will not graze near wood bison as a result of the distinct smell of their urine and feces and have almost disappeared from the Fort Liard area. One ADKFN harvester also described wood bison as "bullies in a playground," having observed them urinating on salt licks (Fanni 2014: 15). However, concerns have been raised with this study and the perspectives it presents. In addition to the study limitations noted earlier (e.g., few interviewees), the effects of the construction of the Liard Highway may have been understated or overlooked (e.g., increased access, traffic, etc.) and little recognition is given to changes in harvesting practices over time (e.g., over-harvesting moose, relying only on big game rather than harvesting chickens (grouse), rabbits, fish, beavers, etc. to supplement the diet). Directly tying wood bison to a decline in moose may therefore be difficult (Allaire pers. comm. 2015 *in* SARC 2016).

In addition to direct competition with other ungulates, wood bison have also been known to consume muskrat push-ups in the winter (Schramm *et al*. 2002). This may leave muskrats without shelter and could lead to negative impacts on local populations (Scramm 2005).

PLACE

NWT Distribution

Wood bison are found the southern NWT (South Slave and Dehcho regions, as well as parts of the North Slave region). Wood bison are social animals that form groups and establish recognizable territories, which facilitates the identification of distinct population ranges by local knowledge holders (Schramm et al. 2002).

Indigenous and community knowledge sources use the terms 'herd' and 'population' interchangeably. For the purposes of this report however, 'population' is used to describe the four groups of wood bison in the NWT (managed distinctly as Mackenzie, Nahanni, Slave River

Lowlands and Wood Buffalo National Park populations), while 'herd' is used to describe the subpopulations within Wood Buffalo National Park (Fig. 8).

Wood bison in the Slave River Lowlands and Wood Buffalo National Park are part of a large population that persisted through the decline and near-extinction of wood bison in the late 1800s and early 1900s. The Mackenzie and Nahanni bison populations were introduced to the NWT (starting in 1963 and 1980, respectively) as part of efforts to re-establish wood bison on their historic range (CMA 2025).

The Mackenzie, Nahanni and Slave River Lowlands populations are managed by the Government of the Northwest Territories (GNWT). Bison in Wood Buffalo National Park are managed by Parks Canada.

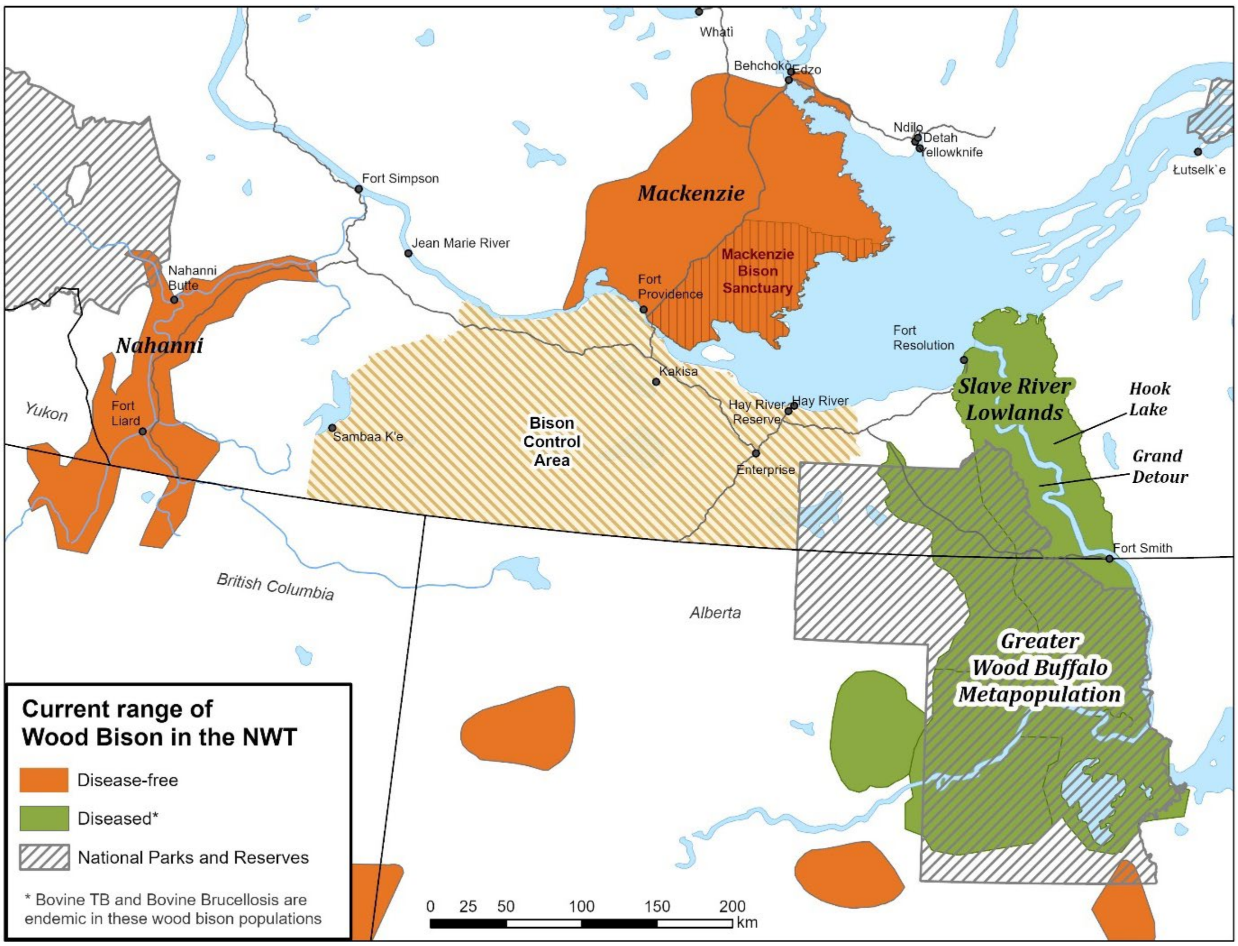


Figure 7. Current wood bison range in the NWT and adjacent jurisdictions. Map by N. Wilson, GNWT-ECC.

Wood Buffalo National Park population

The Wood Buffalo National Park population straddles the NWT and Alberta (Figure 8). Indigenous and community knowledge sources describe four main herds within Wood Buffalo National Park; of these, only the Nyarling River herd occurs within the NWT (the other three herds, while occurring within the park, are present only in Alberta) (SARC 2016). A fifth herd (Grand Detour) occurs on the northeastern periphery of the park, with most of its range outside the park in the Slave River lowlands. This herd is discussed below as part of the Slave River Lowlands population.

The Nyarling River herd's range is south of Great Slave Lake in the NWT, east of Buffalo Lake and straddling the NWT/Alberta border (Gates et al. 2001a; Mitchell 2002) (Figure 8). Kátł'odeeche First Nation members have harvested wood bison along the Yates River, which flows into Buffalo Lake outside of Wood Buffalo National Park (Crosscurrents Associates Ltd. and Maskwa Environmental Services Ltd. 2007). Gates et al. (2001a) also reported a second-hand account of a sighting south of Buffalo Lake near Yates River, and wood bison sightings along the Yates River west of Wood Buffalo National Park and north of the Caribou Mountains, and along the shore of Buffalo Lake (Gates et al. 2001a; Mitchell 2002). The English name "Buffalo Lake" comes from the Slavey placename "Ejie Túé," meaning "buffalo's water"—suggesting wood bison have an attraction to this area (Crosscurrents Associates Ltd. and Maskwa Environmental Services Ltd. 2007).

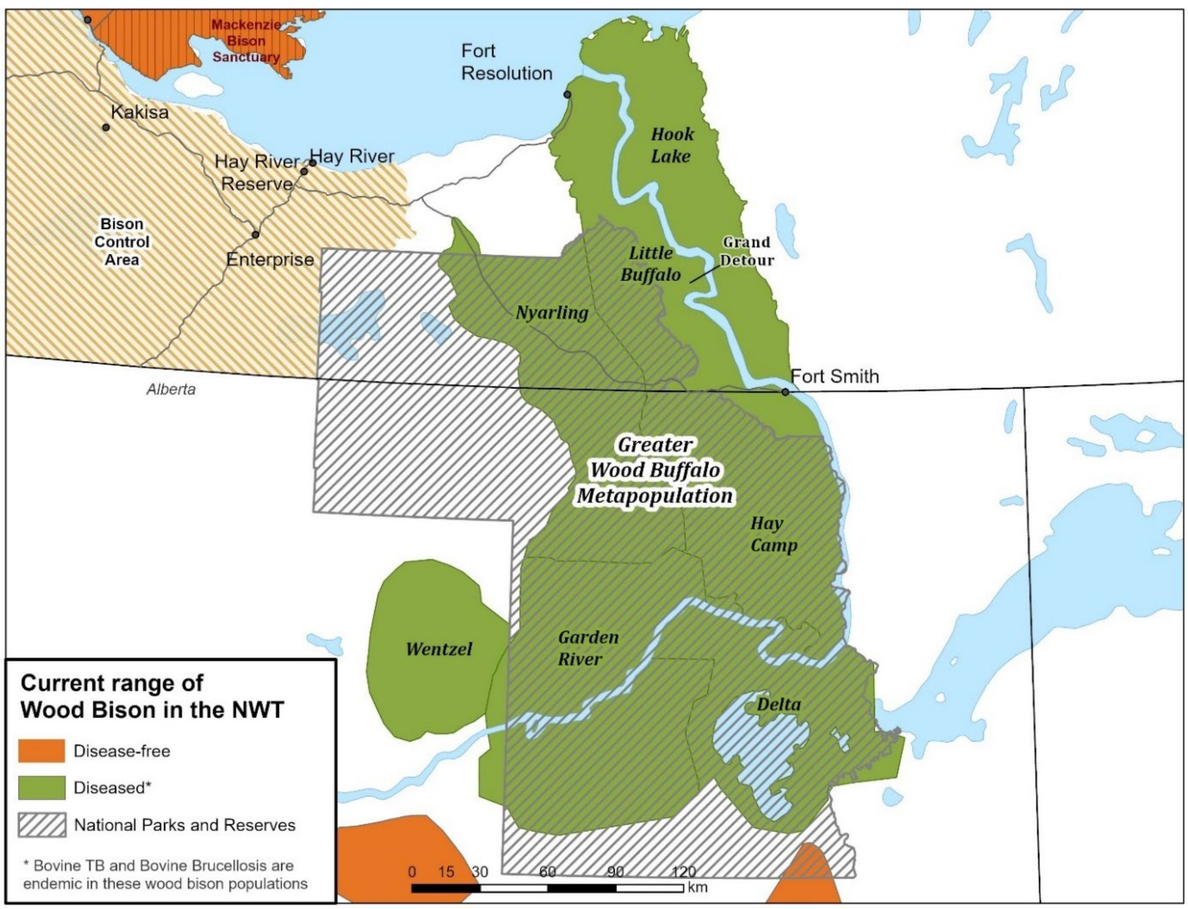


Figure 8. Current wood bison range in and around Wood Buffalo National Park. Map by N. Wilson, GNWT-ECC.

While they are not located in the NWT, the Wentzel Lake and Garden River herds southwest of Wood Buffalo National Park are also discussed in this report. Indigenous and community knowledge about these herds provides important information about wood bison biology and behaviour, state and trends, and threats relevant to bison in the NWT (e.g., in Schramm 2005 and Schramm *et al.* 2002).

Slave River Lowlands population

The Slave River Lowlands population is situated just outside of Wood Buffalo National Park in the NWT portion of the Slave River valley. For the purposes of this report, the Slave River Lowlands population is considered to consist of two herds: Grand Detour (referred to by Parks Canada as Little Buffalo) and Hook Lake. The range of the Hook Lake herd is from just inside Wood Buffalo National Park and in the western portion of the Slave River Lowlands to the east of the Slave River. The range of the Grand Detour herd is around the Little Buffalo River with calving taking place between the Little Buffalo River and the large meadows to the east (Gates *et al*. 2001a; Mitchell 2002).

Information from interviews conducted by Gates *et al*. (2001a) indicates that some of the Grand Detour herd was originally from Sweetgrass, north of Lake Claire in Alberta (Gates *et al.* 2001a; Mitchell 2002). Wood bison from the Slave River Lowlands population have been observed near the Taltson River north of Taltson Prairie in the winter. The eastern extent of their range is the Taltson River. They do not use the rocky Canadian Shield country to the east of the river on a regular basis, although they are known to cross the river occasionally and return (Gates *et al*. 2001a; Mitchell 2002). One year in the late 1990s, a group of wood bison crossed the Slave River at McConnell Island, where they stayed in the meadows around Rat Slough and Ring Lake (Gates *et al*. 2001a; Mitchell 2002).

Mackenzie population

The Mackenzie population is located to the west of Great Slave Lake, including the eastern portion of the Horn Plateau. Fort Providence community members have reported that late in the summer, wood bison from the Mackenzie population have been observed moving further west into the eastern portion of the Horn Plateau and along the Horn River drainage (EBA Engineering Consultants Ltd. and Canadian Wildlife Service [CWS] 2006). The Mackenzie population has also expanded its range to the north and east along Highway 3 (CMA 2025).

Historically, wood bison used routes near the Whatì River, Yellowknife River and Frank Channel (Phelan 2024). In the late 1990s or early 2000s, there were sightings of wood bison about 30km south of Behchokǫ̀ along the Mackenzie Highway (Mitchell 2002; EBA Engineering Consultants Ltd. and CWS 2006; MBWG 2018). While wood bison predominantly inhabit the western side of the North Arm of Great Slave Lake, there are occasional reports of individuals traversing the northeastern and eastern sectors, with Old Fort Rae identified as a favourable location for observing this species (Phelan 2024).

More recently, bison have been observed as far north as Whatì (Judas pers. comm. 2024), although these are considered extra-limital movements and not representative of a true expansion of range (Armstrong pers. comm. 2025). Concerns have been raised by the Edéhzhıe Management Board regarding the potential implications of bison moving further up the Horn Plateau (EMB 2024). There is apprehension among Dehcho First Nations that the presence of bison may displace caribou populations or attract increased wolf activity (DCFN 2011), thereby heightening predation risks and possibly facilitating the transmission of disease, and there is a desire to limit bison encroachment onto the plateau (EMB 2024).

Nahanni population

The Nahanni population range includes the southwestern NWT, southeastern Yukon and northeastern British Columbia. This population occurs within the traditional territory of the Acho Dene Koe First Nation (ADKFN) and the Nahanni Butte Dene Band (Armstrong pers. comm. 2015 *in* SARC 2016), largely in the Fort Liard area and along the Liard River and Highway 7 corridor. Most available traditional knowledge of the Nahanni population is derived from ADKFN compilation efforts (Fanni 2014); however, it should be noted that Fanni (2014) may not have interviewed enough Elders to provide a clear representation of the knowledge in the community as a whole.

Groups of wood bison occurring in this area consist of both males and females of all ages (Fanni 2014). Although wood bison were historically present in the area, ADKFN members interviewed by Fanni (2014) were confident that prior to the reintroduction effort started in 1980, wood bison hadn't occurred in their traditional territory for at least four generations. They also confirmed the general distribution of the Nahanni population developed by ENR (now ECC) (Fanni 2014).

Other herds and areas

Wood bison sightings do occur outside of known herd ranges. Wood bison have been seen along the south shore of Great Slave Lake, and although they do not leave the shore area to venture inland (Gates *et al.* 2001a; Mitchell 2002), they have been known to cross the Mackenzie River at Wrigley Harbour (Environment Canada 2015d). Wood bison have also been seen north of Wood Buffalo National Park along the road to Hay River, particularly in burned-out areas (Gates *et al.* 2001a; Mitchell 2002), and near Buffalo Lake, Copp River, and Buffalo River on the western limit of Wood Buffalo National Park (Environment Canada 2015d). In 2011, a wood bison carcass was reported on the Mackenzie River ice between Fort Good Hope and Tsiigehtchic. A Renewable Resource Officer reported that a grizzly bear was feeding on it (Andre pers. comm. 2012 *in* SARC 2016). Hunters from Trout Lake saw tracks from what may have been a wood bison, possibly from the Nahanni population, at kilometre 45 of the Trout Lake winter road in 1985 (Larter and Allaire 2007).

Historically, wood bison ranged over a much larger area in the NWT, Yukon, and Alaska (Lotenberg 1996; Stephenson *et al.* 2001). According to oral history accounts, wood bison became scarce or extirpated in Alaska earlier than in the lower Mackenzie River area (i.e., the current Gwich'in Settlement Area). This was likely prior to European contact. However, there may have been a very small number of wood bison in Gwich'in territory in Alaska and the adjacent Yukon (around Old Crow, Yukon) as late as the early 19th century (Stephenson *et al.* 2001).

"Charlie Peter Charlie, Sr. of Vuntut Gwich'in First Nation corroborated information about bison occurring around North Mackenzie. He claimed that according to his grandfather, 'the people of Fort McPherson [were] killing bison across the river from the community of Fort McPherson in the 1820s." (Lotenberg 1996: 13)

Tsiigehtchic Elders indicate that wood bison likely disappeared from the area north and south of the Mackenzie River around 200 years ago.

"Hyacinthe Andre [a Tsiigehtchic Elder] said he had heard "old stories" referring specifically to the Travaillant Lake area… as having once supported bison, that bison were once hunted to the north near the arctic coast, and that bison once occurred on the "barren-grounds" adjacent to the Anderson River, mentioning that bison skulls had been found there. He does not recall the Gwich'in name for bison, but notes they disappeared a long time ago and that it has been at least 200… years since bison were hunted in the region… Mr. Andre clearly differentiates bison from muskoxen, and that these animals "were powerful and could run through four feet of snow with no problem." (Stephenson et al. 2001: 133)

When wood bison were living in the area, they were hunted by the Gwich'in (Stephenson *et al.* 2001). In the Yukon, wood bison historically occurred around Ross River and may have dispersed into adjacent regions throughout central and western Yukon, possibly into northern British Columbia, and rarely, perhaps even as far north as Vuntut Gwitchin (Van Tat Gwich'in) territory. Lotenberg (1996) suggests that these sightings were dispersing animals passing through, rather than residents.

Movement and Dispersal

Much of the available information on movement and dispersal patterns is sourced from interviews conducted by Mitchell (2002) and Gates *et al.* (2001a). As Schramm *et al.* (2002) note, knowledge holders have observed that each herd may have its own preferences and patterns of behaviour. The data collected by Mitchell (2002) and Gates *et al.* (2001) focused on bison in Wood Buffalo National Park and may not be indicative of the behaviours of other populations.

The movement and dispersion patterns of wood bison are influenced by a variety of ecological and environmental factors, as well as group dynamics. Wood bison exhibit distinct movement behaviours that vary between bulls and cows. Wood bison that are observed at the edge of established ranges, outside of the main herds, tend to be bulls. Bulls are more likely to travel alone, disperse great distances from their herd, and/or stay in small bull-only groups (Gates et al. 2001a; Mitchell 2002), often leading the way during range expansions (Larter *et al.* 2000). One bull was known to leave the Wabasca herd occasionally, cross into Wood Buffalo National Park, and return with a number of cows (Schramm 2005).

Interviews conducted by Gates *et al.* (2001a) indicate that cows and calves disperse in summer into smaller groups and congregate again in wintering areas (Gates *et al.* 2001a; Mitchell 2002). Females and juveniles are more likely to move in response to competition for resources, particularly when food becomes scarce (Mitchell 2002).

Indigenous knowledge holders from the Little Red River Cree Nation note a difference in the dispersal and congregation behaviour between wood bison occurring within Wood Buffalo National Park and those located outside the park. These experts note that while the Wentzel Lake herd (occurring outside Wood Buffalo National Park) lives in small groups in the summer and slightly larger groups in the winter, the Wood Buffalo National Park herds stay in large herds in the summer and smaller herds in the winter (Schramm 2005).

Environmental factors may play a significant role in shaping the movement patterns of wood bison. For instance, harsh winter conditions, such as deep snow and ice layers, can force bison to abandon traditional ranges in search of food (Gates *et al.* 2001a; Schramm *et al.* 2002; Mitchell 2002). An interviewee from Garden River, AB, explained that "heavy snow causes hay to break over and freeze to the ground, which makes it difficult for bison to reach. Under these conditions it is easier for bison to forage on lichen, which still stand up underneath the snow cover" (Schramm *et al.* 2002: 22).

In winter, especially when there is significant snowfall, larger groups of wood bison are more common. Traveling together helps them move through the snow and benefits the calves in particular. In contrast, when snow cover is minimal or during the summer, wood bison tend to stay in smaller groups (Schramm *et al.* 2002; Schramm 2005).

Movement corridors and water crossings

Wood bison are known to establish trails or corridors between favoured habitat patches (Gates *et al.* 2001a; Mitchell 2002). When colonizing an area, the trails are quickly formed. Trails may develop along human-made linear disturbances such as seismic lines and roads. Once a route is established, it is used continuously over long time periods (ENR 2010a). Wood bison tend to use the most direct route, which may include water crossings. Water crossings are usually at river bends and shallow areas with low banks (Gates *et al.* 2001a; Mitchell 2002). Wood bison mobility increases in the winters when the frozen soil and ice supports their weight (Gates *et al.* 2001a; Mitchell 2002).

Rivers can impede wood bison movement if the banks are steep or the river is too wide – wood bison are not typically known to cross wide expanses of water. The Little Buffalo River in the Slave River Lowlands area is not a barrier to wood bison movement; the river is regularly crossed at numerous locations, allowing the wood bison to move in and out of Wood Buffalo National Park (Figure 9). Likewise, wood bison groups have been seen swimming across the Liard River (Larter and Allaire 2007). In contrast, the wide Mackenzie River is considered a significant barrier (Figure 10).

The Hay River, upstream of Alexandra Falls, is not considered a barrier to wood bison movement, but is not crossable immediately downstream (north) of Alexandra Falls due to steep banks. Wood bison can only cross downstream once the river nears the community of Hay River. They will cross the Salt River and the road exiting Wood Buffalo National Park around Salt Mountain to access the meadows to the north, and some will travel to Needle Lake and head up and down through the ridges and meadows that run between the Slave River on the east and the Little Buffalo River on the west (Larter and Allaire 2007), as well as travel in the small meadows between Hook Lake and Needle Lake (Gates *et al.* 2001a; Mitchell 2002). These wood bison travel to Grand Detour and then travel north along the sloughs adjacent to the Slave River to Hook Lake. A crossing point for wood bison exists at Point Brule on the Slave River (Gates *et al.* 2001a; Mitchell 2002) (Figure 9). The Slave River is only rarely crossed by wood bison, in locations where the banks are low (Gates *et al.* 2001a; Mitchell 2002). The crossing locations of wood bison in the Slave River Lowlands are known to local hunters (Nishi *et al.* 2000).

Wood bison have also been seen on the Slave River both near Point Ennuyeuse and north of Long Island (Gates *et al.* 2001a; Mitchell 2002). To get to preferred meadows, wood bison will travel through brushy areas, but this poor habitat is considered a partial barrier to their movement, so they tend to move through it quickly (Gates *et al.* 2001a; Mitchell 2002). In the northern portions of Wood Buffalo National Park, good habitat is widely dispersed (Gates *et al.* 2001a; Mitchell 2002).

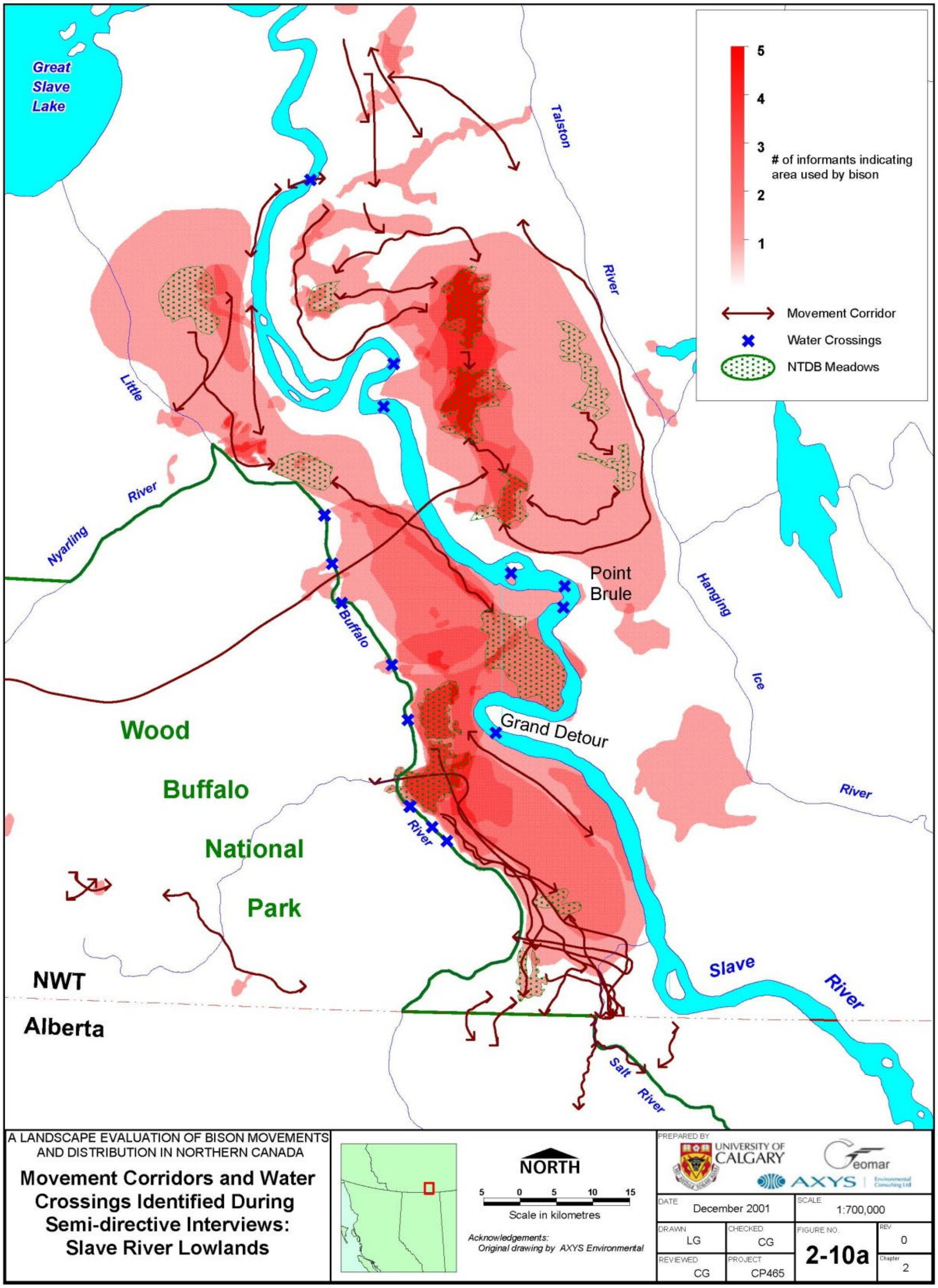


Figure 9. Movement corridors and water crossings identified during semi-directed interviews: Slave River Lowlands [study area] (Hook Lake and Grand Detour subpopulations) (Gates *et al.* 2001a).

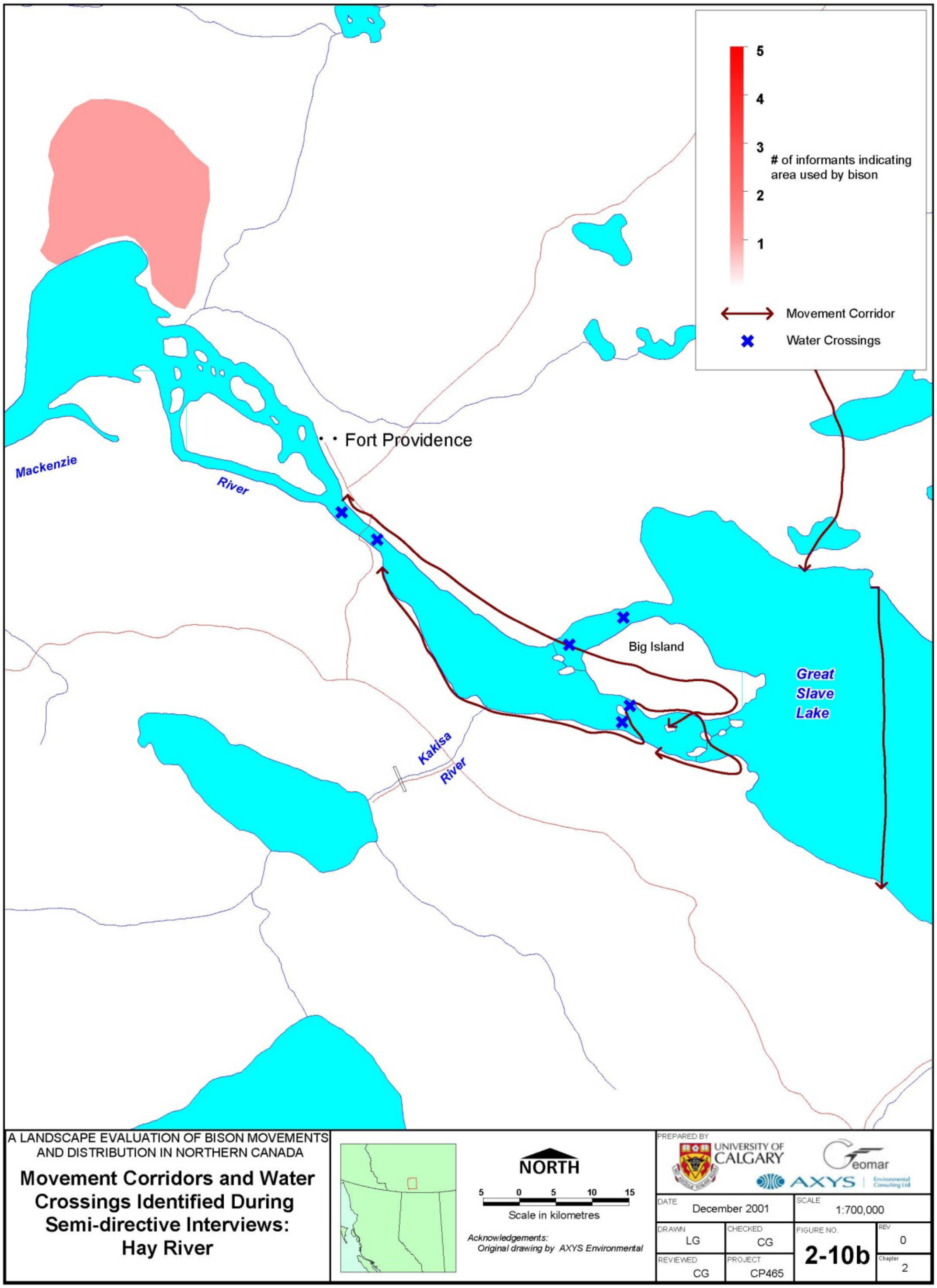


Figure 10. Movement corridors and water crossings identified during semi-directed interviews: Hay River [study area] (Gates *et al.* 2001a).

Information collected by the GNWT (ENR 2010a) indicates that collared bison in the Nahanni population use roads and seismic lines a lot and move extensively in the summer, including into British Columbia and back. This is supported by limited interviews conducted by Fanni (2014), in which ADKFN members noted that bison movements occur principally along the Liard River and the Highway 7 corridor. These movement routes consist of hard ground, which is seen to facilitate movement more than in areas with muskeg or swamp. Animals in the Nahanni population also use ATV trails and old seismic cut-lines to access Maxhamish Lake, Fisherman Lake and Bovie Lake (Fanni 2014; see Figure 2a). While animals can be seen year-round at Fisherman Lake, they only access Maxhamish Lake and Bovie Lake rarely, in small numbers and when the ground is frozen. The area is generally considered to be too swampy to constitute ideal habitat for wood bison. Wood bison may also use the Celibeta Lake area, but only tracks (no direct sightings) have been observed (Fanni 2014).

Little Red River Cree Nation and Tallcree First Nation participants in a traditional knowledge study indicated that hunting pressure was a major barrier to wood bison movement and range expansion in northern Alberta (Schramm *et al*. 2002). In addition, when pieces of river ice pile and jumble together, the resulting ice jams also obstruct bison movement (Gates *et al.* 2001a; Mitchell 2002). Steep and high elevation areas limit bison dispersal as well; for example, the Caribou Mountains in northern Alberta just south of the NWT border (Gates *et al.* 2001a; Mitchell 2002).

Table 1 summarizes biophysical factors influencing bison movements and distribution, interpreted from Indigenous and community knowledge interviews conducted by Mitchell (2002).

Table 1. Biophysical factors influencing bison movements and distribution, from Mitchell (2002).

Factor	Nature of Effects
Slope	• Bison are associated with riparian meadows and avoid steep slopes. • Water crossings occur in areas with shallow banks.
Lake size	• Bison do not cross wide expanses of water unless adequate ice has formed. • Bison do not swim in waves (i.e., high wind, wide rivers and lakes).
River width	• Bison rarely cross wide rivers; however, small rivers are readily crossed.

Habitat as a barrier	• Large expanses of muskeg are barriers. • Shield country is a barrier.
Ice conditions	• Ice cover provides opportunity for crossing water bodies. • Spongy or weak ice is avoided and, if used, may be a hazard. Drownings. • Rough ice on lakes or rivers is a barrier.
Habitat affinity	• Graminoid meadows (i.e., grasses and/or sedges) are preferred habitat. • Meadows are typically riparian (i.e., associated with water bodies and drainages), for example, inundated areas along lakes and rivers.
Cut blocks and disturbed habitat	• Bison use early seral stage (regrowth after disturbance). • Linear disturbances (seismic lines and road edges) may provide grazing habitat.
Fire	• Bison move into recently burned areas in response to availability of grasses, sedges and forbs. • Bison move into burned forests in which downed trees (deadfall) provide escape cover from hunters and wolves.
Hunting	• Pressure from hunters increases in winter because hunters can track bison and can move more freely on frozen ground (increased access). • Seismic lines and roads increase hunting pressure (improved access). • Bison avoid areas with high hunting pressure. • Hunting can eliminate local populations.
Roads and seismic lines	• Bison do not avoid roads and seismic lines unless hunting pressure is heavy. • Use of roads and seismic lines by bison depends on forage plant abundance (grasses and sedges).
Natural corridors	• Corridors are associated with watercourses. • Corridors follow and link graminoid habitat patches.
Cattle	• Cattle do not generally influence bison movements.
Fences	• Serve as a barrier to movements.
Population density	• Area occupied is positively related to density.
Human disturbance	• Growth of human population and infrastructure displace bison.

Changes in Distribution

Wood bison populations have expanded rapidly in the NWT (Cluff *et al.* 2006). The Mackenzie population in particular has expanded north towards Whatì as the result of newly constructed roads and trails providing increased access to the area (Judas pers. comm. 2024; TG and Firelight 2025a and b; Figure 11). Members of the North Slave Métis Alliance have also reported an increase in wood bison on the to the east of the North Arm of Great Slave Lake, especially at Old Fort Rae (Phelan 2024). This expansion is not supported by Tłįchǫ communities, which are concerned about potential impacts to communities as well as competition with moose and caribou (Cluff *et al.* 2006; INF 2023b). Dehcho communities have expressed similar concerns about the western movement of Mackenzie bison towards the Horn Plateau (EMB 2024) and support further research into the impacts of bison encroachment on boreal caribou habitat (ECC 2023).

As the Mackenzie wood bison population expands northwards along the Tłįchǫ Highway towards Whatı̀, some harvesters speculate they are moving north to access better habitat and resources, while others emphasize the lack of good food sources further north. One harvester described seeing wood bison traveling back south because they couldn't find enough to eat (TG and Firelight 2025b).

Search Effort and Harvest Patterns

Wood bison distribution around Wood Buffalo National Park is considered to be well known by NWT hunters (Northern Diseased Bison Environmental Assessment Panel 1990a, 1990b). Indigenous and community knowledge of the Nahanni population was compiled by Fanni (2014) in a limited study that collected geospatial information, ADKFN traditional knowledge of bison, and ADKFN attitudes towards bison. As noted earlier, constraints associated with sample size and verification limit the ability to draw broad conclusions from this study.

Harvest patterns are discussed in more detail in *Relationship with People* and *Threats and Limiting Factors*.

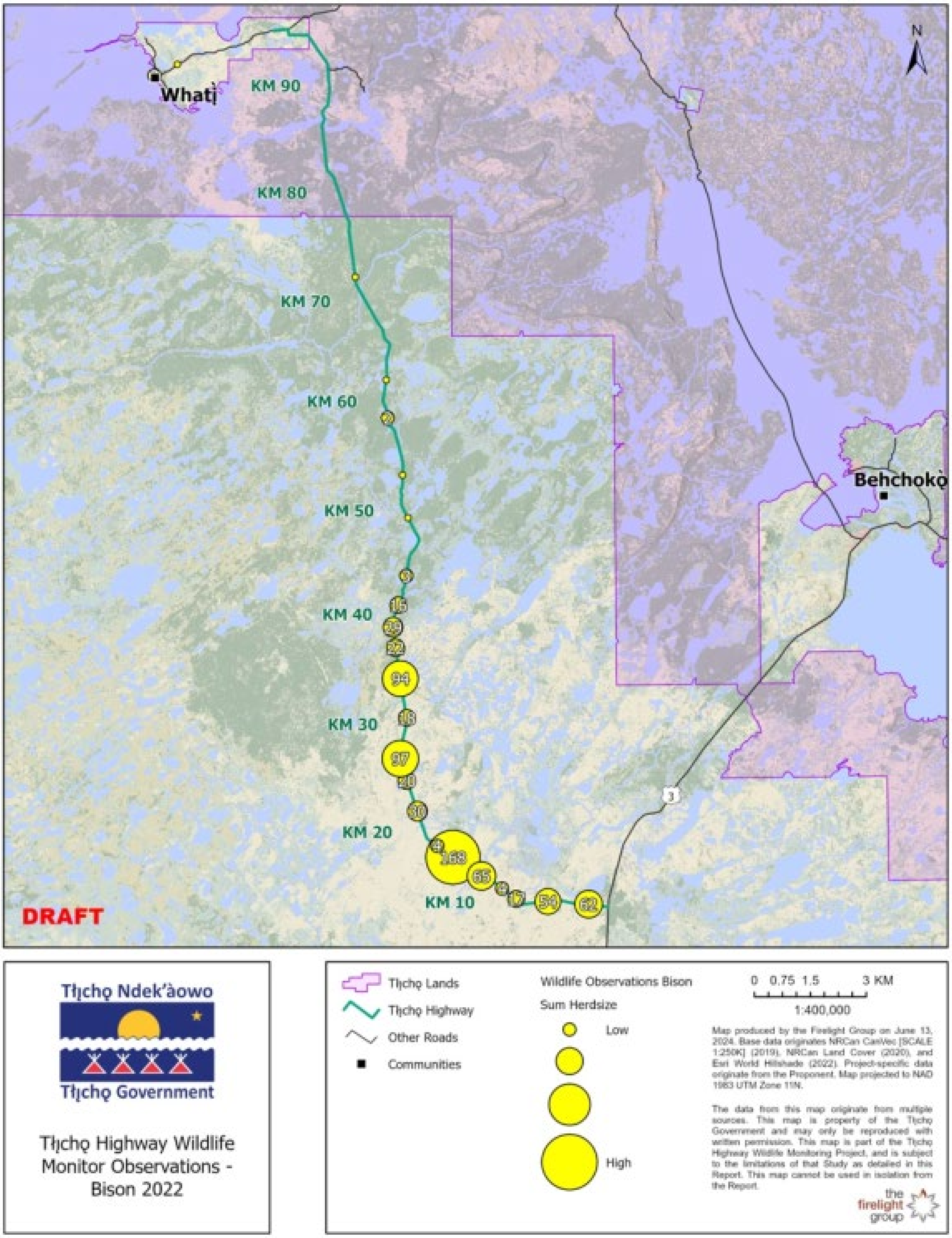


Figure 11: Map of wood bison observations by wildlife monitors in 2022 (January-December) along the Tłı̨chǫ Highway (TG 2025a).

Key Habitats

Based on oral history of wood bison range extending to the Beaufort Sea (Lotenberg 1996; Stephenson *et al*. 2001), much of the NWT may have, or may have been, suitable wood bison habitat that is currently not used by wood bison.

Preferred habitats are generally characterized by a mix of grasslands, wetlands, and forested areas but the complexity of habitat requirements varies significantly across different herds (Schramm *et al.* 2002). Overall, and recognizing different regional habitat preferences (Environment Canada 2015e), wood bison tend to prefer grass and sedge meadows, such as those associated with dry lakebeds and oxbows, sloughs near rivers, and old beaver meadows. Meandering rivers with multiple oxbows provide good habitat (Gates *et al*. 2001a; Mitchell 2002). Cut blocks offer areas of preferred habitat (Schramm 2005) wood bison are also known to use burned-out areas (Gates *et al.* 2001a; Mitchell 2002).

As described in *NWT Distribution*, key habitat areas include the Slave River Lowlands, the Mackenzie Bison Sanctuary, and much of Wood Buffalo National Park. Local knowledge holders have identified movement corridors in both the Slave River Lowlands and Nahanni regions (see Figures 9 and 10, above) (Mitchell 2002; Fanni 2014).

Little Red River Cree and Salt River First Nation hunters and Elders indicate that habitat preference cannot be generalized across populations/herds and is instead herd-specific and implicated in the appearance and size of individual herds (Schramm 2005; Environment Canada 2015e).

"Wood bison need free-ranging access to their habitat in order to get certain required plants. These plants may assist in healing the Wood Bison from certain diseases: "Same thing with humans, [if we are] fed food we don't want to eat, we'll get sick too. Same as buffalo. ... they eat lots of things [in the wild]...they eat spruce bough for their digestion, willows, everything."" (Interviewee in van Kessel 2002: 91)

Slave River Lowlands

The Slave River Lowlands are characterized by a patchwork of wetlands, grasslands, and forested areas. This region supports a wide array of plant species that are vital for wood bison, particularly during the summer months when they rely on nutrient-rich grasses and sedges (Mitchell 2002). Wood bison calve in the high ground areas between the Little Buffalo River and the large wet meadows to the east (Gates *et al.* 2001a; Mitchell 2002).

Mackenzie Bison Sanctuary

The Mackenzie Bison Sanctuary is another important area for wood bison, providing a refuge to maintain sufficient population levels to ensure genetic diversity (Mitchell 2002). This area includes a mix of open grasslands and forested regions, which are essential for seasonal migration and dispersal patterns. The sanctuary's management practices aim to balance ecological integrity with the needs of local communities, ensuring that bison populations remain stable and healthy (Mitchell 2002).

Wood Buffalo National Park

Wood Buffalo National Park is perhaps the most well-known habitat for wood bison, as it is home to one the largest populations of wood bison in North America. The park's diverse ecosystems, including wetlands, boreal forests, and grasslands, provide essential resources for wood bison throughout the year (Mitchell 2002). The higher ground in the northern portions of Wood Buffalo National Park provide widely dispersed but good wood bison habitat (Northern Diseased Bison Environmental Assessment Panel 1990a; Gates *et al.* 2001a; Mitchell 2002).

Seasonal Habitat Requirements

Spring

In the early spring, south-facing slopes are snow-free earlier and are attractive to wood bison. Where a deep and crusted snow remains later into the spring, such as in the Caribou Mountains, forage is less available (Schramm *et al*. 2002). Wood bison avoid muskeg, dense forest, and regions of steep terrain (Gates *et al.* 2001a; Mitchell 2002).

In the spring, wood bison seek the new growth of grasses and sedges, which they will select over broad-leaf plants. This becomes their dominant food source for the season. New grass is particularly favoured by wood bison. They may feed on the small new leaves of willows and small willow-like plants (Schramm 2005) although this is disputed by members of the Salt River First Nation (Environment Canada 2015e) and are known to consume horsetails (Schramm 2005). Some grasses can make them sick and are avoided (Environment Canada 2015e).

Summer

Wood bison use the drier edges of wet meadows in the summer where forage is plentiful as well as forestry cut blocks and open prairie. Wood bison are known to prefer areas where the ground is solid to make walking easier. The high-quality forage, including buffalo grass (Environment Canada 2015e), allows wood bison to gain weight in the summers to prepare them for the August rutting season (Schramm 2005; Gates *et al*. 2001a; Mitchell 2002).

During the summer, wood bison in the Nahanni population often use areas and gravel/sand bars along the Liard River. Residents of Fort Liard and Nahanni Butte often see wood bison swimming across the river. Residents of Nahanni Butte report two places in particular where wood bison cross the Liard River: an area near Swan Point, east of Nahanni Butte, and an area near Netla, south of Nahanni Butte (Konisenta pers. comm. *in* Larter *et al.* 2003: 410). Residents of Fort Liard report that wood bison also cross the Liard River just north of the confluence of the Muskeg and Liard Rivers and north of the confluence of the Kotaneelee and Liard Rivers (Dale Timbre and Jimmy Deneron pers. comm. *in* Larter *et al.* 2003: 410).

Fall and Winter

Dry grasses and sedges are the most important winter feed for wood bison. Wood bison may use river banks where dried grass hanging over the edge of the bank is not covered by snow, and frequent the edges of frozen beaver ponds where grasses and sedges are available (Schramm 2005; Environment Canada 2015e). Wood bison also rely on caribou lichen, and possibly arboreal lichen, in the winter if dried grasses and sedges are inaccessible due to large amounts of snow in January-March. Also, while this vegetation may lodge and freeze in the wet meadows, lichens found in spruce stands will 'stand up' and be available under the lighter snow cover (Schramm and Krogman 2001; Schramm *et al.* 2002; Schramm 2005). The centres of meadows that were too wet to use in the summers have high-quality forage that is used in the winter when the ground is frozen and can support the wood bison. The shifting use of different portions of the meadows helps to maintain the meadows (Gates *et al.* 2001a; Mitchell 2002). Bison have also been known to consume muskrat push-ups in the winter (Schramm et al. 2002).

Wildfire

Fire was used by Indigenous peoples to maintain these habitats (Gates *et al.* 2001; Mitchell 2002). In northeastern British Columbia, Fort Nelson First Nation members use fire to improve wood bison habitat in their territory (Christianson *et al.* 2020; Christianson *et al.* 2022). Several studies indicated that burned areas provide high-quality forage (Christianson *et al.* 2022; Mitchell 2002; Wells 2014; Figure 12) and wood bison may find some protection from predators as both wolves and humans may find deadfall difficult to move through (Gates *et al.* 2001a; Mitchell 2002). However, Salt River First Nation members note that deadfall is also a barrier to the movement of wood bison and large fires may ultimately be detrimental to wood bison (Environment Canada 2015) (discussed in further detail in *Threats and Limiting Factors*).

Prescribed burns such as those undertaken during the Hook Lake Wood Bison Recovery Project were also considered to be valuable for the local ecosystem. The burns maintained high-quality grassland areas open for use by wood bison and other wildlife (Gates *et al.* 2001a; Mitchell 2002). One Fort Resolution resident indicated that prescribed burning in the area was required as there were not enough wood bison to prevent shrub encroachment through grazing. Respondents were divided on the issue of when the prescribed burns should happen – either spring, or late summer (van Kessel 2002). The decrease and disappearance of wood bison in the Yukon is blamed on increasing forest cover replacing open areas, which brought moose and displaced the bison.

Figure 12: Wood bison grazing in a recently burned portion of Wood Buffalo National Park. Photo courtesy P.-E. Chaillon.

Following particularly severe wildfire seasons in 2014 and 2015, Fort Providence harvesters observed bison moving into recent burn areas to consume the fresh grasses (Environment Canada 2015b). Between 2020 and 2023, approximately 15% of the Slave River Lowlands bison range was burned by wildfires (ECC unpubl. data 2024a). Community members expect wood bison populations will benefit from the availability of the high-quality forage in these burned areas across the southern part of the territory (Beaulieu pers. comm. 2024).

Habitat Trends

Changes in bison habitat are driven by various factors affecting meadow ecosystems. Key forage areas rely on periodic flooding to maintain vegetation. However, since the 1970s, reduced flooding has led to habitat decline, particularly in the Mackenzie population range (ENR 2010b). This is particularly evident to travellers passing along the highway from Fort Providence to Behchokǫ̀, as the landscape is now dotted with former wetlands.

The encroachment of willows into meadows, which are important wood bison habitat, has been noted in the Slave River Lowlands (Gates *et al.* 2001a; Mitchell 2002; Schramm 2005;

Environment Canada 2015c). Cree Elders and hunters in northern Alberta have also described changes in habitat, including an increase in willows and brush-dominated areas where more open grasslands used to exist. The brush is considered to be poorer bison habitat than the previous open grassland. The encroachment of willows may also relate to water table changes brought on by the construction of the Bennett Dam (Schramm 2005; Environment Canada 2015c) and the cessation of over-bank flooding in some springs due to ice-jams forming on the Peace and Slave rivers (Armstrong pers. comm. 2015 *in* SARC 2016). This same pattern of brush incursion into open grasslands having a negative impact on wood bison is also reflected in oral history accounts from Alaska. When wood bison were extirpated from Alaska, oral history indicates that some open grassy areas were replaced with brushier vegetation (Stephenson et al. 2001; Schramm 2005). In the Yukon, open areas suitable for wood bison have also been overgrown with willows and forests over the last four hundred years (Lotenberg 1996).

Wildfire activity in the NWT in the first half of the 2020s may encourage the growth of high-quality forage such as grasses and sedges (CMA 2019; ECCC 2018), which is viewed as good for the local wood bison populations (Beaulieu pers. comm. 2024).

Habitat Fragmentation

Linear features attract bison and provide forage but also increase hunting risks and the possibility of collisions with motor vehicles (GNWT 2023). Logging tends to drive wood bison away, while development sites may lead to more human-bison conflicts, such as equipment damage, vehicle collisions, and disruptions to industry. While no significant development of this type has occurred in wood bison range in the NWT to date, concerns have been raised in relation to the development of new all-season highways within the NWT (INF 2023a).

POPULATION

Abundance

Information on abundance in the NWT was not included in sources reviewed.

Changes in Population Size

Changes in populations size of wood bison in the NWT were not well covered in the available literature. One Fort Resolution resident did note that the population there had not yet returned to the peak levels observed in the 1970s (Environment Canada 2015c), while members of the Kátł’odeeche First Nation indicated that the bison population in their region has been fairly stable over time (Environment Canada 2015d). Communities around Wood Buffalo National Park expressed uncertainty about how the bison populations in the park are doing (Will 2015).

"You can't tell [how well bison are doing]. And I believe [WBNP is] in limbo just as much as we are when it comes to bison (...) because they're free-roaming, right? They can't monitor every buffalo or every calf or how many dead, or how many born... It's a guessing game you see, and we can't do that either." (Anonymous member of the Fort Smith Métis Council in Will 2015: 77)

For residents of Fort Resolution, there were differing views on the effect of the three key diseases (brucellosis, tuberculosis, and anthrax) on wood bison. Some felt that the effect of the diseases on bison population trends was overstated by government officials and a few respondents even suggested that the diseases were an invention of, or at least very exaggerated by, government officials. Diseases were described as a natural part of life for wildlife. Some felt that only older animals became ill with disease; however, some participants did feel that disease was a factor in bison population trends, and was a threat – even if government interventions caused the disease (van Kessel 2002).

In northern Alberta, members of the Little Red River Cree Nation expressed concern about the status of the Wabasca herd, southwest of Wood Buffalo National Park. One trapper described how in the past he would see wood bison every day; now he can't find them even when he tries to track them (The Narwhal 2023). Community members have formed an advocacy group to push for more protection for the herd (The Narwhal 2023).

Some reports reference concerns about the expansion of wood bison range potentially having a negative impact on other species but there was no information how this expansion was occurring or if it reflects a change in abundance or population dynamics (EMB 2024).

Wood bison have been observed along NWT Highway 9 as far north as Whatì (Judas pers. comm. 2024; TG and Firelight 2025a and b). It is unclear if this increase in wood bison distribution reflects a change in abundance within the Mackenzie population. Community members in Behchokǫ̀ have expressed concern at the encroachment of wood bison and a perceived rapidly expanding bison population (Cluff *et al.* 2006; TG 2025).

Health

Tuberculosis, brucellosis (Ferguson 1989) and anthrax (Schramm *et al.* 2002) are known diseases of wood bison. These diseases and their impacts are discussed in more detail in *Threats and Limiting Factors*.

Community members in Fort Smith and Fort Chipewyan are aware of the presence of disease in bison in Wood Buffalo National Park and some of the risks involved with these diseases (Will 2015), although knowledge about which diseases are present, their origins and their symptoms varied. As discussed above, there are differing views on the effect of these diseases on wood bison. Diseases are generally considered to be a natural part of life for wildlife (van Kessel 2002; Will 2015). Will (2015) heard the following regarding anthrax outbreaks:

"Well that disease must just come at a certain time of the year (...) and never [hear] of it for years again. And it'll come again. It's just like any other thing. It's natural." (Anonymous member of Fort Chipewyan Métis Local 125 in Will 2015: 79)

Oral history suggests that some wood bison diseases may have been present in the mid- to late-1800s in the NWT. According to information gathered and presented in a paper by Ferguson and Laviolette (1992):

"Oral tradition from the Fort Smith area also provides an example of sudden mortality among the wood bison of the area. Laviolette recalls the story passed on by the late Germaine Tourangeau and others, a story told to them when they were young men by the late Chief Pierre Squirrel, who was then an elder himself. Chief Squirrel said that when he was a young hunter, there were many wood buffalo. 'Then one summer season the wood bison died off so quickly at Foxhole prairie that the bones were almost side by side' (Laviolette 1989). 'That big Salt Plain was just black with dead wood buffaloes'." (Louis Brown pers. comm. 1985 in Ferguson and Laviolette 1992: 48)

Ferguson and Laviolette (1992) also noted fur trade references of Indigenous hunters describing disease outbreaks in wood bison as well as other ungulates in proximity to Fort Chipewyan in 1821, 1823 and 1831. Unfortunately, these sources only note mortality; they do not provide the details necessary to determine cause of death.

Will (2015) found that some believed tuberculosis and brucellosis to have originated from outside the park. The origins of anthrax were not as clear, although many understood that anthrax is in the soil and that hot, humid summer weather creates ideal conditions for anthrax outbreaks (Will 2015). Anthrax was also perceived as the largest threat of the diseases present in the park, likely because it kills many animals at one time and is often covered in the media (Will 2015).

According to Will (2015), little is known about the rates of tuberculosis and brucellosis in the park; however, the presence of disease in bison was not seen as a serious issue as a long as outbreaks do not wipe out the population.

"That's alright if some of them die, but like as long as there's some left in the end, that would be okay." (Anonymous member of the Athabasca Chipewyan First Nation in Will 2015: 80)

Hunters interviewed by Will (2015) said a clear sign of a healthy animal is an active animal. One knowledge holder from Fort Providence (Beaulieu pers. comm. 2024) stated that multiple years with good growing conditions for wood bison's preferred forage has been good for the general health of bison in the Mackenzie range.

Rescue Effects

The possibility of rescue was not covered specifically in sources reviewed; however, traditional and community knowledge sources confirm that wood bison occur in Alberta and that long distance movements are possible (refer to *Movement and Dispersal* for more information). This implies that rescue of NWT populations/herds is possible.

Wood bison, in particular bulls, are known to travel long distances (Gates *et al.* 2001a; Mitchell 2002). Barriers to wood bison movements include large areas of poor habitat such as muskeg, some wide rivers, ice jams, steep terrain, and areas with increased hunting pressure. Barriers are discussed in *Movement and Dispersal*.

The possibility of future reintroduction programs was not covered by the available sources. However, some Fort Resolution residents felt that the innate 'wildness' of wood bison captured as part of the Hook Lake Wood Bison Recovery Project, an unsuccessful attempt at creating a new disease-free herd, would allow them to re-adapt to wild conditions if released. Others felt that captive bison would need to be weaned slowly from their human-supplied feed and fenced from wolves for a time for the wood bison to learn how to survive (van Kessel 2002).

THREATS AND LIMITING FACTORS

Indigenous and community knowledge holders in available sources described various threats to wood bison populations, including overhunting, disease/disease eradication efforts, efforts to preserve genetic/subspecies purity, and lack of detailed studies. Hunting was considered to be the largest threat by some knowledge holders, while others felt that vehicle collisions and anthrax were the threats of greatest concern. Disease eradication efforts were considered by some to be a larger threat to wood bison than the diseases themselves.

Wood bison are also known to die off in large numbers in extreme events, due to a variety of reasons: disease, winter starvation, and in particular, drowning due to flooding or falling through the ice (Northern Diseased Bison Environmental Assessment Panel 1990a, 1990b).

Disease

One of the most significant threats to wood bison populations is the prevalence of diseases such as tuberculosis, brucellosis, and anthrax, which have been documented in various herds, particularly those in and around Wood Buffalo National Park (Ferguson 1989; Northern Diseased Bison Environmental Assessment Panel 1990a; Shury *et al.* 2015; Will 2015).These diseases can cause chronic health issues or death, weakening bison populations' resilience to environmental disturbances and impacting overall population numbers (Shury *et al.* 2015).

Indigenous and community knowledge holders stress the importance of understanding these health challenges in the context of traditional ecological practices and the historical relationship between people and bison (Will 2015). Managing these diseases is critical not only for the health of wood bison populations, but also for the continued connection between the species and Indigenous communities and cultural practices (Ferguson 1989; Shury *et al.* 2015).

Diseased wood bison carcasses are identified by hunters through an examination for lumps, puss, discolouration, swelling and other abnormalities (Will 2015). They also look for fluid or whiteness in the animals' lungs, and for a healthy liver. Hunters may leave the carcass for scavengers, bury/burn it, or feed the meat to their dogs if the animals are considered diseased (van Kessel 2002; Schramm 2005). Although some hunters from Fort Smith and Fort Resolution indicated that diseased wood bison meat is not consumed (Gates *et al.* 2001b; Will 2015), other hunters indicated that thoroughly cooked or dried wood bison meat was consumed (Beck pers. comm. 2016 *in* SARC 2016; Will 2015).

In interviews conducted by Schramm (2005) and Will (2015), community members expressed greater concern about anthrax than tuberculosis or brucellosis. This may stem from the differing patterns of disease outbreaks. Tuberculosis typically affects older bison, which are less targeted by hunters, making encounters with visibly infected animals rare. Bison can also live with tuberculosis and brucellosis for extended periods without dying directly from these diseases. In contrast, anthrax outbreaks can rapidly kill large numbers of younger bison, directly impacting hunting activities and food security.

"Well anthrax is probably the number one. Like the real killer of them I'd say." (Anonymous member of Smith's Landing First Nation in Will 2015: 79)

There is limited Indigenous and community knowledge about the current rate of disease in the NWT's wood bison population. Disease is recognized as a significant threat to bison in Wood Buffalo National Park; however, knowledge of the diseases, their origins, and symptoms varies (Will 2015). It is widely understood that anthrax resides in the soil and that hot, humid summers create favourable conditions for outbreaks (Will 2015).

"Well that disease must just come at a certain time of the year (...) and never [hear] of it for years again. And it'll come again. It's just like any other thing. It's natural." (Anonymous member of Fort Chipewyan Métis Local 125 in Will 2015: 79)

The anthrax vaccine given to animals in the 1970s is also considered to be a lingering threat, passed from cow to calf. The actual vaccination program is known to have been deadly to wood bison. Cree hunters also indicate that the time it takes for anthrax to kill a wood bison is longer than several days, as wood bison were observed dying from anthrax on high ground, more than two days travel from the infection site (Schramm *et al*. 2002).

In the late 1980s, Indigenous hunters felt that disease occurrence was over-estimated by scientists. However, they also indicated that disease may be harboured outside of the diseased animal within the wood bison's habitat or perhaps by other animals such as predators, scavengers, or other ungulates, and felt that eradicating diseased individuals and herds may not be effective in eliminating the presence of disease from wood bison altogether (Ferguson 1989; Environment Canada 2015e).

Some consider bison diseases such as brucellosis and tuberculosis to be a normal aspect of the natural life cycle of wood bison (van Kessel 2002; Schramm 2005). Disease will not infect every animal of a population (Schramm 2005). In order to heal from diseases, certain plants and herbs must be consumed (Northern Diseased Bison Environmental Assessment Panel 1990a; van Kessel 2002). Therefore, wood bison need free access to their habitat to have free choice of these plants (van Kessel 2002).

Will (2015) notes that there are a range of opinions how disease outbreaks should be managed within Wood Buffalo National Park.

"When we see a buffalo on the road staggering, ribs hanging, there's fur just hanging on the ribcage... I mean that animal should be put down. But the parks, they'll drive right by it and think nothing of it. It will die on its own; they won't do nothing. (...)That animal's suffering, you know." (Anonymous member of Fort Smith Métis Council in Will 2015: 80)

"Let Mother Nature care for it... But now when the buffalo come into the Northwest Territories they chase them back [into the park]. Why won't they let Mother Nature look after where they want to go? (...) Why not let that same buffalo roam wherever it wants to roam instead of chasing it back? It goes both ways, you know. Sure you can let Mother Nature take over. Let her have her way. But [let] those buffalos roam wherever they want to roam." (Anonymous member of Fort Smith Métis Council in Will 2015: 80)

Overhunting

Herd animals such as wood bison are relatively easy for hunters to find and can provide more targets than a solitary animal (Schramm 2005). Oral history from Alaska indicates that wood bison may have been hunted to extirpation there during times of high human population and game scarcity. Hunting was implicated in the historic extirpation of wood bison from Alaska (Stephenson *et al.* 2001). However, members of the Kátł'odeeche First Nation question whether the extirpation of wood bison from their region in the late 1800s or early 1900s was the result of overharvest, or whether it was simply a reflection of the land being unable to support wood bison (Environment Canada 2015d).

In 2002, members of the Deh Gáh Got'ı̨ę First Nation (Fort Providence, NWT) expressed concerns about overharvest by their own people; the species of concern was not specified but may have included the Mackenzie bison population. They noted that the attitude of shooting an animal just for the sake of shooting it is something that needed to change (DFN and RWED 2002).

A big game outfitter harvested Hook Lake bison in the Slave River Lowlands during the late-1960s/early 1970s, but this harvest was closed as a result of community concerns that too many large breeding males were being harvested, which affected the breeding stock (Beck pers. comm. 2016 *in* SARC 2016).

Indigenous hunters in some of regions Alberta have at times voluntarily refrained from hunting caribou and wood bison in response to declines (Schramm *et al.* 2002; FNFN 2015). However, increased ease of access due to road development have raised concerns about the sustainability of harvests (Schramm et al. 2002). The Mackenzie Bison Working Group (MBWG 2018) notes that demand for bison hunting may increase when other species (such as moose or caribou) are not available. Members of the working group agreed that hunters should not be encouraged to hunt bison as a replacement for other species that have declined.

Today, wood bison in the NWT are managed under three bison management plans (for the Mackenzie, Nahanni and Slave River Lowlands populations). These plans were developed by working groups that include communities in the range of each of the populations and include guidance on setting harvest quotas based on population size (CMA 2025). Harvest is prohibited inside Wood Buffalo National Park.

Quotas are in place for the Mackenzie and Nahanni populations, with 40 and 7 tags (respectively) distributed annually (CMA 2025). Harvest of the Mackenzie population was closed from 2012-2020 in response to declines following a major anthrax outbreak. Hunting reopened in 2021, and based on the advice of the Mackenzie Bison Working Group, tags are distributed among the Deh Gáh Got'ı̨ę First Nation, Fort Providence Métis Council, Tłı̨chǫ Government, NWT Métis Nation, North Slave Métis Alliance, Yellowknives Dene First Nation and through a limited entry draw. The Nahanni population has had a harvest quota in place since 2018 (CMA 2015).

There is no quota for Indigenous bison harvesters in the Slave River Lowlands. Resident hunters are limited to one bison per hunting season. Reporting for resident hunters is mandatory and shared with the working groups for each bison population (CMA 2025). The bison management plan for the Slave River Lowlands (SRLBWG 2019) emphasizes the importance of determining the rate of harvest for the population, including the Indigenous harvest, and recommends methods for collecting harvest data, but to date this data has not been publicly reported.

Hunting pressure tends to increase in conjunction with increased access to wood bison habitat. Seismic lines and other linear disturbance, while creating forage for wood bison, also increase hunting pressure through increased access (Schramm 2005). When hunting pressure increases, wood bison are known to move into the bush (poorer habitat) and away from access routes (Gates *et al.* 2001a; Mitchell 2002; Schramm 2005).

Human-bison conflicts

As the Mackenzie Bison Management Plan (MBWG 2018) explains, wood bison and people often share the same habitats because areas suitable for roads and communities also provide ideal conditions for wood bison (Fanni 2014). The Recovery Strategy for Wood Bison in the Northwest Territories (CMA 2019) notes that wood bison have never injured a person in a community in the NWT, but the potential exists, and most community members would rather not have large, wild animals in town. In communities where bison populations have only recently been reestablished, or where there are frequent conflicts with humans (including property damage, traffic collisions and other safety concerns), there may be calls for bison to be removed (Clark *et al.* 2016; Doney *et al.* 2018; Jung 2020; CBC News 2021; APTN News 2023).

Landscaping practices, such as maintaining lawns and gardens in communities and clearing woody vegetation along roadsides, power lines, and pipeline corridors, create environments that appeal to wood bison. Wood bison are drawn to linear features like roads and seismic lines, which offer easy travel paths through dense forests or wetlands. During winters with heavy snowfall, bison are especially likely to use roads for easier movement increasing the potential for collisions with motor vehicles (MBWG 2018). Members of the Dehcho First Nation and Tłı̨chǫ citizens noted concern with the number of wood bison being killed on highways, with some knowledge holders in the Dehcho and North Slave regions indicating they considered this the most important threat facing wood bison (Environment Canada 2015a and b). They noted that this appeared to be related, in part, to the use of road salt on highways, which attracts bison (ENR 2012; Environment Canada 2015a).

Concerns have also been expressed that the expansion of the all-season road system in the NWT may increase negative interactions between wood bison and people (Schramm *et al.* 2002; INF 2023a). For example, the Tłı̨chǫ Highway, which was completed in 2021, has steep slopes on either side that make it difficult for bison to step off the highway. This means vehicles must follow bison slowly along the highway, creating a hazard for vehicles and a threat to bison, who may hurt themselves stepping off a high slope. The risk of vehicle-bison collisions along the highway is especially severe at night when the animals are difficult to see (TG and Firelight 2025b).

Habitat loss

Currently, there is limited industrial development in the NWT portion of the wood bison's range. In Alberta, wood bison populations are at risk of being seriously impacted by activities that include oil and gas development, agriculture, forestry and road construction (Schramm *et al.* 2002; O'Connor and MNAA 2015; The Narwhal 2023).

According to knowledge holders in northern Alberta, it is likely that any logging activity on the south-central and south-eastern slopes of the Caribou Mountains will seriously negatively affect the wood bison herds (Schramm *et al.* 2002). Forestry is considered a threat in several ways. Active logging causes wood bison to leave an area, and regions with a greater amount of logging are less attractive to wood bison. Although cleared areas may create good forage, wood bison tend to stay in areas with less logging (Schramm and Krogman 2001; Schramm 2005).

In the NWT, Forest Management Agreements are in place for timber harvesting near Fort Providence and Fort Resolution, which allow for the harvest of 150,000 m^3 of timber per Agreement (ECC 2024). At the time when the agreements were signed, it was assumed that harvesting would most likely begin south of the Mackenzie River to take advantage of existing access and proximity to a proposed wood pellet mill in Enterprise (CMA 2019), but to date the pellet mill has not been constructed and it is unclear how any current activities are impacting wood bison or if any of the concerns raised by Deninu Kų́ę́ First Nation members (Environment Canada 2015c) during the project permitting consultation phases have been realised.

The impacts of linear habitat disturbance on hunting are discussed above in *Threats and Limiting Factors – Overhunting*.

Predation

Predators such as wolves and black bears negatively impact the wood bison population in the NWT (Northern Diseased Bison Environmental Assessment Panel 1990b; Environment Canada 2015a, c and e). Wolves have been seen killing more bison than they can eat. Members of the Salt River First Nation have reported wolf packs of 100 individuals attacking smaller groups of 30 wood bison around Lake Claire in Wood Buffalo National Park (Environment Canada 2015e). Trapping, which controlled wolf populations somewhat, has declined. The end of the bounty on wolves for trappers was considered to be harmful for wood bison populations (Northern Diseased Bison Environmental Assessment Panel 1990b).

Disease eradication efforts

In the late 1980s, Indigenous hunters indicated that scientific assessments of disease prevalence were inflated because of the small sample size of biological specimens and other problems with the data:

"Overwhelmingly, Native groups and individuals challenge the [Diseased Wood Bison] Task Force's statement that the wood bison of the Wood Buffalo National Park area currently suffer such a high rate [>35%] of disease." (Ferguson 1989: 4)

In their experience of hunting wood bison in the 1970s and 1980s, wood bison were not diseased at the high level suggested by scientists at that time (Ferguson 1989). Indigenous hunters in the South Slave region of the NWT and northern Alberta suggested that only about ten per cent of wood bison in and around Wood Buffalo National Park were diseased. Some hunters indicated that the Hook Lake herd was disease-free at the time. Indigenous hunters indicated that a declining population of wood bison is likely due to many factors, rather than just disease, which is naturally present in wood bison. Additionally, they recommended that the issue of disease eradication must be based on a whole ecosystem approach, and management plans must deal with all diseased herds together, rather than piecemeal (Northern Diseased Bison Environmental Assessment Panel 1990a).

Indigenous hunters indicated that some presence of disease in herds is natural. Eradicating diseased animals and herds is indicated as a threat to wood bison generally (Ferguson 1989). In 1990, disease eradication efforts were seen by northern communities as a way to bring northern forests into agricultural or logging productivity, rather than to deal with the issue of wood bison disease (Northern Diseased Bison Environmental Assessment Panel 1990a; Environment Canada 2015e).

Another aspect of disease eradication efforts that was noted in the late 1980s as a threat to wood bison was the way disease monitoring and prevention were carried out, including driving the animals by helicopter flights, herding, corralling, and other techniques (Ferguson 1989). Forcing wood bison to run using herding practices can also have disastrous consequences. Many animals, perhaps several thousand, drowned during misguided herding attempts (Northern Diseased Bison Environmental Assessment Panel 1990a).

"Respondents described seeing healthy animals chased by helicopters and people during the winter months. They reported that the animals would foam or froth at the mouth, appear to have severely laboured breathing, and that as a result, many bison collapsed, were trampled, aborted calves, or died from other injuries." (van Kessel 2002: 81)

Indigenous hunters noted that diseased animals often showed signs of handling (for example, ear tags), indicating that they were possibly vaccinated or otherwise corralled. The vaccine itself and the stress of corralling were noted as possibly increasing the likelihood of disease (Ferguson 1989; van Kessel 2002). Some Indigenous hunters link the start of the anthrax vaccination program with the decline of the herds. The effects of the vaccine may also be lingering, as some hunters indicated that the flavour of the non-vaccinated herds outside the park is superior. The non-vaccinated animals are leaner and better-tasting than those that were vaccinated (Schramm *et al*. 2002). A hunter in the Taltson River area indicated that the only two diseased wood bison he had killed out of twenty had ear tags (Northern Diseased Bison Environmental Assessment Panel 1990a). A tuberculosis testing project proposed by the University of Saskatchewan and Parks Canada was opposed by the Salt River First Nation (Environment Canada 2015e).

The anthrax vaccination program itself was considered to have been very damaging to the wood bison populations. Community members recall many wood bison dying while being rounded up in inappropriate ways, breaking legs, splitting hooves, or becoming too tired to continue running.

"Many people in Fort Smith saw buffalo staggering along with blood pouring out of their frozen mouths to fall along the way… buffalo lying all along the road, dead, some with calves sticking halfway out of them." (Northern Diseased Bison Environmental Assessment Panel 1990a: 150)

Additionally, community members have heard that anthrax was injected into wood bison, which were then allowed to die from it as a scientific experiment, along with other practices considered extremely inhumane, such as allowing crippled wood bison to die over a period of months rather than euthanizing them (Northern Diseased Bison Environmental Assessment Panel 1990b). Game wardens killed wood bison during anthrax outbreaks and continued to kill them even after the community noted that the outbreak was already subsiding (Northern Diseased Bison Environmental Assessment Panel 1990a).

Bison recovery activities conducted under the Hook Lake Wood Bison Recovery Project, such as corralling wood bison, in particular in small pens during calving, and feeding the wood bison and allowing them to become dependent or 'lazy' was seen as inappropriate to some Elders. The feed was noted to be dry, and not containing the plants required for the wood bison to remain healthy and heal from disease. The removed bison calves were also at risk of not learning the proper skills they would need to survive in their own habitat, generally taught to them by their mothers. Subsequently, released captive wood bison may shape or use the environment differently from the existing wild herds. Some respondents would have preferred minimal handling and contact between wood bison and people during the program (van Kessel 2002; Schramm 2005). Replacement wood bison, which might be captured or raised in captivity prior to being released after an extermination, might also be less healthy and capable or 'weak and tame' (Northern Diseased Bison Environmental Assessment Panel 1990b).

In the 1990s, government policy relating to the re-establishment of disease-free wood bison after eradication of diseased herds was considered a threat by Indigenous communities: considering the long-term nature of the disease eradication process (over a decade or more), changes in government policy could endanger the wood bison herds if the government changed their policy direction during the time when there were no bison in the area – in other words, decided to not proceed with re-introduction (Northern Diseased Bison Environmental Assessment Panel 1990a). If the diseased wood bison herds are destroyed and replaced, a lack of genetic variability within the replacements is considered a threat to the future of wood bison (Northern Diseased Bison Environmental Assessment Panel 1990a, 1990b).

Efforts to preserve genetic/subspecies purity

Efforts to preserve the genetic distinctiveness of wood bison from plains bison imported to the Wood Buffalo National Park area during the 20th century was considered a threat at worst, or unnecessary at best. There is a suggestion that it is considered more acceptable or justifiable to government policy makers and conservationists to slaughter the 'impure' and diseased bison and to replace them with rescued wood bison, rather than commit to other forms of management. The categorization of the wood bison as hybrids also denied the Wentzel Lake herd protection from hunting in Alberta until 2021 (Schramm 2005).

"Subspecies purity is not a valued concept to local Native peoples. The establishment of a wood bison population in itself is seen as a worthwhile endeavour but the slaughter of another wood bison population to make way for wood bison is seen as irrational. Why place a higher value on an animal which is, let's say, 90% wood bison, 10% plains bison than on an animal which is 90% plains bison, 10% wood bison?" (Ferguson 1989: 5)

"From the harvester's point of view, the value of the two subspecies is seen as the same: 'they both taste the same'. Over and above this, Native people commented that this EuroCanadian cultural value on subspecies purity is actually a dangerous philosophy." (Ferguson 1989: 5)

Additionally, local views of whether or not the bison are 'hybrids' question if an animal can be considered a hybrid after more than half a century. The concern was expressed that 'purebred' wood bison are more under the control of the federal and territorial governments, suggesting a political reason for the eradication of hybrid bison (Northern Diseased Bison Environmental Assessment Panel 1990a, 1990b). However, it should be noted that this is not a universally held belief, with knowledge holders in the Tłı̨chǫ region indicating that hybridization with domestic or plains bison, or cattle, was a threat that should be mitigated by preventing contact among these animals (Environment Canada 2015a). More recent efforts to restore wood bison genetic diversity by establishing a bison genome bank have also been met with some positive response from First Nations in Saskatchewan (CBC 2024).

Lack of detailed studies

In the late 1980s, Indigenous hunters indicated there was a lack of clear information about wood bison diseases; how they spread and how or if they can or should be managed (Ferguson 1989). Community members from Fort Smith and Fort Chipewyan interviewed by Will (2015) also expressed a lack of information about the status of wood bison in Wood Buffalo National Park, threats to the population, and management actions. Mismanagement of diseased wood bison herds, without better information, threatened the herds. The transportation of diseased plains bison to the Wood Buffalo National Park area was used as an example of how management intervention had threatened wood bison. Additionally, Indigenous hunters felt that perhaps domestic animals should be tested upon entering the NWT for the protection of the disease-free status of the Mackenzie population (Ferguson 1989). A decade later, in the 1990s, some Fort Resolution residents maintained an uncertainty about how wood bison diseases are spread and prevented (van Kessel 2002).

In the 1990s, during the Northern Diseased Bison Environmental Assessment Panel (1990a, 1990b), numerous representatives from communities around Wood Buffalo National Park indicated that further studies on wood bison, wood bison disease, changes to the water system, wolf predation, and many other topics were needed in order to make informed decisions about disease management in particular.

Other threats

Captive wood bison herds are considered less healthy than free-ranging wood bison, even if the captive herds are disease-free. An excess of human handling and the use of fenced-in areas is considered a threat to the health of those wood bison being contained (Schramm 2005). The introduction of ranching in wood bison habitat in the NWT was considered a future threat (Northern Diseased Bison Environmental Assessment Panel 1990a).

Although fire is recognized as a natural component of the landscape, and small-scale fires as being beneficial to wood bison, the large, intense wildfires experienced in the southern NWT in recent years are seen by some as a potential threat to wood bison. These fires can destroy animals and habitat, resulting in immediate mortality and longer-term decline owing to a lack of food resources, increased vulnerability to predation (Environment Canada 2015e), and reduced capacity for movement because of deadfall within burn areas. These large fires are blamed on a combination of climate change and fire management decisions, and it has been recommended that the focus should be on keeping fires small (Environment Canada 2015e). In areas where lichen provides emergency food for wood bison during extreme weather (i.e., in the Caribou Mountains in northern Alberta), forest fires can damage the soil (Environment Canada 2015a) and lichen supplies. Lichens do not regenerate quickly after a forest fire (Schramm 2005).

In contrast, harvesters from Fort Providence, an area that experienced a number of fires in recent years, have noticed that bison seem attracted to the fresh plant growth in burn areas (Environment Canada 2015a). Intense wildfires and smoky conditions also make it harder for hunters to get out on the land and may therefore reduce harvest pressure in years of extreme wildfire (Dodd *et al.* 2017).

Drowning events can also adversely impact bison populations. A number of instances of bison falling through thin ice and drowning have been documented (Allaire pers. comm. 2015 *in* SARC 2016; Environment Canada 2015a). Boat and barge traffic have also been noted as a potential threat to wood bison in the NWT, given the waves and wakes this type of traffic can create.

Wood bison sit quite low in the water while swimming, with their noses just a few centimetres above the water, which makes them vulnerable to drowning from any increase in wave action (Larter *et al.* 2003; Allaire pers. comm. 2015 *in* SARC 2026; Environment Canada 2015c).

POSITIVE INFLUENCES

Co-management

Indigenous knowledge systems and cross-cultural approaches to wildlife management provide a vital foundation for the stewardship of wood bison in the NWT. The integration of Indigenous and community knowledge with contemporary wildlife management practices, and the reintroduction of wood bison across the NWT and Yukon, exemplify a cross-cultural approach that respects both scientific and Indigenous perspectives (Schramm *et al.* 2002; Van Kessel 2002; Clark *et al.* 2016; Christianson *et al.* 2022).

In the late 1980s-1990, exclusion of Indigenous governments and Indigenous organizations from wood bison management processes and bison-free zone monitoring was considered a threat (Ferguson 1989; Northern Diseased Bison Environmental Assessment Panel 1990a, 1990b; Environment Canada 2015d). In particular, there existed a fear that the management of wood bison was to allow for increased agriculture at the expense of the wildlife-based economies of the north (Ferguson 1989; Northern Diseased Bison Environmental Assessment Panel 1990a, 1990b; Environment Canada 2015e).

The NWT's approach to wildlife management has changed significantly over the last four decades. The *Recovery Strategy for Wood Bison in the NWT* (CMA 2019) recognizes that recovery and restoration of wood bison in the NWT cannot be achieved without the cooperation and support of Indigenous governments and organizations and NWT communities. The approach to management must be collaborative, forward-thinking and adaptive, based on all available sources of knowledge, including Indigenous and community knowledge and science.

Three bison working groups were established in the early-2010s to provide guidance on the management of NWT bison populations (Mackenzie, Nahanni and Slave River Lowlands). These working groups are comprised of members from communities that harvest wood bison, agencies that have management authorities for each population, and Indigenous governments and Indigenous organizations whose land-use areas include wood bison range. The working groups developed management plans for the Mackenzie, Nahanni and Slave River Lowlands bison populations and continue to bring important information and perspectives into decision-making about wood bison in the NWT (CMA 2025).

Harvest management

Management of hunting is likely the most important and effective way to achieve conservation and recovery of wood bison in the NWT (MBWG 2018); in some cases, it may be the most important factor in the dynamics of a wildlife population (SRLBWG 2019).

Traditional Indigenous protocols of only hunting what is needed for comfortable existence and following traditional 'rules' are a positive influence on wood bison by promoting reasonable hunting levels (Ferguson 1989; van Kessel 2002). Management plans have been completed for the Mackenzie, Nahanni and Slave River Lowlands populations, which include guidance for sustainable harvest levels based on population size and trend (CMA 2025). All three NWT bison working groups have stated that is important to collect harvest information to determine the rate of harvest (MBWG 2018; NBWG 2019; SRLBWG 2019).

Interviews conducted by Will (2015) emphasized the importance of showing respect for animals being harvested, including taking only what is needed, not spoiling the meat, and sharing with the community. Community members expressed disdain for hunters who killed several bison at a time and explained that bison are sometimes chased into Wood Buffalo National Park so hunters do not kill too many (Will 2015).

"Us people, we were told to respect the animals. Don't over-kill, you know. Take what you need, leave the rest. And don't spoil meat. But I noticed that there's some guys that went hunting (…) don't skin the buffalos until the next day and spoil them. And then they throw it away. It's not right. Yeah so don't go and kill fifty buffalo if you can only skin ten, you know! If you can skin ten, skin ten buffalo." (Anonymous member of Fort Chipewyan Métis Local 125 in Will 2015: 86)

Conservation planning

Land use and conservation planning initiatives could have a positive influence on wood bison. For example, the Edéhzhíe Dehcho Protected Area, established in 2018 (Dehcho First Nations and Government of Canada 2018), includes the eastern part of the Mackenzie bison range. A Dehcho K'éhodi Stewardship and Guardian Program, run by the Dehcho First Nations, conducts patrols to support protection of the land, water and wildlife. In 2022, Edéhzhíe was also designated as a National Wildlife Area under federal law, which restricts activities that may interfere with the conservation of wildlife. Indigenous harvesting rights and other traditional activities within Edéhzhíe are not affected.

The Dehcho Land Use Plan has the potential to complement wood bison management in the Dehcho region (DLUPC 2006). A Draft Interim Dehcho Land Use Plan has been under development since 2002, and revisions are ongoing (Wiebe pers. comm. 2025). The draft Interim Plan considers important areas for conservation, including areas of important wood bison habitat, in determining appropriate land uses.

Changing attitudes towards wood bison

As noted earlier (*Relationship with People*), Fanni (2014), in a limited study, observed that negative attitudes towards wood bison among ADKFN members were most often present among men and Elders. With youth having more open attitudes towards wood bison (having spent their lives around them), Fanni (2014) noted that working with youth presents an opportunity to improve community attitudes towards wood bison.

Fire

Forest fires of moderate intensity can increase bison habitat by encouraging forage such as grasses and sedges (Schramm 2005). Following severe 2014 and 2015 fire seasons in the Mackenzie bison range (ENR 2015; CBC News 2015), Fort Providence harvesters observed bison moving into those burn areas to consume the fresh plant growth (Environment Canada 2015b).

Community members emphasize that fire is a natural process essential to the land's vitality (Wells 2014; FNFN 2015; Christianson *et al.* 2022). Prescribed burns were historically used to maintain diverse ecosystems (FNFN 2015). In Liard River, B.C., the Fort Nelson First Nation started a burning program to restore wood bison habitat.

"I spent most of my childhood in Nelson Forks, and I remember burning every year in the south. We burned to control grass and brush, and it was done mostly for animals, and to make travel much easier within the area. Overgrown brush is a hazard—with build up of brush you could have a big fire and it could burn the cabin. Fire brought in moose and rabbits, and it's been done for centuries. My family has been burning for many generations." (Anonymous in FNFN 2015: 13)

"Fire, used properly, is a friend, not an enemy." (Tribal elder Rose Loe [Fort Nelson First Nation] in Wells 2014:7)

Prescribed burns associated with the Hook Lake Wood Bison Recovery Project were seen by some Elders as being vital and important to wood bison (van Kessel 2002).

"The old timers used to do that [prescribed burning] all the time. This time of year springtime. They knew, eh- like they knew that the land is dependent on fire." (Interviewee in van Kessel 2002: 83)

Similarly, dry years and the absence of natural flooding and spring freshet may improve wood bison habitat by promoting the growth of grassy meadows (Environment Canada 2015a).

Disease management

The wood bison-free buffer zone between diseased and hybrid wood bison in Wood Buffalo National Park and the Mackenzie Bison Sanctuary was seen as effective (i.e., wood bison-free), in the late 1980s (Ferguson 1989).

The intensive management of wood bison in the Hook Lake Bison Recovery Project was seen by some respondents in van Kessel's (2002) study as a positive influence - that people were 'taking care' of the diseased bison even if it was not traditional – it was recognized to be a required step to control disease.

ACKNOWLEDGEMENTS

We thank Kristi Benson for her work preparing the original species status report for wood bison in the NWT (Indigenous and community knowledge component) and Adam Bathe for his contributions to this update.

We extend our heartfelt gratitude to all the individuals and community members who contributed their feedback, Indigenous knowledge, and community insights, which were invaluable to the research and writing of this report.

Your collective efforts and dedication continue to play a critical role in supporting wood bison conservation and stewardship across the North.

AUTHORITIES CONTACTED

2026 Update

Indigenous Organizations, Resource Management, and Wildlife Advisory Boards

Boyd Clark	Acting Band Manager, Acho Dene Koe First Nation, Fort Liard, NT
Danny Beaulieu	Mayor of Fort Providence, Member Fort Providence Métis Council, Fort Providence, NT
Jessica Jumbo	Director, Lands & Resources, Dehcho First Nations
Jody Pellissey	Executive Director, Wek'èezhìı Renewable Resources Board, Yellowknife, NT
Joseph Judas	Chair, Wek'èezhìı Renewable Resources Board, Yellowknife, NT
Jon McDonald	Community Field Worker, Fort Smith Métis Council, Fort Smith, NT
Orna Phelan	Wildlife Biologist, North Slave Métis Alliance, Yellowknife, NT
Stephanie Behrens	Wildlife / Fisheries Biologist, Lands Protection & Renewable Resources Department, Tłı̨chǫ Government, Behchokǫ̀, NT

Territorial Government Contacts

Allicia Kelly	Tłı̨chǫ All Season Road Biologist, Environment and Climate Change, Yellowknife, NT
Ashley McLaren	Manager, Wildlife Research & Monitoring (South Slave Region), Environment and Climate Change, Fort Smith, NT
Terry Armstrong	Bison Ecologist, Environment and Climate Change, Fort Smith, NT
Tracy Davison	Regional Biologist, Beaufort-Delta Region, Environment and Climate Change, Inuvik, NT

Federal Government Contacts

Patrick Carroll	Cultural Resource Management Advisor, Parks Canada, Fort Smith, NT

Other Species and Language Experts

Abigail Turner	Language Specialist, Yukon Native Language Centre, Whitehorse, YT
Chuck Blyth	Retired Biologist and Hunter, Fort Simpson, NT
Eileen Beaver	Dene Language Specialist, Fort Smith, NT

Kyle Napier	Faculty of Education, University of Alberta, Edmonton, AB
Pierre-Emmanuel Chaillon	Biologist and Wildlife Photographer, Fort Smith, NT

2016 SARC Report

Indigenous Organizations, Resource Management, and Wildlife Advisory Boards

Annie Boucher	Executive Director, Akaitcho Territory Government, Fort Resolution, NT
Dora Tsetso	Acting Executive Director/Finance Management, Dehcho First Nations, Fort Simpson, NT
Earl Jacobson	Executive Director, Northwest Territory Métis Nation, Fort Smith, NT
Georgina Chocolate	TK Researcher, Tłı̨chǫ Government, Behchokǫ̀, NT
Jim Thorassie	Chief, Sayisi Dene First Nation (Manitoba Denesuline), Tadoule Lake, MB
Jody Snortland Pellissey	Executive Director, Wek'èezhìi Renewable Resources Board, Yellowknife, NT
John Carter	Chief Executive Officer, Salt River First Nation, Fort Smith, NT
Kerri Garner	Lands Protection Director, Tłı̨chǫ Government, Behchokǫ̀, NT
Kyle Napier	Cree Language Manager/Communication and Research Manager, Northwest Territory Métis Nation, Hay River, NT
Lee Mandeville	Lands Program Coordinator, Dene Nation, Fort Simpson, NT
Raymond Sonfrere	Executive Director, Yamozha Kue Society (Dene Cultural Institute), Hay River, NT
Rosaline Cayen	Executive Director, Yamozha Kue Society (Dene Cultural Institute), Hay River, NT
Roy Fabian	Chief, Kátł'odeeche First Nation, Hay River, NT
Tim Heron	Interim Measures Agreement Coordinator, Northwest Territory Métis Nation, Fort Smith, NT
Tina Giroux	Biologist, Prince Albert Grand Council (Saskatchewan Denesuline), Prince Albert, SK
Victor Marie	Public Works, Salt River First Nation, Fort Smith, NT

Territorial Government Contacts

Allicia Kelly	Regional Biologist, South Slave, Environment and Natural Resources, Fort Smith, NT
Brett Elkin	Disease/Contaminants Specialist, Environment and Natural Resources, Yellowknife, NT
Dean Cluff	Biologist, North Slave Region, Environment and Natural Resources, Yellowknife, NT
Terry Armstrong	Wildlife Biologist – Bison, Environment and Natural Resources, Fort Smith, NT

Federal Government Contacts

Don Aubrey	Senior Policy Advisor, Wood Buffalo National Park, Parks Canada, Fort Smith, NT
Queenie Gray	Species at Risk Biologist, Environment Canada, Yellowknife, NT.
Greg Wilson	Species at Risk Biologist, Environment Canada, SAR Recovery Unit, Edmonton, AB.
Linh Nguyen	Biologist, Parks Canada, Inuvik, NT
Robert Kent	Southwest NWT Field Unit Superintendent, Parks Canada, Fort Smith, NT

Other Species Experts

Alice Will	MA Student, Memorial University, Department of Geography, St. John‗s, NL
Dr. Cormack Gates	Faculty of Environmental Design, University of Calgary, Calgary, AB
Cynthia Pyc	British Petroleum, Calgary, AB
David Natcher	University of Saskatchewan, Saskatoon, SK
Donna Hurlburt	Co-chair, COSEWIC Aboriginal Traditional Knowledge Subcommittee, Annapolis Royal, NS
Earl Evans	Métis Hunter, Northwest Territory Métis Nation, Fort Smith, NT
Gail Lotenberg	Vancouver, BC
John Nishi	Biologist, EcoBorealis Consulting Inc., Millarville, AB
Sharon Showshoe	Executive Director, Gwich‗in Social and Cultural Institute, Inuvik, NT
Sonja Leverkus	PhD Candidate, Oklahoma State University, Fort Nelson, BC.
Tom Chowns	Environmental Consultant, Powassan, ON

BIOGRAPHY OF PREPARERS

Adam Bathe, Bathe and Blyth Inc.

Adam studied in Natural Resources Management at the University of Iceland, during which he has gained experience in establishing monitoring programs, developed a GIS-based analysis of habitat disturbances, and blended publicly available traditional knowledge data with his scientific work. Adam has been involved in numerous wildlife stewardship initiatives in the NWT including working as a technical writer for the Advisory Committee for Cooperation on Wildlife Management (ACCWM) since 2018, and for the Bathurst Caribou Advisory Committee (BCAC) since 2022, and compiling the species status report for barren-ground and porcupine caribou in 2017. Adam has also been involved in delivering training programs for guardians programs in the Sahtú, the Imaryuk guardians on the Inuvik to Tuktoyaktuk Highway, the Ni Hadi Xa program, and in numerous communities across the range of wood bison in the NWT.

John Blyth, Bathe and Blyth Inc.

John Blyth currently resides in Fort Smith, Northwest Territories, Canada. For the last 13 years, John has operated a multidisciplinary consulting firm, blending environmental education, outdoor professional safety certification, and Indigenous guardianship training. John has been involved in numerous wildlife stewardship initiatives in the NWT including working as a technical writer for the Advisory Committee for Cooperation on Wildlife Management (ACCWM) since 2018, and for the Bathurst Caribou Advisory Committee (BCAC) since 2023, and compiling the species status report for barren-ground and porcupine caribou in 2017. John has also been involved in delivering training programs for the Tłı̨chǫ Ekwǫ̀ Nàxoèhdee K'è, the Imaryuk guardians on the Inuvik to Tuktoyaktuk Highway, the Ni Hadi Xa program, and the Tłı̨chǫ Caribou Monitoring Program at Mackay Lake, and in numerous communities across the range of wood bison in the NWT.

Kristi Benson, B.A., M.A. Heritage Specialist

Ms. Benson has more than 25 years of experience in conducting anthropological, oral history, traditional knowledge, archaeological, heritage policy, GIS, and other heritage projects. Her experience in the heritage field has taken place primarily with NWT communities. Ms. Benson co-prepared the species status reports (traditional and community knowledge component) for boreal woodland caribou, Dolphin and Union caribou, northern mountain caribou for the NWT Species at Risk Committee in addition to preparing the original NWT species status report for wood bison (traditional and community knowledge component). Ms. Benson has also acted as research manager for TK projects specifically relating to species at risk. She has conducted primary research, prepared relevant reports, and managed the review process for numerous Gwich'in knowledge of species at risk over more than 15 years: Rat River char, boreal woodland caribou, grizzly bears, wolverine, Bluenose caribou, bank swallows, amphibians, insects, Porcupine caribou, Dall sheep, muskrat, and birds. During these projects she conducted interviews, managed information and files, trained and supervised local interviewers, conducted community review and verification sessions, and prepared final reports. Ms. Benson has also provided traditional knowledge about barren-ground caribou for the designatable units assessment in 2011, and has compiled traditional knowledge for other species at risk assessments (pika, polar bear, and others). Ms. Benson also has experience as the project director for a multi-year Gwich'in traditional knowledge study relating to the Mackenzie Gas

Project, where she managed the budget, participated in the hiring committee for assistants, conducted community consultation, conducted interviews, handled contracts for transcribing, wrote reports, and many other tasks. Ms. Benson has conducted numerous studies with the Gwich’ in Social and Cultural Institute and Department of Culture and Heritage of the Gwich’ in Tribal Council since her first association with them in 2004, and has worked with harvest study data and traditional trails data in the Sahtú Settlement Region as well. She has also worked with Inuvialuit communities conducting heritage research and worked with the International Polar Year with scientists and communities across the NWT. As of 2024, Ms. Benson is a member of the NWT Species at Risk Committee.

SCIENTIFIC KNOWLEDGE COMPONENT

ABOUT THE SPECIES

Names and Classification

Scientific name:	*Bison bison athabascae*
Common Name (English):	American bison, subspecies wood bison
Other common name:	Buffalo
Common name (French):	Bison des bois
Population/subpopulation:	Greater Wood Buffalo metapopulation (in the NWT, the Nyarling River, Grand Detour/Little Buffalo, Hook Lake subpopulations)
	Mackenzie population
	Nahanni population
Synonym:	*Bos bison* (Linnaeus 1758)
Class:	Mammalia
Order:	Artiodactyla
Family:	Bovidae (horned ruminants)
Life form:	Animal, vertebrate, mammal, ungulate (hoofed)

The American bison (*Bison bison*) and the European bison (*B. bonasus*) are recognized as the two extant species of bison. The American bison is represented by the subspecies known as wood bison (*B. b. athabascae*) and plains bison (*B. b. bison*). In the NWT, there are three distinct free-ranging populations of wood bison: the Mackenzie and Nahanni populations, and the Greater Wood Buffalo metapopulation.

The Greater Wood Buffalo metapopulation consists of several intermixing subpopulations: the Hook Lake, Grand Detour (also known as Little Buffalo) and Nyarling River subpopulations are found at least partly in the NWT, and the Hay Camp, Garden River, Delta, and Wentzel Lake subpopulations are in northern Alberta. Bison may occur inside or outside of Wood Buffalo National Park.

The two subpopulations that occur outside of the park, Hook Lake and Grand Detour, are known together as Slave River Lowlands bison. They rarely cross the Slave River, which divides the

Slave River Lowlands subpopulation in two groups. The Hook Lake subpopulation ranges east of the river. The group on the west side of the river is known as Grand Detour by local people and the Government of the Northwest Territories (outside of Wood Buffalo National Park) and known as Little Buffalo by Parks Canada (inside the park).

Because of the different approaches various studies have taken, this report will refer to bison in and near the park as the Greater Wood Buffalo metapopulation, and where appropriate, to the two geographic ranges occupied by portions of the metapopulation found in the NWT: Wood Buffalo National Park and the Slave River Lowlands. Wood Buffalo National Park is home to the Nyarling River, Hay Camp, Garden River and Delta subpopulations and part of the Little Buffalo subpopulation. The Slave River Lowlands are home to the Hook Lake and Grand Detour subpopulations.

For the purposes of this report, the term 'herd' may be used interchangeably with subpopulation.

Systematic/Taxonomic Clarifications

There have been a series of taxonomic revisions of North American bison. Allen (1876) carried out the first study that included both living and extinct species. After a proliferation of new fossil discoveries led to descriptions of several genera and dozens of species and subspecies, Lucas (1899) attempted to disentangle the complicated synonymy in bison taxonomy by recognizing seven species. However, a confusing array of new genera, species and subspecies continued until Skinner and Kaisen (1947) carried out a very comprehensive revision of bison systematics. For all living and extinct North American bison, they attempted to stabilize the levels of genus to one, subgenus to five, species to 10, and subspecies to four, but because of dating limitations, their morphotype groupings were prone to error (Schultz and Hillerud 1977). With improved dating methodology and rejection of unusual fossil characteristics that were fragmentary, insignificant, or unlikely to have adaptive value, the detailed revision by McDonald (1981) resolved the classification of North American bison to five species and four subspecies. His revision, which included the one living species (*Bison bison* Linnaeus 1758) and two subspecies known as wood bison (*Bison bison athabascae* Rhoads 1897) and plains bison *(Bison bison bison* Linnaeus 1758), has been supported by the American Bison Specialist Group (ABSG) (Boyd *et al*. 2010a; Plumb *et al*. 2024). The most recent systematic study was conducted by Van Zyll de Jong (1986), who analysed the morphometrics of extinct, historical, and remnant populations, particularly as they relate to wood bison.

As research into taxonomic issues continues, genetic distances and degree of relatedness among all bovines could become more precise, but the ranking of genus, species and subspecies may not be resolved without universally accepted criteria. The origin of the unique lineage of wood bison was surmised by McDonald (1981) to be about 5,000 to 4,000 years before present, even though no samples were available to him for dating.

The wood bison subspecies distinction issue became complicated during the period of 1925 to 1928, when more than 6,000 plains bison from Buffalo National Park near Wainwright, Alberta, were released into Wood Buffalo National Park and hybridized with the wood bison there (Raup 1933). These plains bison also carried tuberculosis and brucellosis, two debilitating diseases for bison (for more information on disease, refer to p. 182). To rescue the subspecies, some purportedly pure wood bison from a remote portion of the range near Nyarling River were rounded up. Eighteen were sent north of the Mackenzie River to reintroduce a free-roaming, disease-free population in 1963, and after another roundup in 1965, 23 were sent to a newly created captive isolation area at Elk Island National Park (Novakowski 1963a; Novakowski 1963b; Novakowski and Stevens 1965).

From analyses of body shape, pelage, and multivariate morphometric skeletal characteristics among specimens of pre-1925 wood bison, post-1928 Elk Island/Mackenzie wood bison, and descendants of the Allard-Pablo plains bison herd, Van Zyll de Jong (1986) concluded that all extant wild wood bison have had some genetic introgression from plains bison. However, he also concluded that *B. b. athabascae* traits predominate. The prevailing position of the International Union for the Conservation of Nature (IUCN) Bison Specialist Group (Gogan *et al*. 2010) and the Government of the Northwest Territories (CMA 2025) concurs with Van Zyll de Jong *et al*. (1995) that all bison in the NWT are wood bison. Whether wood bison is a *bona fide* subspecies, or a lower taxonomic variant of the American bison (*B. bison*) does not alter the unique evolutionary pathway of wood bison, nor diminish the validity of its conservation as a morphologically and genetically distinct entity (*Species at Risk Act* 2002; *Species at Risk (NWT) Act* 2009). For more information on systematic and taxonomic clarifications, refer to *Appendix A1*.

Description

Physical Characteristics

Wood bison are noted for their enormous size, high hump at the shoulders, long woolly pelage especially on the head and forequarters, wide muzzle, and short, round, curved horns extending upwards from the sides of the head. In mature animals, the coat is generally dark brown and black. Calves are born with a ruddy, coppery yellow appearance, which becomes darker after a few months when they start to form their hump.

As the largest native terrestrial mammal in North America, mature wood bison bulls measure over 1.8 metres (m) at the shoulder and reach a maximum, on average, of 910 kilograms (kg) at 13 years of age, whereas females average a maximum of 567 kg at 12 years of age (Olson 2002).

Wood Bison vs. Plains Bison

Olson (2006) found that wood bison in the Elk Island National Park Isolation Area average 17 per cent (%) heavier than plains bison of Elk Island National Park. Wood bison are also darker than plains bison, have a more pronounced forwardly placed hump, less slope along the back to the rump, and a lighter line extending from the crest of the hump to the hindquarters. In addition, plains bison have a very distinctive golden-coloured cape on the forequarters, and more hair on the front legs and throat. Detailed descriptions of the differences between wood and plains bison are found in Hind (1860), Allen (1876), Geist and Karsten (1977), Van Zyll de Jong (1986), Van Zyll de Jong *et al*. (1995) and Olson (2006).

From an original population of tens of millions, nearly all plains bison existing today (outside of Yellowstone National Park) originated from 76-84 animals that were found in five private herds in the late 1800s (Garretson 1938; Meagher 1973; Coder 1975; Halbert 2003). Unfortunately, such shrinkage leads to descriptions of plains bison based on a very diminutive, poorly representative subset. Geist (1991) cautioned that precision sampling of the small range of the natural variation remaining in today's herds, and ignoring phenotypic plasticity, increase the risk of accepting taxonomic deviants and peculiarities as normal.

Figures 13, 14, and 15 are some of the rare photos on record of a wood bison before hybridization with plains bison. Figure 16 is a photo taken since the hybridization event.

Figure 13. Bull wood bison collected by Harry Radford in 1911 near Fort Smith (photo from MacBeth 1913).

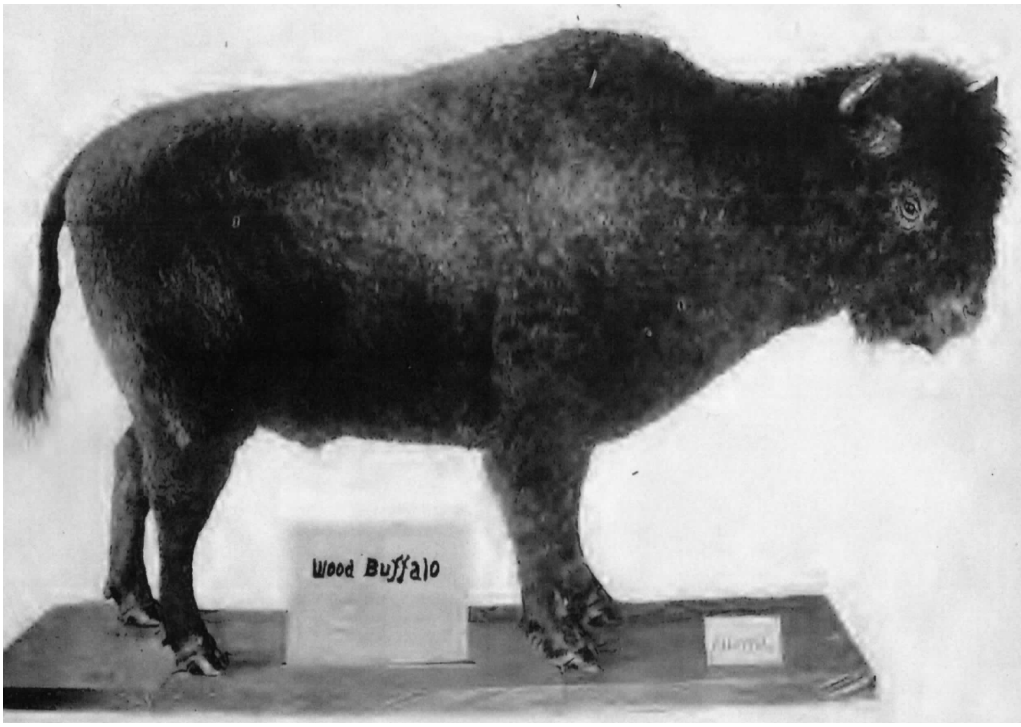


Figure 14. Mounted wood bison bull collected by Harry Radford in 1911 (photo from Garretson 1923).

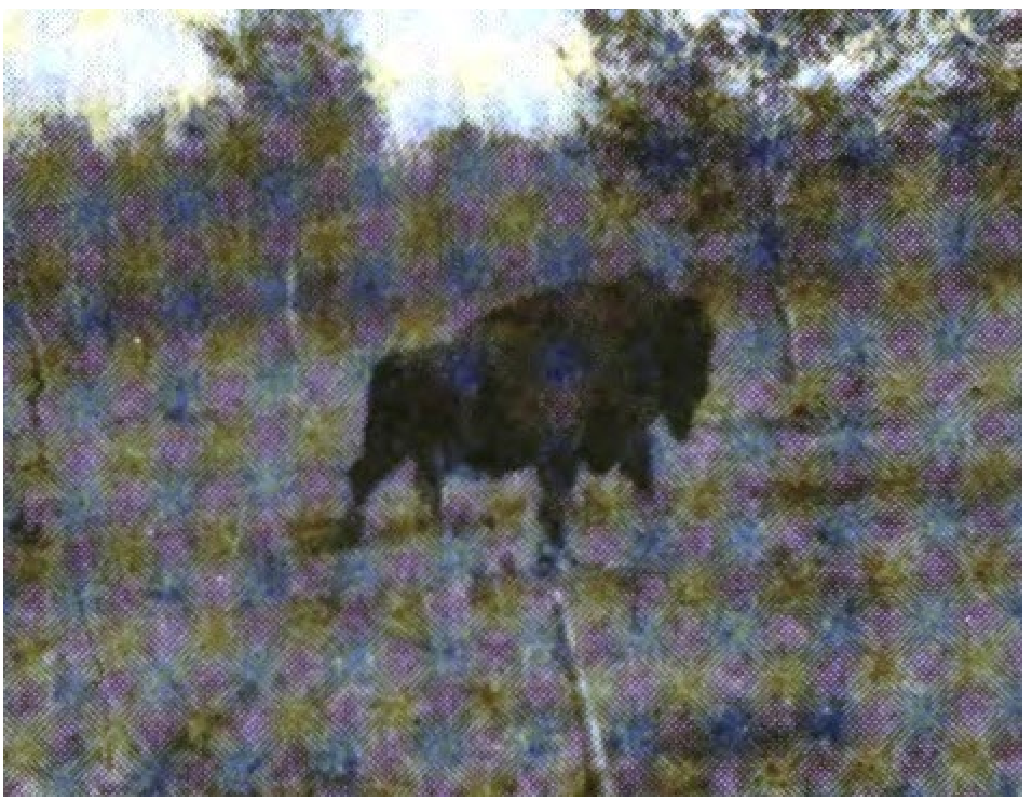


Figure 15. Wood bison bull in the newly created Wood Buffalo National Park (photo from Graham 1923).

Figure 16. Wood bison in the Mackenzie Bison Sanctuary. Photo courtesy T. Armstrong, GNWT-ECC.

Life Cycle and Reproduction

Age Groups

Bison are usually classified into seven different sex and age classes based upon body size, pelage, horn shape and horn wear (Fuller 1959; Gates *et al.* 1991; Komers *et al.* 1993):

- **Calves** – Young-of-the-year of both sexes, typically being born in April-May with calving largely completed by July. Their reddish-tan coats turn dark chocolate brown at about three months of age and by four to six months horn nubs may be visible.
- **Yearlings** – Animals one to two years old of both sexes with spike-shaped horns of 10-30 centimetres (cm) in length. Body size is smaller than adult females.
- **Cows or adult females** – Animals of two years and older in breeding condition. Horns have grown long enough to curve, so there is no 'spike-horn' stage. Their horns are more slender than those of all males and have a pronounced recurve toward the middle line of the skull resulting in a distinct S-shape in older cows. The front of the skull is narrower than that of adult males.

- **B1 males or juvenile bulls** – Two, three and some four-year-olds. 'Spike-horns' point upward or outwards and always point away from each other. Body size is similar to, or slightly smaller than cows; however, the horn base is wider than cows.
- **B2 males or sub-adult bulls** – Animals four to six years of age. Starting to become successful breeders. Horn base is wider than cows and the horns point straight up or towards the middle line of the skull. The hair on the head and shoulders is shorter than in adult bulls. Body size ranges between that of cows and adult bulls.
- **B3 males or younger mature adult bulls** – Animals of seven to 12 years of age. Horns are curved toward the middle line of the skull and may show the start of wear on the tips. Hair on the chest and head is fully developed leaving no open space between the horns. Body size is much larger than cows.
- **B4 males or older mature adult bulls** – Animals of at least 10 years of age. The distinction between B3 males and B4 males is the noticeable wear on the horns in B4 males, often resulting in wide blunt ends.

Age at Maturity

At the Elk Island National Park Isolation Area, weights of female bison begin to level off (asymptotic body weight) by six years of age, and females achieved their maximum body weight at 10 years. Male bison reached an asymptotic body weight at eight to nine years and maximum body weight by 13 years (Olson 2002; Reynolds *et al.* 2003).

From the annual bison reduction slaughters in Wood Buffalo National Park from 1952-1956, Fuller (1961, 1966) investigated the sexual maturity of bison. He found some pregnant yearling females that had conceived when they were about 15 months of age. This ranged between 4% at Hay Camp and 12% in the Peace-Athabasca Delta. Among females, 40% of two-year-olds and 52% of three-year-olds had bred for the first time. Of the few male bison studied, 1 of 6 yearlings, 3 of 8 two-year-olds and all 6 three-year-olds had attained sexual maturity.

The breeding success of sub-adult males is suppressed when there is competition with older bulls; therefore, male wood bison generally do not begin to breed until they are five or six years old (Egerton 1962; Komers *et al.* 1994a, 1994b; Wilson *et al*. 2002). Among wood bison at Elk Island National Park, Wilson *et al*. (2002) found that the average age of first reproduction was 7.7 years, and maximum reproductive success seemed to range from 7 to 14 years of age.

Average longevity of bison has never been determined. McHugh (1958) documented females in captivity living into their fourth decade. Fuller (1966) identified the oldest age class from the reduction slaughters of the 1950s as up to 30 years, but it is unlikely that many animals in the wild live past 20 years (Meagher 1973). Meeting nutritional requirements is hampered when teeth wear to the gumline. Haynes (1984) found tooth wear in Wood Buffalo National Park bison to be much lower than in plains bison, and he attributed this to dietary differences. Grasses, the main food of plains bison, contain more abrasive silica than the sedges that wood bison largely depend upon, and more gritty material is masticated when grasses are grazed from drier substrates. Horsetails (*Equisetum* spp.) contain high levels of silica. Nahanni bison are particularly susceptible to tooth wear (and likely shorter lifespans), compared to other wood bison because of the unusually high amount of these plants in their diet (Larter and Allaire 2007).

Sex Ratio

Upon examination of 840 mature females at the Wood Buffalo National Park bison slaughters, Fuller (1960, 1961, 1966) found the primary sex ratio (in utero) to be 112 males:100 females, or 53% males. Palmer (1916) calculated a similar ratio of 54% males from a sample of 460 bison from United States (U.S.) national herds. The adult sex ratio is difficult to determine as accurately because composition surveys usually target groups of mixed sex and age in open habitats, while bull only groups that spend more time in forest cover are more likely to escape detection. The males of many ungulate species often have higher rates of early mortality than females. This appears to be true for wood bison and the sex ratio would be expected to skew more towards females as the average age of the population becomes older.

Calef and Van Camp (1987), in a study of population dynamics between 1974 and 1983, suggested that hunting may favour higher survival of females if males are selected for their size and trophy value, as in the Hook Lake subpopulation where the ratio was 32 males:100 females (24% males).

From a sample size of 1,156 in the entire Mackenzie bison range, Gates *et al*. (1991) determined the June 1989 adult sex ratio to be 94 males:100 females (48% males). However, the sample subset of 895 from the Mackenzie Bison Sanctuary showed a ratio of 83 males:100 females (45% males). Where range expansion was being led by pioneering bulls in the Mink Lake area of the Mackenzie population, they found the proportions to be significantly different ($\chi^2 = 16.18$, df = 1, $P > 0.05$) at 150 males:100 females (60% males). Gates *et al*. (1995) determined the July 1993 adult sex ratio to be 78 males:100 females (44% males) from a sample size of 473 in the Mackenzie Bison Sanctuary. With a ratio already tipped in favour of females, the anthrax outbreak that began three weeks later removed 119 more males than females from the population.

In 2013, the Mackenzie ratio was 87 males:100 females (47% males), from a sample size of 169. Since 1999, the sex ratio has averaged 86 males:100 females and ranged between 66 and 105 males:100 females (40-51% males) (Armstrong 2013a).

From 1999 to 2006, the sex ratio in the Nahanni population averaged 92 males:100 females (48% males) and ranged between 65 and 121 males:100 females (39-55% males) (Larter and Allaire 2007).

Generation Time

Gross *et al*. (2006) used the Carey (1993) formula to calculate generation times for U.S. National Park Service plains bison herds. For a scenario with adult sex ratios near parity and random removals of animals, the average generation time was approximately seven years. Hedrick (2009), using the average of highest reproductive success, also estimated generation length for plains bison at seven years.

An average generation time of seven years is probably an equally valid estimate for wood bison.

Breeding Behaviour

The earliest indication of the wood bison breeding season (rut) is restlessness of the bulls as they uproot small trees and increase vocalization (Fuller 1960). Mating activity begins in late June or July and that the peak is reached in mid-August (Fuller 1966; Larter 1988; Carbyn and Trottier 1987).

The ritual begins when a male approaches a female with his neck lowered, head extended, lip up-curled (Flehmen), tail erect, and tests her external genitalia or fresh urine for olfactory cues regarding her state of estrus (Fuller 1960). In the early stages the bull is little roused sexually, but through repeated sensory stimulation a highly excitable nervous and physical condition is reached by the time the cow is receptive (Egerton 1962). Copulation lasts a few seconds and may occur most often at night (Fuller 1960; Egerton 1962).

The close association between a bull and a cow during the rut is referred to as *tending* (McHugh 1958). This bond is a form of courtship behavior which ensures that a bull is nearby when a cow is ready for breeding (Egerton 1962). Tending continues for a short period after copulation, presumably to guard against sperm competition from rivals (Lott 1981).

Rutting wood bison undergo a decrease in group size as members of bull groups became more solitary and mixed herds fragment into smaller units (Soper 1941; Egerton 1962; Calef and Van Camp 1987; Melton *et al*. 1989). From observations in Wood Buffalo National Park, Egerton (1962) considered the basic herd unit during the rut to contain 11-30 animals, including more than one bull.

Within the polygynous mating system of bison, selection for body size and aggressive behaviour in males restricts access to females. Although the age at which male bison may breed is a selective factor, Bork *et al.* (1991) found that most Elk Island National Park wood bison bulls will eventually mate through the course of their lifetimes. Bulls are promiscuous, but each cow is served by only one bull (McHugh 1958). Compared to the large breeding aggregations of plains bison where access to females is controlled by a dominance hierarchy, the wood bison mating structure may more closely resemble a harem system (Melton *et al*. 1989; Wilson *et al.* 2002). When rutting wood bison break up into smaller groups in the forest, they increase the number of breeding clusters available. This could allow subordinate bulls greater opportunity to contribute to the gene pool (Komers 1992), or, alternatively, less opportunity if the harems are well defended (Wilson 2001; Wilson *et al.* 2002). However, Egerton (1962) found no evidence of direct competition between bulls for cows, nor that herd bulls were consistently successful in defending harems and breeding each cow. The most sexually active bull at one time may be a lone bull a few hours later, and several adult bulls in a herd may share temporary dominance as they tire from aggressive interactions.

Roaring, pawing, horning the ground and wallowing all seem to be a display of threat behaviour to intimidate other bulls and minimize fighting (Egerton 1962). When combat is about to ensue, the bulls slowly approach each other in a stylized advance with lowered heads carried slightly to one side, before locking one horn and shifting their footing (Fuller 1960). Fights consist mainly of a series of shoving matches, combatants losing ground alternately, often without a clear winner, and usually ending abruptly in less than five minutes (Fuller 1960; Egerton 1962).

Although older, dominant wood bison bulls do not exclude younger bulls from female groups, the older ones interrupt younger animals whenever they show interest in cows (Egerton 1962; Komers *et al*. 1992). At Elk Island National Park, Wilson *et al*. (2002) observed that the youngest bull competitive in the rut was 5 years of age, and the oldest was 14 years. Despite younger males' ability to enter the rut, they may lack sufficient energy resources to adequately sustain tending or achieve high levels of reproduction (Komers *et al*. 1994b; Wilson *et al*. 2002). They become more successful at later stages of the rut when older bulls are exhausted and more easily displaced (Komers *et al*. 1994b). Approximately 40% of mature males contributed reproductively to the population in Elk Island National Park each year (Wilson *et al*. 2002).

The entry of lone bulls into mixed herds and younger males investigating cows and displaying flehmen attracts the attention of the dominant bulls. These activities raise the intensity of rutting behavior in the herd which likely improves the overall conditions for successful conception (Egerton 1962).

Bork *et al.* (1991) suggested that increased random mating within a bison population is facilitated by extensive movements through home ranges and thorough population mixing. Wood bison likely avoid inbreeding by travelling in mixed herds that interchange frequently with unrelated individuals, and bulls entering these groups during the rut have low chance of encountering a closely related cow (Wilson *et al*. 2002).

Fecundity

Most of the knowledge about bison productivity has been derived from studies of plains bison. The estrous cycle in bison lasts about three weeks (19-26 days) and have 1 or 2 ovulations during a breeding season (Haugen 1974, Rutberg 1986, Kirkpatrick *et al.* 1991) and the gestation period has been estimated at 285 days or 9.5 months (Haugen 1974, Rutberg 1986). Ovulation and gestation time in wood bison is likely similar; Armstrong (pers. comm. *in* SARC 2016: 82) has noted a gestation period of 270-300 days (9-10 months) in wood bison in the NWT. Evidently, nutritional condition has a direct effect on the fecundity of bison. For example, McHugh (1958) reported an average pregnancy rate for mature cows at 90% on the National Bison Range in Montana, as opposed to 35% observed by Lott and Galland (1987) for undernourished bison on Santa Catalina Island, California.

Although mature females in some other plains bison herds bear calves every year (Rutberg 1984; Shaw and Carter 1989; Wolff 1998), this has not been apparent in Yellowstone National Park. Meagher (1973) found that approximately 50% of sexually mature cows produced calves, and suggested the majority of females produced calves every other year.

Similarly, a 1990 to 1993 study in Yellowstone National Park by Kirkpatrick *et al*. (1996) showed a 48.2% annual pregnancy rate with 85% of all mature cows becoming pregnant on alternate years, and only 15% of lactating cows being fertile. They also found that more than 80% of all pregnancies (in either lactating or non-lactating cows) occurred in cows older than three years, and that 100% of all pregnancies among lactating cows occurred in cows older than four years. These results were consistent with bison herds subjected to harsh environments or poor nutrition. Adverse environmental conditions seemed to contribute to prolonged lactation and delayed ovulation the following season, and these effects were more pronounced for younger cows. Of the three variables Kirkpatrick *et al*. (1996) found to be influencing the reproductive success of bison in Yellowstone National Park, environmental conditions such as winter severity appeared to have more profound impacts than either age or lactational status.

Mature wood bison females usually do not breed every year (Fuller 1966; Soper 1941). For Wood Buffalo National Park, Fuller (1961, 1966) estimated the average conception rate of an adult female to be 67% during her lifetime. This was at a time in the 1950s when there were no reports of harsh environmental conditions for the bison population. Calef (1984) suggested that in some years all cows in the Mackenzie population would have been bearing calves in order to achieve the high rate of increase reported for this population in the first two decades following reintroduction (26%). Reynolds *et al*. (2003) reported a negative relationship between density and fecundity in bison at the Elk Island National Park Isolation Area.

The age of first successful pregnancy is expected to be delayed by brucellosis in bison of the Greater Wood Buffalo metapopulation (Canadian Food Inspection Agency [CFIA] 2012). Embryos from cows that were lactating tended to be smaller than those from cows not lactating (Fuller 1961, 1966) and Green and Rothstein (1991) found the young born to females following a year of not breeding were larger and more fecund than the young of females that reproduced the previous year. The highest reproductive success for females is between 3 and 12 years of age. Wilson *et al*. (2002) and McHugh (1958) reported a significant decrease in pregnancy after age 12, although females may continue to breed until more than 16 years of age (Green 1990).

Maternal Behaviour

In Wood Buffalo National Park, Soper (1941) found that calves are usually born from early May to early June. Females usually give birth while lying down (Reynolds *et al*. 2003). Soper (1941) noted from warden testimony that the neonates are seldom encountered during the time of calving, probably because parturient cows prefer the seclusion of wooded areas to have their young. Wood bison and plains bison may calve at remote forested locations away from other bison, or in the midst of herds (Gogan *et al*. 2010).

The innate maternal behaviour of plains bison documented by Egerton (1962) study at Waterton National Park is likely shared with wood bison. Egerton (1962) observed that all cows became restless in the hours before calving and depart the herd to give birth. Short excursions away from the herd may display a conflict between remaining with the herd and an urge to be alone. The period when a cow and her calf are alone may be important for bond formation and imprint recognition between them. As the cow licks the amniotic fluid from the newborn, this appears to stimulate activity in the calf. Standing begins within minutes following birth, while udder seeking and suckling begins almost immediately after the calf is on its feet. During its first few days of life, the calf continues to nurse at frequent intervals and the mother grazes in circles around it. Cows stay close to their young, keeping between them and any intruder until the calves are able enough to follow. Low ranking cows in the dominance hierarchy try to repel attempts by other bison to investigate their new calves. The close cohesion between a cow and her calf declines after about a week when they join cow-calf subgroups and calves begin to cavort with each other in pods (Egerton 1962; Green 1992; Carbyn and Trottier 1987).

In their study plains bison cow-calf relationships at Wind Cave National Park, South Dakota, Green *et al*. (1993), found that a calf is typically weaned from 9 months until the end of the first year if the mother is pregnant again, whereas nursing may extend late into the second year if the mother is barren. Green *et al*. (1993) could not clearly define a weaning period which seems to be influenced by gradual maturational changes of parents and offspring more than by conflict. The longest post-weaning associations are between cows and their female offspring which may continue through a third summer, while a male seldom remains with his mother past a second summer (Green *et al*. 1989).

Maternal wood bison become highly focussed on anti-predator strategies when the calves are young (Carbyn and Trottier 1987). Vocalization by a calf under threat has been observed in the Mackenzie Bison Sanctuary to trigger a cow's defence response by charging (Chowns pers. comm. 2025).

Physiology and Adaptability

Physiological Requirements

While protein and lipid content are deficient in winter forages, bison target coarse sedges, especially awned sedge (*Carex atherodes*), which is high in digestible carbohydrates (e.g. hemicellulose), maximizing short-term energy gains this time of year when demands are greatest (Fortin *et al*. 2003; Hecker *et al*. 2021b). Of all forage species tested in the Slave River Lowlands, Hawley *et al.* (1981b) found *C. atherodes* to have the greatest digestibility for bison. *C. atherodes* is also highly profitable in digestible energy relative to the time required for cropping, chewing and swallowing (Fortin *et al*. 2002). Other coarse sedges (e.g. *C. rostrata*, *C. aquatilis*, *C. retrorsa*, and *C. bubulosa*) appear to be less palatable. Consumption of *C. aquatilis* seems to be more apparent in spring, possibly because it greens-up earlier than other forages, and in more nutrient-rich environments.

Coarse sedges have unique characteristics beneficial for satisfying the energy demands of wood bison through the long winters. A portion of the next spring's shoots are formed the previous autumn and the biomass of this green standing crop available in winter may be quite high (Bernard and Bernard 1977). Reynolds *et al.* (1978) observed that when sedges freeze in the autumn, they retain digestible nutrients. During winter, these levels may actually be twice as high as in summer (Bernard and Hankinson 1979). After the long winters, bison capitalize on sedges' ability to undergo high nutrient uptake at the beginning of the next growing season, and these plants do this most effectively when the supply of nutrients is low (Bernard *et al.* 1988).

Other food items such as reedgrasses (*Calamagrostis* spp.) have very low winter digestibility, whereas willows (*Salix* spp.) are most digestible in winter and show the least amount of change through the seasons (Hawley *et al*. 1981b; Larter 1988). In Yukon, bison have been observed foraging on push-ups during winter (Clark *et al*. 2016). Muskrat push-ups offer a valuable source of high-quality forage that bison should use to supplement their winter diet (Jung *et al*. 2019).

Browse items are the soft parts of woody shrubs and saplings which are utilized mainly in the growing seasons. Hudson and Frank (1987) found that the critical amount of forage biomass in summer and autumn to support wood bison was 779 kg/ha. According to Strong and Gates (2009), treed habitats in northern Alberta generally produced less than the amount of biomass needed for wood bison to maintain an efficient foraging rate and did not provide adequate nutrition in winter. However, Mackenzie bison disperse into forests from late August until October when these habitats produced superior quality forage (Larter 1988). At sample sites north of Fort Providence, Penner (1978) found annual production of willow browse alone ranged from 2,535 kg/ha in wet sedge meadows, 1,406 kg/ha in willow-shrub, 530 kg/ha in aspen-willow, to 442 kg/ha in willow dominated grassland.

Bison enter the spring season with depleted fat reserves that need to be replenished, and females have additional energetic demands of lactation (Hudson and White 1985). Hecker *et al.* (2021b) found that dietary breadth expanded, and greater concentrations of crude protein were consumed, in spring. Increased use of browse and forbs in summer diets has been documented for northern bison (Waggoner and Hinkes 1986; Larter 1988; Larter and Gates 1991; Bergmann *et al.* 2015; Jung *et al*., 2015; Leonard *et al.* 2017; Hecker *et al.* 2021). This switch may be due to lignification and decreasing protein content of graminids as summer progresses, and higher physiological demand for lipids (Hecker *et al.* 2021b).

The voluntary feed intake for bison has been calculated to be 0.009 kg/kg body mass/day for sedge, and 0.011 kg/kg body mass/day for grass (Richmond *et al*. 1977). On a sedge diet, Hawley *et al.* (1981a) measured an average weight gain of 0.42 kg/day in summer and 0.04 kg/day in winter. Bison probably need to consume water every day (McHugh 1958).

Foraging Habits

Wood bison are generalist herbivores. Although bison are primarily grazers, meaning they eat a variety of grasses and sedges according to their abundance (Reynolds *et al.* 1978; Rivals and Semprebon 2011), they will supplement their diet by browsing on the soft parts of woody vegetation. Also, in the Mackenzie Bison Sanctuary and the Yukon, lichens constitute a significant part of the bison diet in the autumn (Larter and Gates 1991; Fischer and Gates 2005), whereas this type of plant material is less important in Wood Buffalo National Park (Raup 1933). Horsetails are a major dietary component for Nahanni bison (Larter and Allaire 2007), but not so much in Wood Buffalo National Park (Raup 1933), and have not been identified in the diets of other populations.

As the largest North American ungulate, wood bison are exposed to extreme seasonal shifts in forage quality and availability. Where quality is a limiting factor for the population, large body size is advantageous (Case 1979; Eastham and Feranec 2024). Larger ruminants can consume a lower quality diet because of a lower specific metabolic rate, associated with slower passage of food through the gut, and longer retention time permits more thorough digestion of a diet high in cellulose (Westoby 1974; Hanley 1982). Relying on foods which are abundant but of low nutritional value means that large generalist herbivores must keep their digestive tracts almost continuously full and are limited by the time required to digest food rather than by how fast they can obtain it (Westoby 1974). According to the criteria espoused by Hanley (1982) that ungulate diets can be predicted by certain morphological features, Larter (1988) indicated that the diet of wood bison should be intermediate between strictly monocotyledonous and eudicotyledonous, allowing wood bison to use a diversity of forages while avoiding plant parts high in lignified carbohydrates. Because lignin is nearly indigestible, it slows the rate of passage through the gut of ruminants and restricts consumption of additional forage (Hanley 1982).

Hawley *et al*. (1981b) determined that willows in the Slave River Lowlands had high digestibility in winter and suggested if snow depth or ice conditions forced the bison to browse extensively, willow may be an important source of energy. In 1987, decreased precipitation in the Mackenzie Bison Sanctuary reduced the standing crop of all forages, especially sedges in the preferred summer foraging habitat (Smith 1990). This was offset by higher consumption of grass and willow, indicating the capability of wood bison to broaden their diet when sedge biomass declines (Larter and Gates 1991).

The quantitative model of the *forage maturation* hypothesis (Fryxell 1991) predicts that the food intake of ruminant ungulates is constrained by availability at low forage biomass, and by digestibility at high forage biomass. Bergman *et al*. (2001) observed that digestibility of awned sedge (*C. atherodes*) declined with increasing biomass, while short-term sedge intake rates by wood bison increased with decreasing biomass. This indicates that bison behave as time minimizers rather than energy maximizers. The adaptive value of this trait is that bison can spend minimal time grazing in the open, and more time digesting a large volume of low-quality food in cover where they can be less exposed and more alert to predation. Hudson and Frank (1987) found that bison compensated for low biomass in boreal aspen habitats by foraging more efficiently, and suggested that efficient foraging on swards (stretches of grass) at low biomass density is a competitive advantage where forage is limited and there are few opportunities to forage selectively.

Preferred forage is sensitive to overgrazing and may be replaced by less palatable species such as common spike-rush (*Eleocharis palustris*) if grazing is excessive (Millar 1973). Bison have lesser tendencies than cattle to overgraze their range, and they generally only bite off the top third of the plant (Reynolds *et al.* 1978). Bison show strongest selectivity for leaves and strongest avoidance of stem tissue when grazing tall swards (Bergman *et al.* 2000).

The *herbivore optimization hypothesis* predicts that the net primary productivity of a plant community will be higher under moderate grazing pressure than with little to no grazing or heavily grazed (McNaughton 1979, Hilbert *et al*. 1981). In the Mackenzie Bison Sanctuary, Smith (1990) found that moderate grazing increased the productivity of forage species only in the most productive sites, mainly by reducing the accumulation of dead plant material.

In winter, bison clear snow from food patches by sideways swinging of their heads, and pushing and pulling with their noses and chins, also known as *cratering*. Since there is likely little nutritional difference between sedge species at this time of year, energy efficiency of searching and cratering selectively for *C. atherodes* neutralizes as the depth of snow increases (Rawleigh *et al*. 2024). High snow water equivalent also imposes a high energy cost which may cause bison to forage over smaller areas and consume less vegetation in craters (Harvey and Fortin 2013).

Adaptations for Sustenance

Hofmann (1989) described large bovids such as bison as well-adapted to consumption of monocotyledonous graminids (e.g. sedges and grasses), specializing in the digestion of rigid cell wall structural carbohydrates. Food retention time is extended by their relatively voluminous rumens and long intestines that are very efficient at extracting protein and other nutrients from graminids. Many eudicotyledonous plants (e.g. forbs, herbs and browse items) consumed by bison are important for their cell contents which are usually higher in protein than monocots, but contain chemical repellents (e.g. phenolic compounds, tannins etc.) which require salivary and liver functions to detoxify (Hofmann 1989).

As grazers of immense volumes of soft fibrous forage, the cutting action is performed entirely by the incisors. The premolars which are unreduced and strongly molarized, aid the molars in grinding (Köhler 1993). Hypsodont cheek teeth, characterized by continuous growth, high crowns, and complex folding of the enamel filled with cementum counter excessive wear from fibrous graminids containing abrasive silica, phytoliths and grit (Fortelius 1985; Janis 1990; Köhler 1993). Masticatory muscles used for side-to-side grinding evolved far more massively than those used for biting (Köhler 1993; Solounias *et al*. 1995).

Susceptibility to Environmental Changes

Compared with other NWT ungulates such as moose (*Alces alces*), and caribou ecotypes (Rangifer tarandus), which range across hundreds of thousands of km^2, the Area Occupancy of NWT wood bison (refer to Figure 23) is quite restricted at approximately 46,773 km^2. High-quality wood bison habitat tends to be patchier and more insular (isolated) on the landscape. Also, bison expansion from the original Falaise-Dieppe-Calais lakes core area required decades to reach important habitats within 50 km to the north and west. Shachak and Brand (1988) proposed that decisions by an organism about where and when to settle at a new site involve weighing the benefits of new high-quality habitat against the cost of mortality due to increased searching time. Relatively restricted range and slow colonization could be particularly detrimental to wood bison if any parts of current range were to deteriorate.

Bison are particularly susceptible to agricultural development. Both bison and farmers have a penchant for extensive level tracts of fertile soils (e.g. Reynolds and Hawley 1987).

Vulnerability to Extreme Conditions

Bison face many adversities that may be compounded by more than one factor. Bison can tolerate shallow, soft snow, but deeper, longer lasting snow tips the energetic balance against them. Bison exhibit poor morphological adaption to deep snow when compared to North American cervids (Telfer and Kelsall 1979, 1984). Because bison have a lower morphological index for snow-coping ability than wolves (Telfer and Kelsall 1984), extreme snow depths increase their vulnerability to predation.

Van Camp (1975) concluded that undisturbed snow deeper than 50-60 cm in the Elk Island National Park Isolation Area hindered the movements of calves and undisturbed snow deeper than 65-70 cm impeded adults. He also observed that the amount of work required for bison to excavate feeding craters doubled during the winter because of increasing snow density, and calves stopped cratering when snow density approached 0.18-0.20 g/cm^3 and 60 cm in depth. In the Slave River Lowlands, Reynolds and Peden (1987) observed that 53-60 cm of snow curtailed extensive movements by calves, and high snow density and hardness related to spring thaw hindered foraging (Reynolds and Peden 1987). In Prince Albert National Park, Fortin *et al.* (2003) observed that bison were less likely to visit meadows when snow depth was 38 cm deep, but during a winter with less snow (27 cm), meadow use was unaffected by snow depth.

Carbyn *et al.* (1993) tracked snow depth, the duration of the period of critical snow depth, and snow density from Fort Smith and Fort Chipewyan from 1965 to 1980 to assess impacts on bison. Snow hardness data were unavailable. Although cause-and-effect relationships between snow measurements and bison demographics could not be precisely determined, and negative impacts of severe winters are probably offset by benign winters, Carbyn *et al.* (1993) identified some potential relationships. Lower calf production and yearling recruitment contributing to sharply declining bison populations in the first half of the 1970s seemed to be correlated with severe snow conditions, and greater population stability in the second half of the 1970s was associated with moderate snow conditions.

As primarily grazers, food supply becomes a limiting factor for bison during winter, compelling them to spend more time displacing snow from feeding craters and foraging, than travelling

(Fortin 2002; Bruggeman *et al*. 2008; Sheppard *et al*. 2021). Increased cumulative snow depth exceeding 40 cm in the Ronald Lake bison range (south of Wood Buffalo National Park) likely contributed to reduced movement rates associated with the greater energetic cost of travel between forage patches (Sheppard *et al*. 2021).

Snow refrozen after rain or thawing events may be particularly devastating to bison. Such conditions can lead to starvation and heightened vulnerability to wolves and human hunters (Ogilvie 1893; Dawson 1881; Whitney 1898; MacFarlane 1908; Preble 1908; Raup 1933; Soper 1941; Roe 1970; Calef and Van Camp 1987; Alaska Department of Fish and Game 2023).

Fuller *et al.* (2007) found spring calf to adult ratios in Yellowstone National Park bison to be negatively correlated with the winter snowpack, and Delgiudice *et al*. (1994) documented physiological stresses that bison suffered during winter nutritional deprivation.

Because good foraging habitat for wood bison is closely associated with high water tables, excessive levels of precipitation may damage important feeding areas. Flooding may be particularly harmful over the short term if it is widespread. Over the longer term, impacts may be partially offset by wet meadow expansion into areas that are normally drier. Excessive rainfall diminishes landscape fire in the ecosystem, allowing plant succession to proceed unfavourably for bison. Prolonged flooding late into the summer reduces the availability of wet meadow forage resources, and if it lasts for several years in succession, plant mortality occurs (Harris and Marshall 1963; Millar 1973; Squires and Van der Valk 1992).

For additional discussion on the role of flooding in bison habitat, refer to *Habitat Trends*.

Adaptations to Adversity

Bison have a dense, woolly undercoat overlain by longer guard hairs, which makes them resistant to cold temperatures (Peters and Slen 1964; Meagher 1973). Bison feeding activities are not nearly as limited by wind or cold as for cattle (Hawley 1987). Normally, the physiological response of an animal to cold is an elevated metabolic rate. For bison calves, Christopherson *et al.* (1978) found that metabolic rate decreased from 0° C to minus 30° C, probably as an adaptation to conserve energy. However, a slight windchill coupled with minus 30° C increased the metabolic rate. McMillan *et al*. (2021) observed a decline in daytime plains bison movement in favor of nighttime movement, possibly in response to high temperatures. The extent to which extreme cold or warm temperatures affect bison movements has yet to be fully explored.

Compared to cattle, bison are more efficient at digesting forage low in crude protein and high in fibre (Peden *et al.* 1974; Richmond *et al.* 1977; Hawley 1987). Maximum digestion of a limited, low quality food supply allows metabolism to shift from growth to maintenance during winter as a survival mechanism (Fortin *et al*. 2003; Hecker *et al*. 2021b).

Wood bison have longer limbs than plains bison (McDonald 1981), which provides an advantage in deep snow. Of all North American ungulates, bison have the greatest sexual dimorphism in foot loadings, with females much lighter than males (Telfer and Kelsall 1984). Relatively low foot loading gives females an energetic advantage over males in movement over wind-packed snow. Separate winter ranges allow wider use of habitat and less grazing pressure on forage resources. When snow is deep, bison save energy by making trails, switching to higher biomass sedge meadows and coordinating cratering activities (Van Camp 1975). They can also browse tall shrubs and saplings above the snow line.

According to Allen (1877a), bison are quite physically adept at leaping down precipitous banks of ravines and rivers when thirsty or being pursued and are equally capable of climbing the same steep slopes. Otherwise, bison trails usually follow the gentlest grades and most direct courses.

Interactions

Conspecifics

Bison are gregarious animals and splitting and regrouping of herds is quite common (Fuller 1960). Egerton (1962) doubted any fixed dominance hierarchy in wood bison because of the instability of the herd units. Cows with calves, yearlings, and young bulls typically occur in large, mixed herds. Except for during the breeding season, bison bulls roam alone or in small temporary groups. In their analysis of radio tracking data, Chen and Morley (2005) found bison in Wood Buffalo National Park to have a pronounced fidelity to subpopulations and strongest cohesion and coordinated movements during summer.

Komers *et al*. (1993) observed that males were often more solitary with advancing age. As female groups frequently join others and split, males may encounter many potential mates by remaining with a group. Cows with calves tended to aggregate, possibly because of similar high nutritional demands, and as a defence against wolves.

Because large groups should deplete food faster than small groups, conspecific competition for food resources is positively related to group size. However, winter foraging with an increasing number of conspecifics was profitable for bison in Prince Albert National Park, probably because larger groups strengthened their selection for the highly nutritious awned sedge (*C. atherodes*), and the cooperative behaviour of other herd members revealed the location of suitable forage patches hidden beneath the snow (Fortin and Fortin 2009). Furthermore, Courant and Fortin (2012) observed that depression of food intake rate did not seem to have a strong influence on bison departure from meadows, and small groups occupied feeding patches for shorter periods than large groups, even when the biomass of *C. atherodes* remained high. Such movement behaviour may be due to bison perceiving predation risk as higher when in smaller groups and they respond with more frequent travel among numerous food patches over a relatively large area (Fortin *et al.* 2009; Courant and Fortin (2012).

In the Konza Prairie in Kansas, Post *et al.* (2001) found that bison calves had the highest quality diets of all groups in the population, and mature bulls had the poorest diets. Bulls could compensate for the low energy food by consuming greater amounts, and this would reduce competition for higher quality forage that was more vital to the calves and lactating females.

Descriptions of social organization of wood bison may be found in Soper (1941); Fuller (1960); Calef and Van Camp (1987); Chowns (1987); Larter and Gates (1990); Carbyn *et al.* (1993); and Komers *et al.* (1993). Wood bison form post-calving aggregations in June and July with the largest groups occupying the most open habitats. With the onset of rut in mid-July, the herds fragment into smaller groups and larger herds do not begin to reform until early winter.

Competitors

Two species are considered to be in competition when the presence of one leads to a reduced population of the other. Although wood bison often share the landscape with moose, elk (*Cervus elaphus*), woodland caribou (northern mountain and boreal ecotypes), white-tailed deer, mule deer (*Odocoileus hemionus*) and possibly the stone subspecies of mountain sheep (*Ovis dalli stonei*), there is less congruency at finer habitat scales. Little dietary overlap exists between wood bison and these other species (Gogan *et al*. 2010), except where the bison's diet has a high willow or lichen component, such as in the Mackenzie Bison Sanctuary (Larter and Gates 1991). Willow is the most important food for northern moose, and woodland caribou depend on lichens.

Species may be in exploitative competition for resources or exhibit apparent competition if they share a common predator (Holt 1977). A single prey type limits a predator's numbers by one feedback pathway. Apparent competition, also known as competition for enemy-free space (Holt and Lawton 1994) may occur if the entry of an alternate prey species increases the density of the predator by expanding its resource base.

When there is a choice between two ungulate prey species that range in body size, wolves tend to select the smaller species (e.g., Murie 1944; Mech and Frenzel 1971; Carbyn 1983; Bjorge and Gunson 1989). This may also apply to the choice between bison and smaller ungulates. MacNulty (2002) found that bison in Yellowstone National Park were twice as likely as elk to charge wolves, and elk were five times more likely to be attacked by wolves. He also reported that wolves had a 20% kill success rate when attacking elk, but only 2% success with bison. Garrott *et al.* (2007) found that higher vulnerability and stronger wolf selectivity for elk resulted in an abrupt dietary shift occurring only when elk became very rare relative to bison.

When Soper (1941) carried out his studies in Wood Buffalo National Park during the early 1930s, boreal caribou were distributed mainly in the Caribou Mountains and barely reached the bison range from the west, much the same as it is today. He stated that in years past, presumably when the bison population was extremely small, woodland caribou occurred throughout the bison range. Joly and Messier (2005) suggested that wolves relying on moose (possibly in the Nyarling range where predation on bison was low) would incorporate bison into their diet if they rose to some threshold density and continue until bison reach very low density.

According to Jacobson (1976), Kimble (pers. comm. *in* SARC 2016: 90), and Calef (1984), woodland caribou and moose were abundant, and wolf numbers were very low on the bison range in the 1960s and 1970s. Compared to surveys in 1965 and 1971, woodland caribou and moose populations of the Mackenzie Bison Sanctuary appear to have dropped precipitously to 1987, while the resident wood bison population grew exponentially from a few dozen to 1,718 animals during the same time period (Gates and Larter 1990). A study in the Mackenzie Bison Sanctuary and Mink Lake area provided evidence that wolf populations that are buoyed by high bison densities can destabilize the moose populations and exacerbate their decline (Larter *et al.* 1994). A significant decline in the moose population seemed to be confirmed by Bradley *et al.* (1998) and Bradley and Johnson (2000). A comparison of boreal caribou range (Environment Canada 2011) with wood bison distribution shows that most of the caribou range is apart from the bison areas of occupancy. Boreal caribou avoid areas of high predation risk (Environment Canada 2012) and appear to avoid areas where there are bison (Gunn *et al*. 2004).

In the Nahanni bison range, moose are abundant and are the primary prey of wolves. The bison population may not yet be near the threshold that changes predator-prey relationships and results in a prey switch for wolves.

Predators

The only documented source of predation for bison is wolves. However, Van Camp (1987), Chowns (1987) and Carbyn *et al.* (1993) speculated that black bears (*Ursus americanus*) may also be minor predators. They are very common in meadow habitats during the calving season, presumably because of the availability of fresh green forage. After hibernation, bears need to restore their protein requirements (Schwartz and Franzmann 1991), and these activities overlap with calving bison. Likewise, calving Nahanni bison may be exposed to grizzly (*Ursus arctos*) predation. Reports of grizzly attacks on bison in other parts of North America are rare (Roe 1970; MacNulty *et al*. 2001; Wyman 2002). Wolverines (*Gulo gulo*) have never been implicated as a predator, but they occur in bison habitat and can kill other young ungulates.

Changes in habitat use, vigilance, foraging, aggregation and movement patterns are typical anti-predator behaviours. If a predator is effective and a prey population is exploited at a high rate, natural selection on the prey will tend to sharpen its survival mechanisms (Lima and Dill 1990). When predator-prey relationships are near equilibrium, prey has a higher probability of escaping than being killed, unless a vulnerability factor appears that tips the advantage to the predator. The main anti-predator tactics used by bison seem to be fighting off its attacker or flight to heavy timber (Fuller 1960; Calef 1976). Fuller (1960) suggested that bison use the forest to dislodge wolves that have secured a hold by squeezing or crushing them against trees.

Wolves appear to single out a target in a herd which may be attacked repeatedly if the first attempt is unsuccessful (Fuller 1957). Except for the mothers of calves under attack, other members of the herd usually pay little attention to the presence of the wolves (Fuller 1960; Carbyn and Trottier 1988).

Fuller (1966) considered the three classes of bison most vulnerable to predation to be calves, the aged, and the injured. In Yellowstone National Park, Smith *et al.* (2000) observed that wolves killed primarily calves and debilitated older adult bison. A study by Husseman *et al.* (2003), which compared wolf and cougar hunting strategies, found that the longer chases and lower capture success of wolf packs had a stronger culling effect on disadvantaged prey than did ambush hunting by cougars. Selectivity for weakened prey may be due to the victim's slower avoidance behaviour, decreased awareness, reduced stamina, and possibly visual, scent, or behavioural cues (Wild *et al*. 2011). For example, bison suffering from disease-induced lameness should be more vulnerable to wolves (Tessaro 1989; Tessaro *et al.* 1992).

Following observations of bison in Prince Albert National Park, Fortin *et al.* (2009) proposed a *predation risk hypothesis* predicting that large groups provide less per capita danger, frequent movements diminish the predictability of prey location, more frequent inter-meadow movements entail more time spent in the forest matrix, and smaller groups exhibit a weaker selection for meadows. Fortin (2009) noted that bison decreased their selection for *C. atherodes* in risky meadows, but only in winter. Predation risk appeared to be less of a factor foraging site selection in the snow-free season when bison were less vulnerable.

In their Wood Buffalo National Park study from 1979 to 1981, Carbyn *et al.* (1993) observed that wolves focused primarily on herds containing calves, rather than lone bison or bull groups. Carbyn and Trottier (1987) found that anti-predator strategies were more focussed in maternal bison when the calves were young. Defense strategies employed by calves included running to their mothers, a herd, the nearest bull, the front and centre of a stampeding herd, and water bodies. When fleeing from wolves in open areas, cows with young calves took the lead, while bulls often were seen at the rear of the herds. Cows and particularly bulls were sometimes seen defending calves (Carbyn and Trottier 1988).

Bison have a lower morphological index for snow-coping ability than wolves, making them easier for wolves to chase in winter (Telfer and Kelsall 1984). Sheppard *et al*. (2021) found that Ronald Lake bison movements during the first 75 days of winter snow accumulation decreased to a mean daily winter movement rate of 2 km/day. Such limited range of movement likely enable bison to be highly predictable as prey.

Because group size varies according to bison abundance, Carbyn *et al.* (1993) found that wolves could be encountering a stable number of bison groups, but smaller groups as bison numbers decline. If the functional response of wolves is related to the number of bison groups and not the number of individual bison (Huggard 1993), the killing rate would be expected to stay high until bison reach very low numbers.

Wolf packs in bison range often have overlapping territories and some packs seem to be tolerant of others (Van Camp 1987; Carbyn *et al.* 1993). These may be adaptive mechanisms to deal with the spatial behaviour of bison, as a wolf-bison predator-prey relationship may be less constrained by territorial behaviour.

During wolf studies in Wood Buffalo National Park from 1951 to 1952, Fuller and Novakowski (1955) discovered the pup to adult ratio to be 1 to 4 instead of 3 to 1 as would be expected. They suggested this to be indicative of a depressed wolf population suffering significant losses of young in the first six months, probably due to disease. Growth of the Park's bison population in the late 1990s may have been an indication that the wolf population had declined, possibly because of disease or reduced prey availability (Joly and Messier 2004b).

While studies of predator-prey interactions have focused on the demographic effects of wolves killing bison, *risk effects* on bison have never been examined. Risk effects may become apparent when prey alter their behaviour in response to predators (e.g., Boonstra *et al.* 1998). Although anti-predator strategies counter direct mortality, they may also carry costs that have adverse impacts on prey demography. Preisser *et al*. (2005) listed some of these costs as reduced energy income, energetic investment in defensive structures, lower mating success, increased vulnerability to other predators, and emigration.

Hematophagous Arthropods

Hematophagous (blood-feeding) dipteran insects, like horse flies (*Tabanidae*), black flies (*Simuliidae*), mosquitoes (*Culicidae*), and sand flies (*Ceratopogonidae*), have specialized piercing mouthparts, and a multitude of these species torment wood bison. The short summer pelage of bison leaves them particularly vulnerable to these flies breaking their skin barrier (Meagher 1973). Flies may also be vectors for secondary pathogens (Haigh *et al*. 2002). Besides the injury and blood loss due to the bite, adverse effects on bison from these insects also include behavioural and immunological responses to insect attack that are costs to fitness (Benedict and Barboza 2022).

Although all these pests harass and inject toxins, black flies appear to have the most overwhelming effects on hosts. Many species of this insect attack large ungulates including bison, but Currie (2014) considered the vampire black fly (*Simulium vampirum*), a member of the *Simulium arcticum* species complex, to be the most noteworthy. Severe outbreaks in northeastern Alberta were responsible for underweight cattle, sterile bulls, unbred cows, under-nourished calves, and hundreds of mortalities in some years before chemical controls were implemented (Haufe 1980; Khan 1980). Larval stages of *S. vampirum* occur in large silty rivers of the NWT and northern Alberta (Adler *et al*. 2004).

Any physiological adaptations bison might have that allow for greater tolerance of flies remain undescribed. Meagher (1973) suggested that hematophagous flies have a greater effect on the movements and distribution of Yellowstone bison than breeding or foraging activities. Bison forage less and spend more time lying down, standing, grooming, and wallowing as fly activity increases (Melton *et al*. 1989, Mooring and Samuel 1998a, McMillan *et al*. 2000).

In the Mackenzie Bison Sanctuary, Melton *et al*. (1989) observed that hematophagous flies were more prevalent in open habitats. Bison reduced feeding when severely pestered, and increased standing during the windiest conditions may have been related to alleviation of insect harassment. As open habitats offer the greatest exposure to wind, Calef and Van Camp (1987) suggested that large post-calving concentrations in open habitats around Hook Lake may be the result of bison seeking relief from insect harassment.

Wallowing commonly consists of bison lying down and rolling repeatedly onto their sides, repeated forward lunging, and neck, belly and face rubbing (McHugh 1958; Lott 1974; Reinhardt 1985; McMillan *et al*. 2000). Soper (1941) and Lott (1974) suggested that wallowing behaviour in bison alleviates distress from biting insects. A study by McMillan *et al*. (2000) found that among all plausible explanations for wallowing, only seeking relief from biting insects was consistent with both the annual and daily patterns associated with this activity.

Winter tick (*Dermacentor albipictus*) is an arachnoid ectoparasite that attacks ungulates (mainly cervids) across North America, including in the NWT (Chenery *et al*. 2023). It causes anemia, depletion of visceral fat reserves, and weight loss most seriously in moose and elk, while severe loss of winter hair (alopecia) from intense grooming escalates heat loss and fat depletion (Mooring and Samuel 1998a, 1998b). Bison and deer species share a long history with winter tick seem to have evolved a grooming behaviour programmed to remove these ectoparasites before they blood-feed (Mooring 2024). As late immigrants via Beringia with relatively short exposure to North American parasites, moose lack this behavioural mechanism, and their reliance on direct irritation from tick bites to stimulate grooming is an inefficient defense (Mooring and Samuel 1998a). Grooming behaviour and dense pelage of bison are adaptations that moderate tick infestations, as plains bison in Elk Island National Park harboured lower tick densities than sympatric moose, elk, and white-tailed deer (Mooring and Samuel 1998c).

Humans

Interactions with humans include hunting and collisions with vehicles. Wood bison are also subjects of biological study and enjoyed by the viewing public. Detection of human scent is one of the greatest stimuli to cause the flight reaction in bison (Fuller 1960). Nevertheless, bison easily become habituated to human presence and infrastructure when not being harassed, and often must be removed from communities. Bison have displayed a tendency to congregate along roads from the time they were first constructed through bison ranges (Fuller 1960) and continue to be a traffic hazard in many areas (CMA 2025). Bison also utilize cutblocks and linear roadways cut in forested areas in the Liard valley of the NWT and British Columbia (Larter pers. comm. *in* SARC 2016: 87).

Calef (1976) reported that the reaction of bison to aircraft was highly variable. At normal survey altitudes, some groups began to run away when aircraft were as much as two miles (3.2 km) away. Others did not move until circled or approached at low altitude. Some groups ran for long distances and others stopped after the aircraft headed away. Calef (1976) also observed that bison reaction to land vehicles was variable and the animals quickly settle down when not being pursued. Humans walking or on horseback could usually approach within 400 m using tall grass and willows as a screen.

PLACE

Distribution

McDonald (1981) surmised the time when the unique lineage of wood bison originated to be about 5,000 to 4,000 years before present. According to archaeological discoveries, historical records and traditional knowledge, the original range of wood bison included the interior sedimentary plain north of the North Saskatchewan River in the NWT, British Columbia, Alberta, and Saskatchewan, as well as large areas of the northern cordillera in the NWT, British Columbia, Yukon and Alaska (Hind 1860; Allen 1877a; Rhoads 1897; Van Zyll de Jong 1986; Gates et al. 1992a; Lotenberg 1996; Stephenson et al. 2001), as shown in Figure 17.

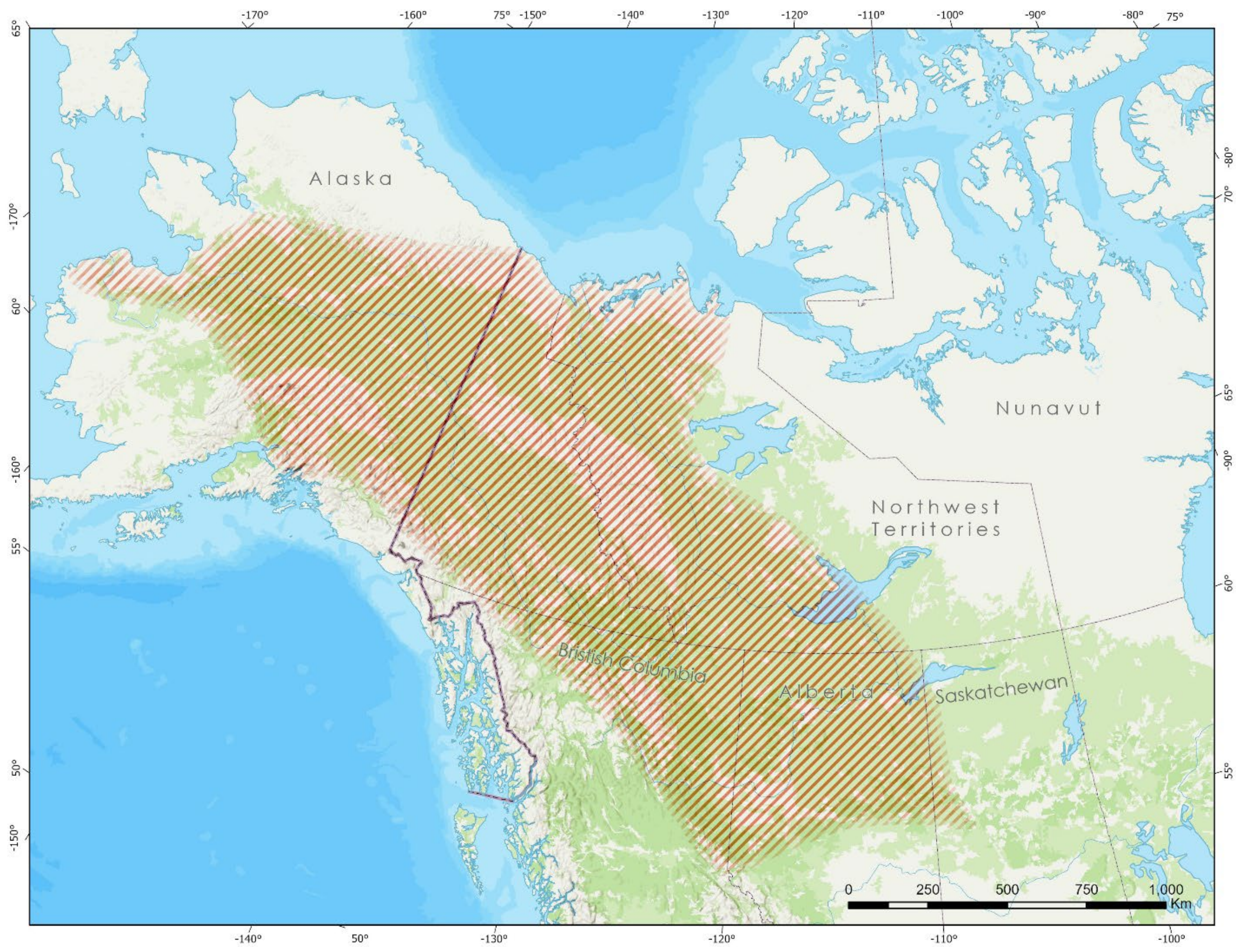


Figure 17. Estimated continental distribution of wood bison over the last 5,000 years, with present day boreal forest represented in green. Map by B. Fournier, based on Stephenson *et al.* 2001.

The current continental distribution of all free-roaming populations of wood bison, as well as the captive herd at Elk Island National Park Isolation Area, are shown in Figure 18. All populations presently occur within, or have originated from, the Greater Wood Buffalo metapopulation. This metapopulation straddles the NWT-Alberta border and is made up of several intermixing subpopulations. To date, seven Canadian reintroductions have been carried out in the NWT, Yukon, British Columbia, Alberta and Manitoba. The first occurred in 1963 when 18 bison were released north of the Mackenzie River near Fort Providence (Novakowski 1963b). Next, the Nahanni population was established near Nahanni Butte and Fort Liard with 28 bison in 1980, augmented in 1989 with 12 and 1998 with 59 bison (Larter and Allaire 2007; ENR 2019).Animals from the Nahanni population have since spread into southeastern Yukon and northeast B.C. (Larter 2021).

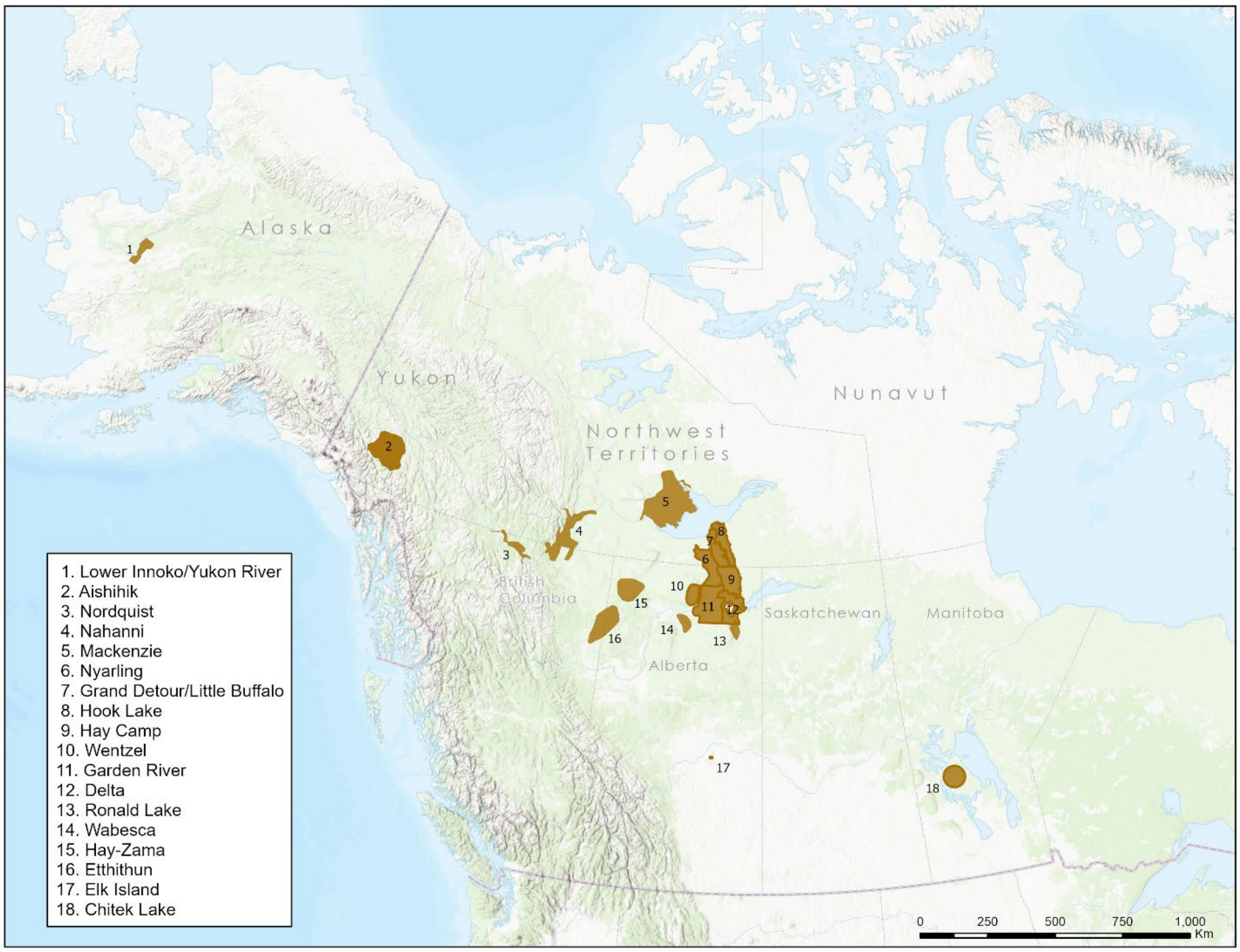


Figure 18. Current continental distribution of wood bison. Map by B. Fournier.

From 1988 to 1992, 170 bison were released at Nisling River, Yukon, and now this population ranges primarily around Aishihik Lake (Jung *et al*. 2012; Miller *et al*. 2023). In northeastern B.C., 49 bison were reintroduced near Aline Lake on Nordquist Flats. Members of this herd also penetrate southeastern Yukon (Harper *et al.* 2000; Thiessen 2010). Another B.C. attempt at Etthithun Lake initially failed because these wood bison joined a herd of feral plains bison, and the mixed herd was recaptured (Harper *et al.* 2000). A successful wood bison population was established at Etthithun Lake after 43 animals escaped prematurely in 2002 (Nishi 2017). This population has since extended its range into northwestern Alberta (Rowe and Backmeyer 2006; Nishi 2017; Lewis and Das Gupta 2021).

In 1993, wood bison being acclimated near Habay in northwestern Alberta also escaped prematurely and became a free-roaming herd in the Hay-Zama Lakes area (Nishi 2017).

From animals raised in captivity for commercial purposes at the Skownan (Waterhen) Wood Bison Ranch in Manitoba, 13 bison were released in 1991 at Chitek Lake (located between Lake Winnipeg and Lake Winnipegosis) which was supplemented by an additional nine bison in 1996 (Stock 2005).

After more than a decade in captivity at the Alaska Wildlife Conservation Center, Alaska released 130 wood bison into the wild in the Lower Innoko-Yukon River area in 2015, establishing the first population of wood bison in the United States in at least a century (Alaska Department of Fish and Game 2015).

To introduce the *Bison* genus to northeastern Siberia after steppe bison (*Bison priscus* Bojanus 1827) disappeared from the region during the early Holocene, four groups of 30 wood bison were shipped to the Republic of Sakha (Yakutia), Russia, between 2006 to 2020. Between 2017-2018, 60 of these bison were released in the Sinyaya River basin (Shadrina *et al*. 2022).

NWT Distribution

Up to the 1500s, wood bison occurred across much of the western NWT and possibly as far north as the Arctic coast (Harington 1990). There are currently three populations of wood bison in the NWT: the Mackenzie and Nahanni populations, and the Greater Wood Buffalo metapopulation, which consists of several intermixing subpopulations in and around Wood Buffalo National Park in the NWT and Alberta (Figure 19).

In 1987, a bison-free management zone (Bison Control Area) was established south of the Mackenzie River and north of the Mackenzie Highway, between Mills Lake and Hay River, to prevent movement of brucellosis- and tuberculosis-infected bison from the Greater Wood Buffalo metapopulation into the ranges of the Mackenzie and Nahanni populations (Figure 19). In 1990, the control area was greatly expanded to the Alberta border, between Trout River and Wood Buffalo National Park (Gates and Gray 1992). Since then, the control area has been searched several times per year, by ground and by air, for the purpose of removing bison that could potentially infect the disease-free herds. The BCA is managed and operated by the GNWT and has been jointly funded by Parks Canada Agency and the GNWT since 1993 (CMA 2019).

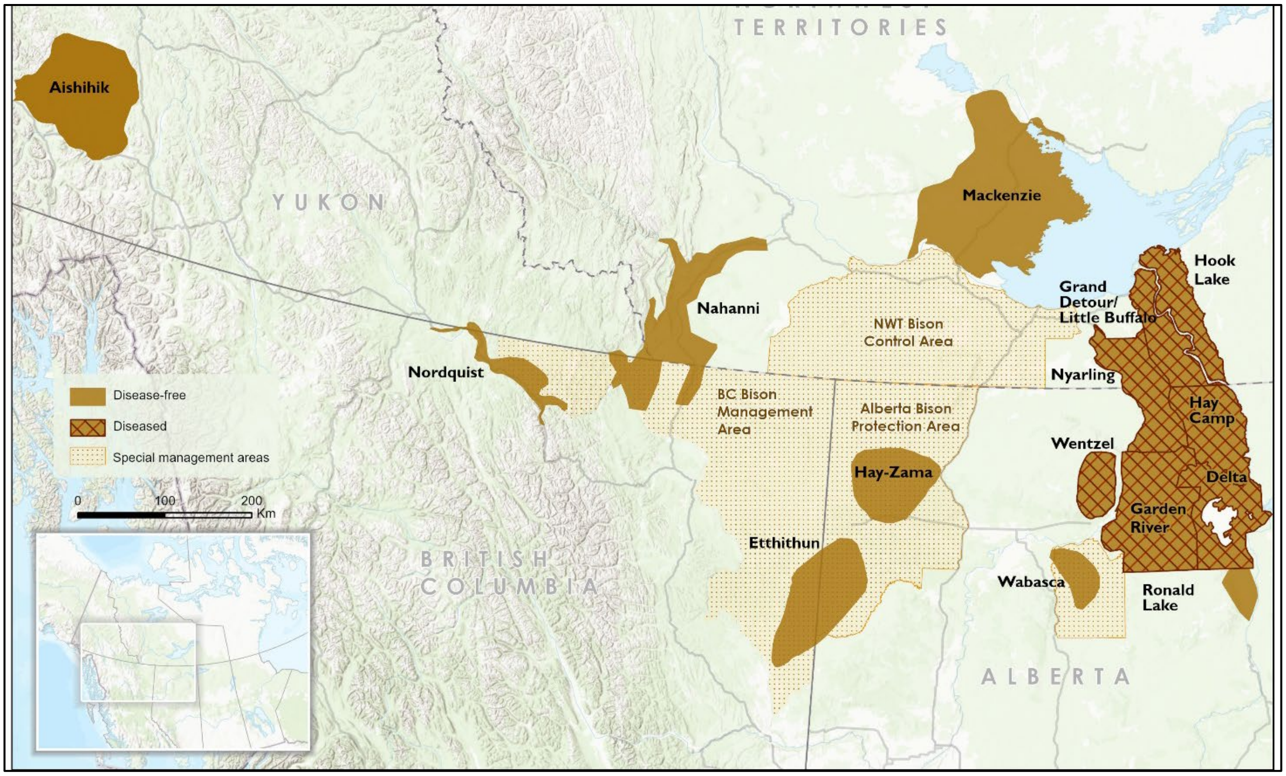


Figure 19. NWT wood bison distribution and adjacent herds. Wood bison have also been observed outside core ranges. Map by B. Fournier.

The Greater Wood Buffalo metapopulation (Figure 20) includes three subpopulations that primarily range into the NWT. Most of the Nyarling River subpopulation may be found in the NWT within the boundaries of Wood Buffalo National Park. There are also two herds that occupy the Slave River Lowlands, both inside and outside the park. The Slave River Lowlands are alluvial plains surrounding the lower Slave River between the rapids at Fort Smith and Great Slave Lake, extending from the eastern escarpment west of the Little Buffalo River to the Precambrian Shield east of the Taltson and Tethul rivers (Day 1972; Reynolds 1987; Vanderburgh and Smith 1988).

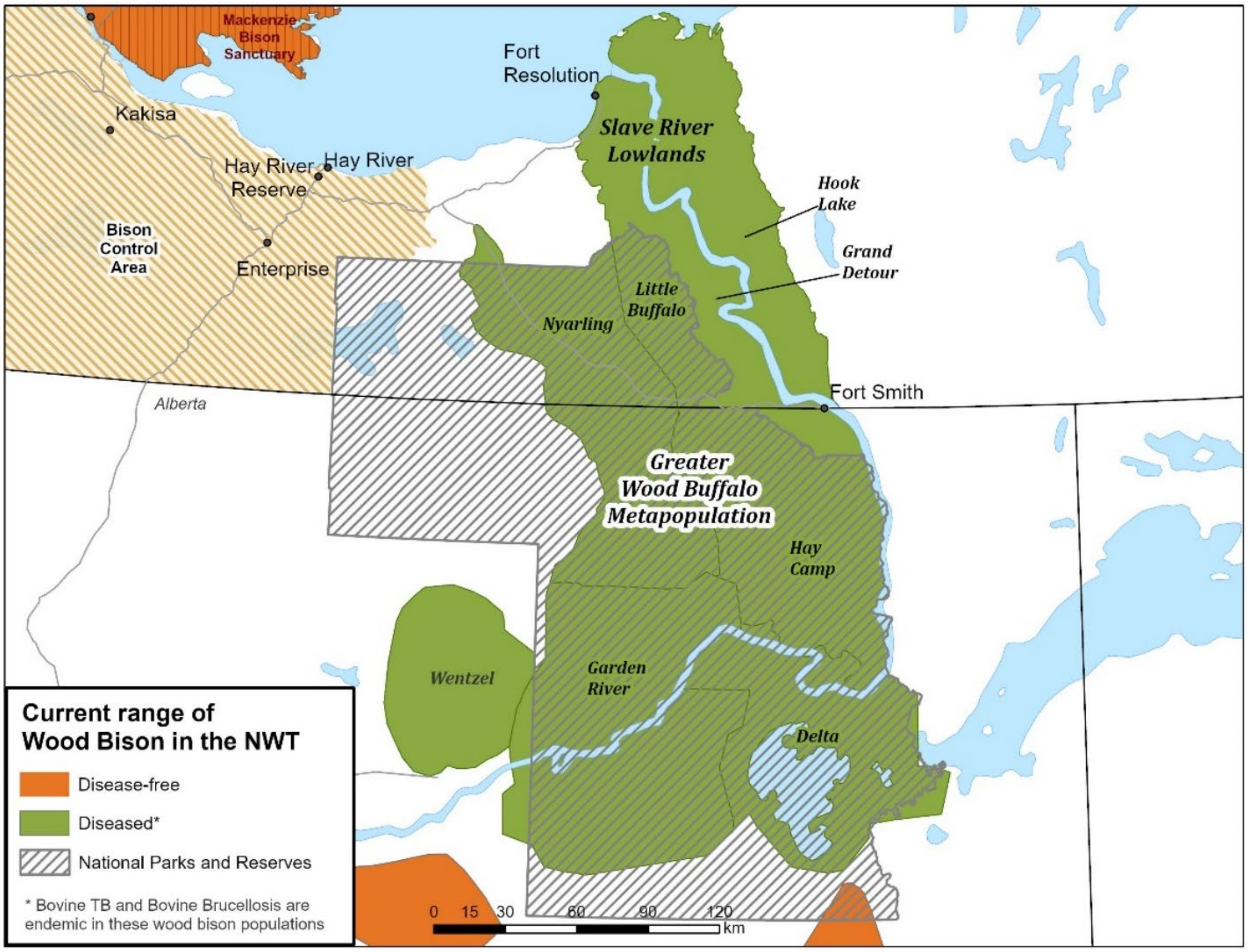


Figure 20. Distribution of wood bison subpopulations of the Greater Wood Buffalo metapopulation. Map by N. Wilson, GNWT.

The Hook Lake subpopulation occurs east of the Slave River and is outside of the park, while the population west of the river is surveyed by both the Government of the Northwest Territories Department of Environment and Climate Change (GNWT-ECC; known as Grand Detour) and Parks Canada (known as Little Buffalo). Figure 21a shows the survey area of the Slave River Lowlands designed by GNWT-ECC, including both the Grand Detour and Hook Lake herds. Figure 21b shows the survey area designed by Parks Canada for the Little Buffalo range, covering the area west of the Slave River both inside and outside of the park (2003-present).

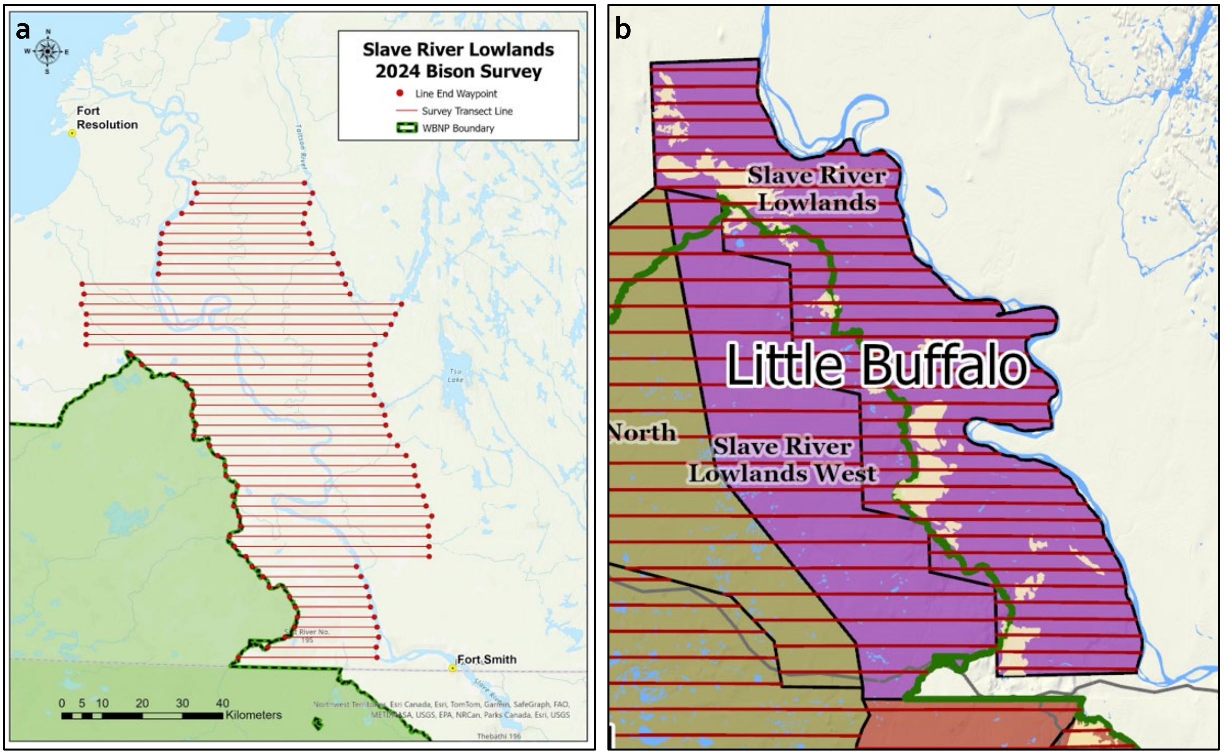


Figure 21. Survey transect lines for wood bison population surveys in the Slave River Lowlands. Surveys designed by (a) GNWT-ECC, including the Hook Lake and Grand Detour subpopulations; and (b) Parks Canada, for Little Buffalo subpopulation.

Understanding the historic range of wood bison in the NWT helps us understand where potential habitat may currently exist. Although historic range of wood bison is well understood in many areas, perimeter of the range is very uncertain away from the main corridors of human travel. Martin *et al*. (2023: 9) described limitations in determining extent of occurrence of bison in North America since 1500. "For example, sampling biases of historical ecology is limited to presence-only of colonial explorers. Some of these sampling biases are balanced by the presence of archaeological and fossil remains, but the northern and eastern fringes of this range may appear less dense in these geographically expansive regions due to preservation biases resulting from acidic soils in these regions and/or discovery biases due to sparse human presence and activity. A dearth of records from historical encounters between humans and bison does not necessarily mean absence of bison in this territory, merely a paucity of the types of evidence used in this study. Moreover, additional evidence forms may be applicable for future studies, including [...] integrating Indigenous traditional ecological knowledge to further understand historic dynamics of the bison range."

As discussed below under *Habitat Requirements*, wood bison appear to have an affinity for the soils of glacial lake basins after waters recede. These lakes partially stabilized at several levels as they changed their size, shape, and location repeatedly due to glacial ablation, breeched blockages, and isostatic rebound of the earth's crust (Lemmen *et al*. 1994; Brown 2012). Figure 22 shows historical bison records from the NWT portion of the upper Mackenzie basin in relation to where the perimeters of McConnell, Mackenzie, Tetcela, and Liard glacial lakes likely stabilized sufficiently to maximize future benefits for bison, adapted from Cameron (1922), Craig (1965), Day (1966), Ford (1976), Rostad *et al*. (1976), Crosbie (1978), Rutter and Boydell (1981), Piet (1992), Smith (1992), Lemmen *et al*. (1994), Smith (1994), Bednarski (2008), Brown (2012), and Ford (2017). For more information on details of historical bison records refer to *Appendix A4 – Search Effort*.

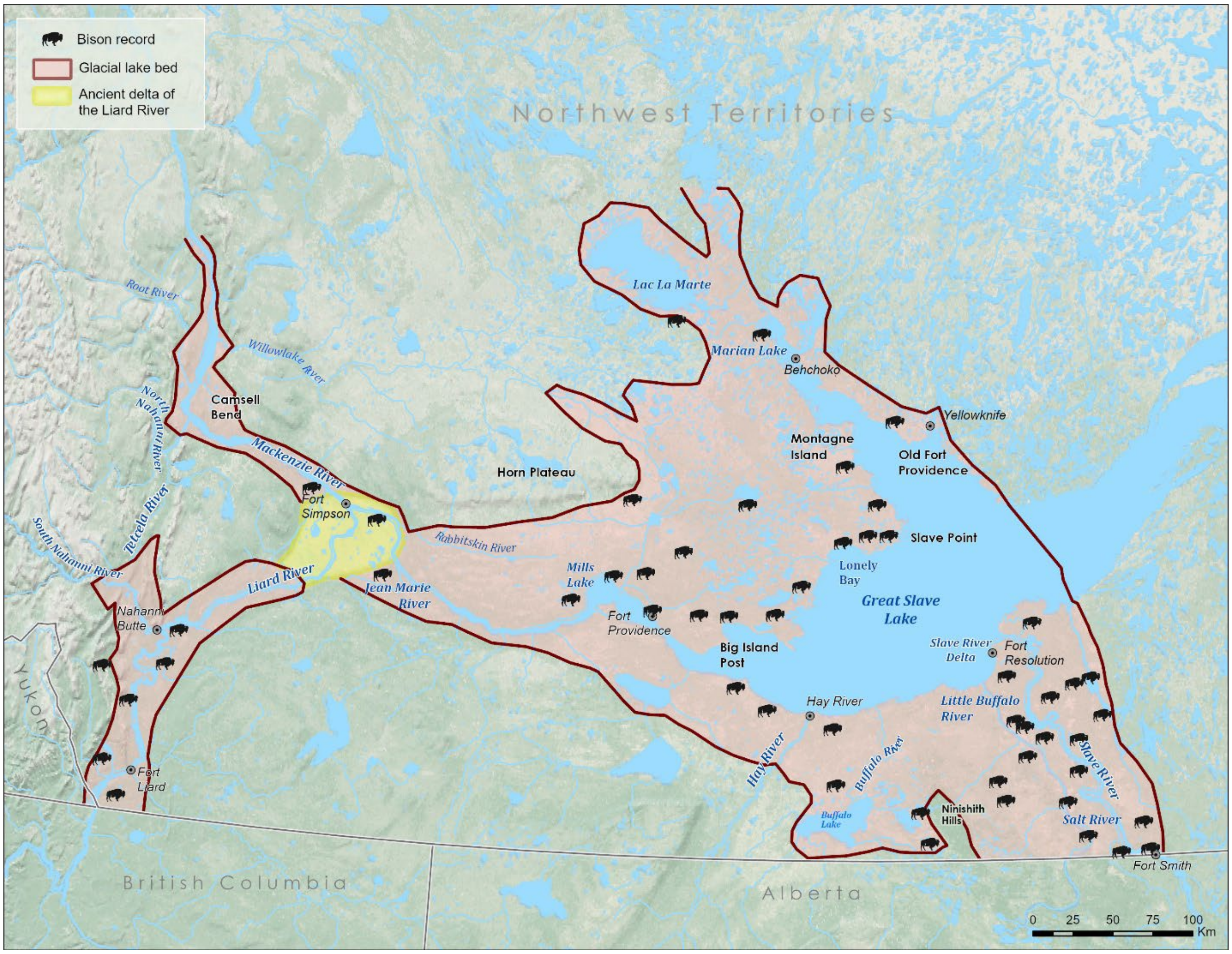


Figure 22. Historical records from late 1700s to approximately 1900 of wood bison and area of glacial lakebasins (McConnell, Mackenzie, Tetcela, and Liard) within the upper Mackenzie drainage of the NWT. Each bison icon represents a general location described in the following sources: Turnor (1792), Fidler (1792), Hearne (1795), Mackenzie (1801), Simpson (1821), Wentzel (1821), Wentzel (1822), Franklin (1823), Sabine (1823), Richardson (1829), McGillivray (1829-30), King (1836), Richardson (1851), Allen (1877b), (Pike 1892), Ogilvie (1893), Jarvis (1897), Rhoads (1897), Russell (1898), Macrae (1901), MacFarlane (1908),

Routledge (1908), Preble (1908), Perry (1909), Radford (1911), Blanchet (1926), Lafferty pers. comm. (1985), Allaire pers. comm. in SARC (2016). Map by B. Fournier.

Ranges

For wood bison in the NWT (encompassing the Greater Wood Buffalo Metapopulation, Mackenzie and Nahanni populations), Figure 23 shows Extent of Occurrence and Area of Occupancy. SARC (2022) defines the *Extent of Occurrence* (EO) as "the area included in a polygon without concave angles that encompasses the geographic distribution of all known populations of a species." EO of NWT wood bison is approximately **159,392 km²**, calculated using a single minimum convex polygon around all three populations and subtracting the area of the polygon that occurs outside the borders of the NWT.

SARC (2022) defines the *Area of Occupancy* (AO) as "the area within the EO that is occupied by a species, excluding cases of vagrancy. The measure reflects the fact that the extent of occurrence may contain unsuitable or unoccupied habitats." AO of NWT wood bison is approximately **46,499 km²**. This was calculated by summing the area totals of polygons drawn around each of the three NWT wood bison populations and subtracting the areas of the polygons that occur outside the borders of the NWT.

SARC (2022) defines the *Index of Area of Occupancy* (IAO) as "a measure that aims to provide an estimate of area of occupancy that is not dependent on scale. The IAO is measured as the surface area of 2 x 2 km grid cells that intersect the actual area occupied by the wildlife species (i.e., biological area of occupancy)." IAO of NWT wood bison is approximately **50,352 km²**.

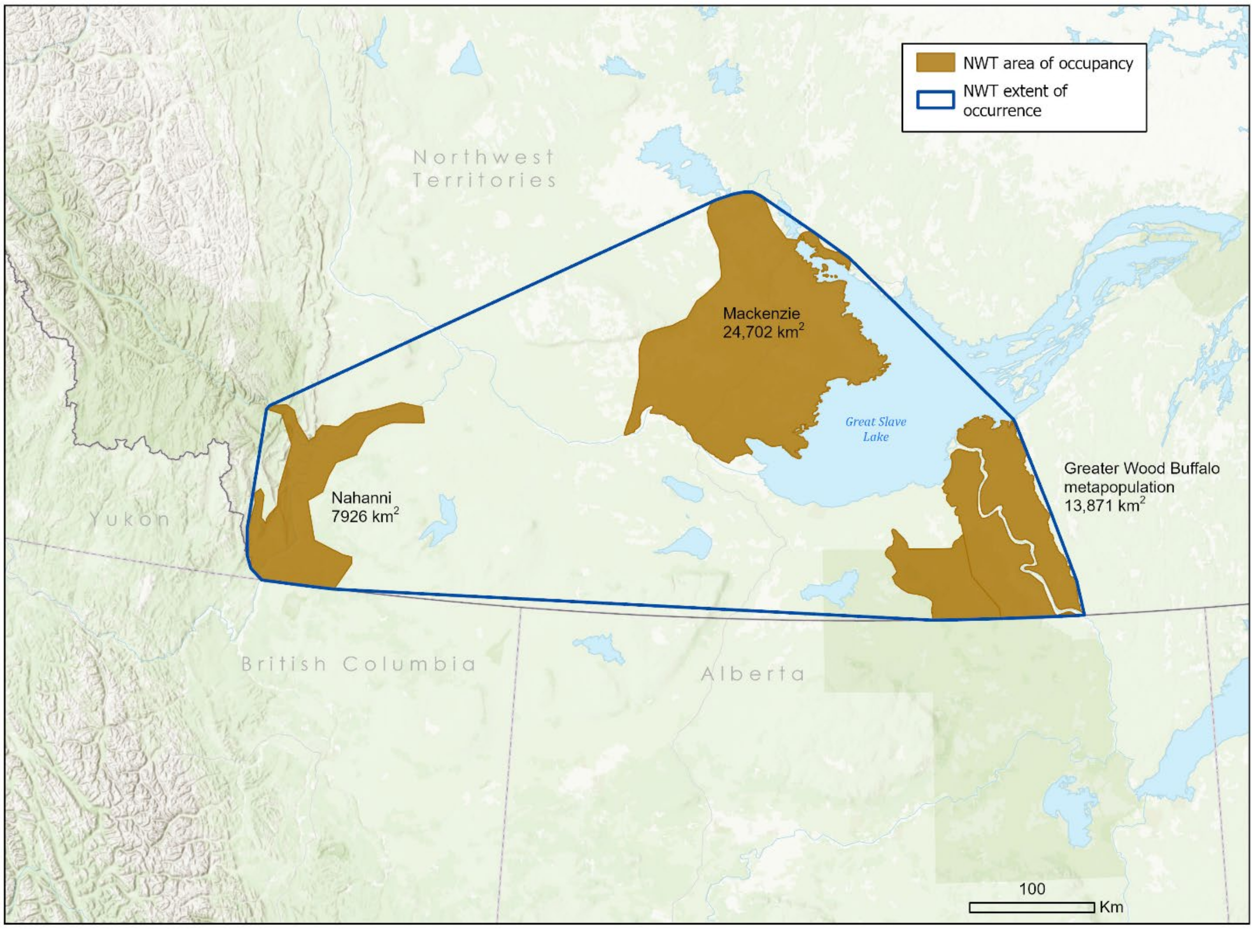


Figure 23. Extent of Occurrence (EO) and Area of Occupancy (AO) for NWT wood bison populations. Map by B. Fournier.

Locations

SARC defines *location* as "a geographically distinct area in which a single threatening event can rapidly affect all individuals of the species present. The size of the location depends on the area covered by the threatening event and may include part of one or many subpopulations. Where a species is affected by more than one threatening event, location is defined by considering the most serious plausible threat." (SARC 2022)

For the Greater Wood Buffalo metapopulation and the Mackenzie population, the most important threatening event is disease (anthrax). For the Nahanni population, a mass drowning event is the most important threatening event, as bison periodically perish in the Liard River and fall through the ice on creek draining Fish Lake (Larter and Allaire 2013). Because these three populations are geographically isolated from one another, each of their ranges represent a separate location. The entire ranges of the Greater Wood Buffalo metapopulation (with its interconnected subpopulations) and Mackenzie population constitute the potential areas in which an anthrax event could occur, because outbreaks of the disease within bison ranges are unpredictable. The area of the Liard and Nahanni rivers within the Nahanni bison range constitutes the potential area covered by a mass drowning location.

Search Effort

By the early 2000s, GPS and tracking with onboard laptop computers were advances in technology that aided in the prevention of double counting. Attempts described below have been made to remedy the problem of inconsistent survey effort that has been recognised in the historical datasets of all three NWT wood bison populations.

The Slave River Lowlands were not surveyed for bison from 2000 until 2009. In 2009, the survey method was changed from attempting to achieve total counts to a sample count that could estimate a confidence interval along with the abundance estimate using transects at fixed intervals (Armstrong 2011). The 2009 Slave River Lowlands survey of the Hook Lake and Grand Detour subpopulations was coordinated with Wood Buffalo National Park's bison survey. The ranges of these two subpopulations are fairly well-defined within the Slave River Lowlands. Searches rarely cross the Taltson River. Although bison have occasionally been reported on the Precambrian Shield, east of the Taltson (Ogilvie 1979), it contains little potential habitat (Armstrong pers. comm. 2012).

As the Mackenzie population became too large and dispersed to rely solely on total counts, the study area was stratified into high, medium and low density units (Gates *et al.* 1991). The high density stratum consisted of the main meadows where bison concentrated, and which were also still covered by total counts. Systematic parallel transects covered medium and low density strata between areas of high density. Since the first Mackenzie bison anthrax outbreak in 1993 (Gates *et al.* 1995), regular searches have been carried out in the summer season for carcass detection and disposal (CMA 2025). The 2013 re-survey of the Mackenzie population following an anthrax outbreak in the summer of 2012 utilized distance sampling, a survey technique particularly useful for estimating wildlife abundance in forested areas (Armstrong 2013b). Distance sampling collects data on the distances of the animals from randomly placed lines (Buckland *et al.* 2001).

A biological program for the Dehcho Region was established in 2002, which included more regular monitoring of the growing Nahanni bison population (Larter and Allaire 2007). In 2003, information from local residents and the governments of British Columbia and the Yukon on bison distribution was added to the knowledge base for compilation of a map of the winter range of the Nahanni bison population. Because most of the Nahanni population's winter range is forested, with major river drainages, mountains and deep valleys bisecting it, bison were equipped with satellite collars to determine a sightability correction factor and improve the delineation of the search area for future surveys (Larter and Allaire 2013).

Since 2012, Mackenzie surveys have used distance sampling (Armstrong pers. comm. 2025), a census technique particularly useful for estimating wildlife abundance in forested areas that collects data on the distances of the animals from randomly placed lines (Buckland *et al*. 2001). Potential areas of expansion for these animals include historical range around the Horn Plateau, Lac La Martre, and these areas are occasionally searched by aircraft (Armstrong pers. comm. 2025).

The Tłįchǫ Highway (NWT Highway 9) is a 97-km, all-season road connecting the community of Whatì to the Yellowknife Highway (NWT Highway 3) that opened in 2021. Since December 2021, the new road has been patrolled five to seven times per week by Tłįchǫ Highway Monitors who record bison and other wildlife observations (Steinwand *et al*. 2025).

Reports from the Taiga Shield east of the North Arm of Great Slave Lake are mainly from highway travelers and this area contains some habitat, mainly near the lake (Armstrong pers. comm. 2025).

For more information on historical search effort, refer to *Appendix A4*.

Distribution Trends

Originally, all wood bison in the NWT and adjacent areas probably existed as one extensive metapopulation (Roe 1970; Reynolds *et al*. 2003). Declining populations through the 19th century coincided with range retraction to a core area north of the Peace River and west of the Little Buffalo and Salt rivers (Seibert 1925). In the NWT, it appears the Nyarling River subpopulation of the Greater Wood Buffalo metapopulation has always been intact. Bison that moved from Wood Buffalo National Park to the western Slave River Lowlands (Grand Detour/ Little Buffalo subpopulation) in the early 1930s (Soper 1941) and continued across the Slave River to the eastern Slave River Lowlands (Hook Lake subpopulation) in the late 1930s or early 1940s (Fuller 1950) quickly reoccupied their former range.

After its reintroduction in 1963, the Mackenzie population has been undergoing range expansion to the west and north. Bison became well established in habitat east of Mink Lake after a fire in 1980. Frequent fires had been maintaining these sedge-grass meadows. Mills Lake was occupied a few years later. Before the 1994 fire north of Lonely Bay, a few bison had wandered to some of the marl lake beds in that area. The fire enhanced movements from core areas in the south and facilitated further range expansion northward into unoccupied habitat (Chowns 1996). Until 1995, bison seldom wandered west of Mink Lake, even though there had been frequent fire in the past and unforested tracts were very widespread. After an extensive fire that summer, bison surged into this new habitat, and it was soon occupied by hundreds of animals. Even while the plains west of Mink Lake were still largely devoid of vegetation, large numbers of bison were very attracted to this open habitat (Chowns 1997).

In December 2021, the Tłı̨chǫ Highway opened, connecting Whatì to the NWT highway system by all-season road. Yearly distribution data has shown that bison are moving further north along the highway corridor and have appeared at the Lac La Martre River (Behrens pers. comm. 2024; Steinwand *et al.* 2025).

The Nahanni population was reintroduced into part of its former range near Nahanni Butte in 1980 with 28 animals being released. This founding population fragmented and dispersed widely into northeastern British Columbia. Augmentations of 12 animals in 1989 near Nahanni Butte and 59 animals in 1998 near Fort Liard bolstered the population along the Liard Valley between the two communities (Larter and Allaire 2007).

Movements

Wood bison movements may best be described as nomadic (Soper 1941). Bison are very faithful to core areas and at a finer scale they have seasonal preferences. Although Ronald Lake bison have been moving seasonally out of their core range into upland meadow calving areas at the base of the Birch Mountains (Buitrago Gutierrez 2024), seasonal movements at this scale have never been reported in the NWT. During historic times, large scale movements of bison herds could be controlled by Indigenous people by alternately greening and burning traditional hunting grounds (Pyne 1997).

For feeding, wet meadows are more accessible in winter than in other seasons when the substrate is frozen (Larter 1988; Belanger *et al*. 2020; Hecker *et al*. 2023). Also, taller sedges allow snow to fall through and form a less compact cover than on the shorter grasses of dry meadows (Carbyn *et al*. 1993). Wood bison decrease movement rates to conserve energy in deep snow (Sheppard *et al*. 2021). Drier sites contain green forage that is most digestible in spring and summer. In late summer and autumn, smaller groups disperse through the forest (Larter 1988).

Some movements may be stimulated by predation, insect harassment, adverse snow conditions or flooding. Carbyn *et al.* (1993) tracked a bison herd in Wood Buffalo National Park that moved for 86 km after a wolf attack. In Yellowstone National Park, bison shifted feeding sites when snow depth exceeded 127 cm (Meagher 1971). Calef and Van Camp (1987) observed a southward movement from normal winter range in the Slave River Lowlands after a snowstorm was followed by freezing rain. In Prince Albert National Park, bison avoided areas of high snow-water equivalent in winter (Fortin *et al.* (2009). After flooding of the most important sedge meadows in the Mackenzie Bison Sanctuary reached its height in spring 1992, many hundreds of bison moved to the drier Great Slave Lake shoreline meadows, and at least 44 animals travelled south into the Bison Control Area (Gates *et al*. 1992b). After high water levels in the Peace-Athabasca Delta during the spring of 1997, Joly (2001) documented 22% of collared bison crossing the Peace River northward from the delta, then a return of 14% of them by summer.

Although bison are good swimmers, they are reluctant to enter the Mackenzie River and generally avoid rough ice in winter. In the Slave River Lowlands, bison rarely cross the Slave River, yet some notable traverses have probably occurred (Calef 1976, Calef and Van Camp 1987). In contrast, the Nahanni bison regularly cross the narrower Liard and South Nahanni rivers year-round (Larter and Allaire 2007; Thomas *et al*. 2022a).

Bison rarely embark upon long distance journeys through inhospitable terrain unless they are aware of favourable habitat at their destination (Chowns pers. comm. 2025). They also concentrate their movements along cutlines and highway rights-of-way which are used as habitat and expansion corridors, but they can make bison vulnerable to collisions (Environment and Natural Resources 2010). Joly (2001) tracked one radio-collared animal from Hay Camp to the Grande Detour area of the Slave River Lowlands west of the Slave River, and another from Hay Camp to the Nyarling River area. During the summer 2014, more than 60 bison from the Nahanni herd followed the Liard Highway right-of-way to the Poplar River bridge and frequented the area through the rest of the summer. In 2020, a similar number of bison followed the Liard Highway right-of-way to the Mackenzie Highway right-of-way, then followed it about 30 km north towards the Liard River ferry crossing (Larter (2021). Range expansion usually begins with pioneering bulls (Larter *et al*. 2000).

Habitat Requirements

Most wood bison habitat in the NWT has a very strong association with the dense lacustrine soils (lake bottoms) exposed by the recession of glacial lakes (Raup 1933; Thieret 1959; Gates *et al*. 1992a; Carbyn *et al*. 1998). As the second largest Pleistocene lake in North America, Glacial Lake McConnell covered an immense area containing Great Bear Lake, Great Slave Lake, and Lake Athabasca within its former basin (Cameron 1922; Craig 1965; Smith 1994). Wave action in the ancient lake drew fine clay and silt particles deep into the basin and deposited coarser sand and gravel as beach ridges (Day 1968). Fluvial processes in floodplains of the large river courses sorted soil particles in a similar manner (Day 1966; Day 1972). Dense, moderately impermeable soils flood easily and produce a high biomass of fine fuel loads that can burn frequently, two processes that allow sedges and grasses to have a competitive advantage over woody plants (Raup 1933; Moss 1953). Similar conditions occur where the smaller Mackenzie, Tetcela, and Liard glacial lakes receded (Rostad *et al*. 1976; Smith 1992; Bednarski 2008; Ford 2017).

Food

Meadow vegetation is essential for wood bison to meet their food requirements, usually in the form sedges and grasses, which are most important in winter for providing energy in the form of carbohydrates (Fortin *et al*. 2003; Hecker *et al*. 2021b). In summer, leafy browse contribute the largest proportion of lipids (fatty compounds), and forbs provide the largest proportion of protein to bison diets (Hecker *et al*. 2021a).

Looman (1979) concluded that meadow communities that occur in boreal regions occur on soils with a high water table and are dominated by coarse sedges (*Carex* spp.) and reedgrasses (*Calamagrostis* spp.). Reynolds *et al*. (1978) differentiated dry meadows from wet meadows. However, the boundary between these two types of habitat shifts according to annual precipitation (Smith and La Roi 2005). If lowland meadows become inundated in wet years, higher soil moisture compensates somewhat by boosting sedge-grass production at slightly higher ground. A mosaic of lowland meadow and upland meadows is necessary to ensure adequate forage resources during fluctuating water table levels. Although bison use wet sedge meadows year-round, selection of these habitats is highest in winter (Campbell and Hinks 1983; Larter and Gates 1991; Fortin *et al.* 2003; Strong and Gates 2009; Hecker *et al.* 2021b). Near Fort Providence, Penner (1978) found annual production (dry weight) ranged from 2,535 kg/ha of herbaceous forage in wet meadows to 1,704 kg/ha of herbaceous forage and 116 kg/ha of willow browse in dry meadows.

In the Nahanni area (Larter and Allaire 2007), Slave River Lowlands (Reynolds *et al*. 1978), and Wood Buffalo National Park (Fuller 1966), sedges were found to be the main source of food. In the Mackenzie Bison Sanctuary, the proportion of sedges in the diet was highest in winter and midsummer, while intake of grasses and shrubs increased dramatically during spring green-up (Larter and Gates 1991). Nahanni bison also consume large amounts of horsetails (Larter and Allaire 2007).

Awned sedge (*Carex atherodes*) is the forage species most preferred by bison. Moss (1953) remarked about the wide ecological tolerance of *C. atherodes* as a leading dominant throughout the reed swamp – marsh – wet meadow – low grassland plant communities of northwestern Alberta. It thrives best in areas that are seasonally flooded with shallow water, and neutral to slightly alkaline pH (Jeglum 1971).

Reedgrasses, especially bluejoint (*Calamagrostis canadensis*) and willows are highly preferred by wood bison at certain times of the year. They are also associated with moist, fertile conditions. By late August, forested habitats in the Mackenzie Bison Sanctuary provided superior quality forage for bison with lichen being the most important, comprising about half of the dietary intake by October (Larter and Gates 1991). Coniferous forests, which supplied the greatest biomass of lichen, were heavily used in this period. Larter and Gates (1991) observed forage quantity and quality becoming more homogeneous during autumn when bison dispersed amongst all habitats.

Larter (1988) found that bison used upland habitats more frequently and consumed a greater diversity of forage during the growing season. In the fall, leaves in deciduous forests are a readily available bulking agent (Hudson and Frank 1987). Although wetter soils of lowland habitats provide more forage biomass for bison, they increase the energetic cost of mobility and have less stable footing when not frozen (Karasov 1992; Belanger *et al.* 2020; Hecker *et al*. 2023). According to Strong and Gates (2009), treed habitats in northern Alberta generally produced less than the amount of biomass needed for wood bison to maintain an efficient foraging rate and did not provide adequate nutrition in winter. However, Mackenzie bison disperse into forests from late August until October when these habitats produced superior quality forage (Larter 1988). At sample sites north of Fort Providence, Penner (1978) found annual production of willow browse alone ranged from 2,535 kg/ha in wet sedge meadows, 1,406 kg/ha in willow-shrub, 530 kg/ha in aspen-willow, to 442 kg/ha in willow dominated grassland.

Pyric herbivory has been described by Fuhlendorf *et al.* (2009) as the ecological interaction of fire and grazing, recognizing that bison select forage from recent burns where the nutritive value has presumably increased in response to fire, and heavy grazing removes accumulations of fine fuel biomass which reduces the probability of fire. This interaction creates a shifting mosaic of disturbance patches across the landscape (Fuhlendorf *et al.* 2009). Nutritionally superior burned patches promote selection of all forage species, thereby excessive grazing pressure on the most palatable species is relaxed, favouring their persistence on the landscape (Coppedge and Shaw 1998; Fuhlendorf and Engle 2001).

Water

Historically, drought was a major limiting factor for plains bison as grasses desiccated and drinking water disappeared, and their range may be restricted by the availability of water (e.g. Truett 1996). In summer, plains bison historically moved to water on an almost daily basis, and on occasion thirst motivated long-distance movements over several days (Hornaday 1889, Dary 1989). Selection of habitat patches by plains bison at Prince Albert National Park was influenced by distance to water (Fortin *et al*. 2003). Similar small-scale movements of wood bison may be expected during periods of drought. Although these animals' requirement for forage plants growing in moist conditions usually predisposes them to maintain a proximity to water, the salt plains of the Greater Wood Buffalo metapopulation are left with large areas of brackish water in late summer that bison avoid.

Cover

Cover has generally been defined as vegetation or topography that veils, conceals, shelters, or protects an organism from predators, unfavourable climate, or other adverse conditions. Wood bison habitat is typically interspersed with forest that is used for shelter, resting, ruminating and avoiding biting flies (Reynolds *et al.* 1978). The main anti-predator strategy for bison is to run for dense timber to rid themselves of their pursuers. Fuller (1960) believed that bison have much less chance of success against a wolf (*Canis lupus*) attack in the open.

Sheltered micro-climates appear to be an important factor in selection of winter feeding sites. During cold temperatures and high windchill, Fuller (1966) observed that bison split into smaller groups and moved into forested cover. Raup (1933) observed a March thaw followed by hard crusting on the snow that resulted in bison retreating to sheltered feeding areas where the thawing had less effect. Foraging often occurs in protected meadows where snow depth, density, and hardness are less than in windswept open sites (Reynolds *et al.* 1978).

Bison appear to seek shade for thermoregulation on warm days (Soper 1941). When bison traveled through forested uplands during the snow-free seasons in Prince Albert National Park, they tended to select deciduous stands (Dancose *et al.* 2011). Hecker *et al*. (2023) found uplands to be important to bison for traveling, bedding and wallowing. These animals also increased their movement rates on linear features, DeMars *et al.* 2020). Furthermore, harassment from hematophagous insects is likely reduced in open, upland habitats compared to wetlands, possibly due to drier and windier conditions (Morgan 1987; Melton *et al.* 1989; Belanger *et al.* 2020).

Soper (1941) described cows about to give birth as secretive and speculated that calving sites were in thick woodland retreats, where they remained until the newborn calf was mobile enough to join the post-calving aggregations. Calef and Van Camp (1987) postulated that the abundance of interspersed woodlands providing cover for calving may be a mitigating factor for the lack of synchrony in wood bison calving, compared to bison of the open plains. The scarcity of information regarding the birth of calves probably attests to the level of seclusion that the maternal cows seek.

Space

As the largest land mammal in North America, wood bison require plenty of space. In their study of Mackenzie bison, Larter and Gates (1990) found home ranges to vary from 179 to 1,442 km^2, which is 4 to 100 times larger than those of other North American ungulates, caribou excluded. The ranges of females were the most extensive, probably because female-dominated mixed herds required larger grazing areas, and these are separated by tens of kilometres of forest. Bull groups were observed using smaller habitat patches ignored by the mixed herds. According to Guthrie (1980), the high shoulder hump of bison permits a cantering gait that is not particularly rapid, but powerful and energy efficient for long distance movements between habitat patches.

Allometry is the study of how characteristics of living creatures change with body size. If there is a strong allometric relationship between body mass and home range of bison, then an allometric calculation can be used to anticipate the expected or ideal amount of space required by individuals in a population. Larter and Gates (1990) tested several interspecific regressions of body mass (M) and home range size (A) for females using the relationship $A = 4.9(M^{1.56})$ (Swihart *et al*. 1988) and determined a range size of 1,030 km^2.

Habitat Availability

Present habitat

The main landscape features providing the highest forage biomass for wood bison are floodplains, marl lake basins, fens, bogs, salt plains, karst terrain, and uplands. Floodplains of the Slave, Mackenzie, Liard, South Nahanni and Horn rivers have perched basins and channels that are at slightly higher relief than present water courses and were formerly more active in the drainage systems. Floodplains also occur below 170 m along low-lying shores of Great Slave Lake.

The origin and development of marl lakes has been described by Wentzel (1975). In closed basins receiving highly calcareous ground water from the limestone bedrock or glacial till, physico-chemical processes cause calcium carbonate, the main component of marl, to precipitate and render essential elements unavailable to plants. When the inundation of calcareous water is reduced, nutrients accumulate, and the pH becomes less alkaline. Plant production is quite variable, as some basins in early stages of marl accumulation are nearly barren of vegetation, whereas others have developed a humus layer and reached ideal pH levels for *C. atherodes* and other forage plants. Marl lake basins occupy large parts of the Mackenzie and Nyarling River bison ranges, generally at elevations exceeding 190 m above sea level.

Fens evolve in shallow basins where the water table remains close to the ground surface throughout the growing season, and a shallow peat layer forms when accumulation of dead plant matter exceeds decomposition (National Wetlands Working Group 1997). Fens are mainly associated with the Mackenzie population range below 190 m and the Nyarling River subpopulation range, although they may be found in all areas of bison occupation.

Fens may transform into bogs if dead plant material accumulates under cold, anaerobic conditions and *Sphagnum* moss species invade at the expense of sedges (Heinselman 1963; Zoltai 1995). Bogs are very extensive in all wood bison ranges and their distribution may be related to past climate regimes (Zoltai 1995). The most extensive bogs (also known as muskegs) tend to occur on the Taiga Plains beyond the confines of the glacial lake beds (Ecosystem Classification Group 2007).

Salt plains develop where brackish water seeps from uplands and is partially trapped in shallow depressions. The salinity may be quite restrictive for plant growth. The Salt Plains of Wood Buffalo National Park and the Slave River Lowlands are found east of the Little Buffalo River (Raup 1935; Pringle *et al*. 1975). They occur mostly within Alberta, except for a northern extension into the NWT (locally known as the 'Foxholes') west of Fort Smith, where this landscape feature merges with the Slave River Lowlands. It appears to be a zone of overlap between the Grand Detour/Little Buffalo and Hay Camp subpopulations. North of the Mackenzie River, there are extensive foxtail (*Hordeum jubatum*) meadows (Chowns 1986; Matthews 1991), which are indicators of saline soils (Raup 1935).

An extensive area of karst terrain stretches through the Nyarling River subpopulation range of north-central Wood Buffalo National Park, continuing to the southern shore of Great Slave Lake. It appears to re-emerge in the Mackenzie range north of Lonely Bay, on the west side of Great Slave Lake (Ecosystem Classification Group 2007). This type of geological formation is described by Parks Canada (2012). It is shaped by the dissolution of soluble carbonate bedrock such as limestone, gypsum or dolomite by rainwater. The most notable karst valley is the Nyarling River, which disappears from the surface to flow underground for 26 km. A similar unnamed drainage way flows from west to east, north of Lonely Bay.

Uplands used by bison are generally forested. Jensen *et al*. (2003) estimated that the area of suitable habitat in the Mackenzie Bison Sanctuary and Greater Wood Buffalo metapopulation contains more than 60% forest, and when bison used treed habitats, they tended to select aspen and jackpine stands disproportionately to their availability. These tree species are less shade tolerant and are present earlier in succession than spruces

Potential habitat

There are areas of the NWT that appear to have suitable habitat but are not occupied by wood bison. As shown in Figure 22, the historical range of wood bison extended to Lac La Martre (Richardson 1829) and bison are now re-entering this region, particularly along the Tłı̨chǫ Highway (Behrens pers. comm. 2024).

There is also a considerable amount of former range contained within the Bison Control Area. Historically, bison were found along the south shore of Great Slave Lake (Allen 1877; Hanks and Irving 1987), but when animals re-appear in this area now, they are removed in accordance with disease control protocols. There are also *C. atherodes* meadows within 50 km of the Nyarling River subpopulation, along the south shore of Buffalo Lake (Chowns 1979; Lemmen 1998). Potential habitat for the south shore of Great Slave Lake and Buffalo Lake could exceed 2,000 km^2, but most of it is not actually available to bison because of current disease management.

Perhaps the largest tract of potential habitat lies within the 12,000 km^2 former basin of Glacial Lake Mackenzie (Figures 24 and 25), which was named and described by Smith (1992). Occupying the middle three-quarters of the Mackenzie Valley, this 800 km-long water body was separated from Glacial Lake McConnell by an ancient delta at the mouth of the Liard River, and extended from near Fort Simpson northward to where it was partially dammed by a limestone upland known as the 'Ramparts' near Fort Good Hope. Perched deltas in most of the Mackenzie tributaries mark upper levels of Glacial Lake Mackenzie. As with other glacial lakes, dense soils in the former basin and its delta provide favourable conditions for sedge-grass vegetation. The Mackenzie River carved an inner valley into the lacustrine sediments and its floodplain and wet sedge fens resemble habitat found in current wood bison range (Ecosystem Classification Group 2007, 2010; Smith 2011).

Figure 24. Lacustrine bench within Glacial Lake Mackenzie. Photo courtesy T. Chowns.

The southernmost section of the former basin, extending from the mouth of the Rabbitskin and Spence River deltas to the mouth of the Willowlake River, is 30 km wide and reaches into the lower valleys of the North Nahanni, Root and Willowlake rivers. Where the Mackenzie River turns northward at Camsell Bend, the surrounding wetlands, including the North Nahanni River floodplain, have extensive meadows containing *C. atherodes* (Porsild and Cody 1980). River islands and tributary streams are disturbed frequently by flooding and ice scouring, which maintains early successional vegetation (Treseder and Graf 1985). The last record of bison in this area was at the mouth of Martin Creek in 1831 (Preble 1908). This section is nearest to existing wood bison populations, but dense forest, extensive bogs, and mountains are barriers to reoccupation. Natural corridors along the lower Liard and upper Mackenzie rivers are constricted in the Fort Simpson area by islands and shorelines that lack floodplains and have steep unvegetated banks (Walton-Rankin 1977).

The northern half of the former basin is the most extensive and ascends several kilometres up into the valleys of the Redstone, Keele, Great Bear, Little Bear, Carcajou, and Mountain rivers. Many of these resemble mountain valleys in the Yukon and British Columbia where bison are thriving (Ecosystem Classification Group 2010). A 50 km embayment east of Tulít'a includes Kelly and Brackett lakes east of the Norman Range. The widest embayment extends 75 km from the Mackenzie River into the Arctic Red Plain (Low Subarctic) Ecoregion, encompassing the lower Hume and Ramparts rivers, and also extends 25 km east of the Mackenzie River. A study of historical bison range in Alaska, Yukon, and adjacent NWT by Stephenson *et al*. (2001) provided the most comprehensive summary of bison evidence from the past for the northern half of the former Glacial Lake Mackenzie basin and its delta.

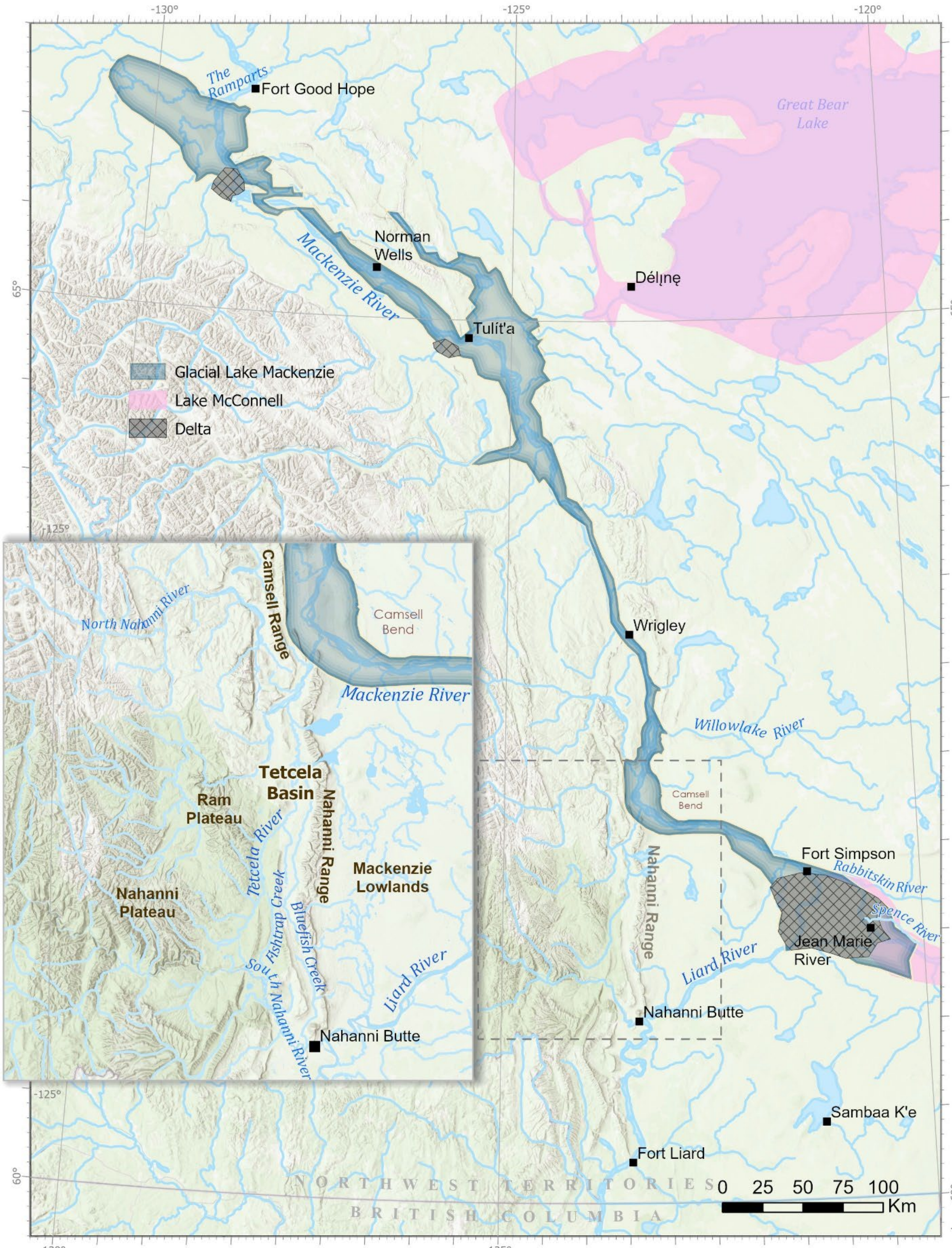


Figure 25. Estimated extent of former Glacial Lake Mackenzie. Map by B. Fournier, based on Smith 1992 and Crosbie 1978.

Bounded by the Ram and Nahanni plateaus on the west and Nahanni Range to the east, the Tetcela basin forms a connection between the South Nahanni valley where bison occur, and the North Nahanni valley and Camsell Bend area of the Mackenzie River, which may provide potential bison habitat (Figure 26). In its southern portion, the Tetcela basin occupies the glacial lakebed of Glacial Lake Tetcela and a glacial meltwater outwash channel that flowed northward now contains the Tetcela and North Nahanni rivers. Crosbie (1978) described the Tetcela basin as an extensive lowland, so flat that its central wetlands drain both southward into Fishtrap and Bluefish creeks (tributaries to the South Nahanni River), and northward into the profusely wandering Tetcela River, (tributary to the North Nahanni River). The floodplains, oxbows, and other wetland habitats may be favourable to wood bison, but dense forest has probably restricted access for bison. That could change with a burn exceeding 100,000 hectares from one fire or multiple fires within a few years, but nothing of that magnitude has occurred in the Tetcela basin since before 1965 when accurate records began (Coyle 2018; CNFDB 2023). Although there have been more small fires (less than 200 hectares) in nearby Nahanni National Park compared to the Mackenzie Bison Sanctuary, Bothwell *et al*. (2004) found the average fire size in the sanctuary to be about 7 times larger than in the park. The relative lack of large fires in this region's historical record in may be influenced by climate and landforms (Bothwell *et al*. 2004).

Figure 26. Potential bison habitat in an ancient spillway east of Camsell Bend (Mackenzie River). Photo courtesy T. Chowns.

None of the potential habitats listed above have ever been evaluated. Because bison range has largely been a function of long-term climatic effects that shift the extent of forest, grassland and peatland on the landscape, former range does not necessarily predict potential range for the near future. All bison remains discovered at latitudes higher than current limits in the NWT have been dated to times when the climate and vegetation were different from today. The climatic thresholds of wood bison physiology for higher latitudes are unknown. Beringian bison were able to thrive in periglacial areas where the winters were cold, but snow was shallow and exceptional summer growing conditions produced an abundance of food (Guthrie 2001).

Opportunities for bison to use these habitats may also be limited by people who do not want these animals to become a nuisance around their communities (CMA 2019). For example, the people of Whatì have expressed a desire to prevent bison from crossing the Lac La Martre River where their community is located (Behrens pers. comm. 2024, Steinwand *et al.* 2025).

Habitat Trends

Wood bison habitat is constantly changing in area and quality in the NWT through vegetation succession and retrogression, which progresses differently in lowlands and uplands. When moisture levels are most favourable, *C. atherodes* meadows provide the greatest volume of high-quality bison forage; however, sedge meadows and grasslands in wood bison range are inherently unstable. These early seral stages of vegetation succession must be revitalized and maintained by frequent cycles of floods and drawdowns, and fires. Since 2015, the NWT forest health monitoring program has expanded from its focus to include abiotic disturbances such as drought, flooding, and permafrost-related issues in response to a changing climate (Brett and Melnik 2023).

If flooding persists, *C. atherodes* loses vigour, reduces seed production and eventually dies (Dirschl et al. 1974; Cordes 1975). Recruitment of *C. atherodes* in wetlands occurs primarily during periods when the substrate is free of standing water, referred to as 'drawdowns' (Van der Valk and Davis 1978). Seeds of *C. atherodes* from the soil seedbank germinate on the exposed substrate, and when flooding returns, *C. atherodes* and other emergent species survive and reproduce vegetatively (asexually, without need for seeds or spores), while other plants are eliminated (Welling *et al*. 1988). However, if desiccation is prolonged, woody perennials often invade (Timoney and Argus 2006). Large fluctuations in water levels also favour decomposition of dead plant material, which impedes excessive peat accumulation (Damman 1979). Accordingly, high amplitude flood/drawdown cycles are important for maintaining wood bison habitat. However, prolonged flooding or prolonged absence of floods can be detrimental to wood bison (Carbyn *et al.* 1993)

Adverse climatic conditions may be confined to a single season, or climatic oscillations such as the Pacific North American Pattern, North Pacific Oscillation, and Southern Oscillation Index (La Niña and El Niño) could have multi-year impacts on forage production and availability. Sedge growth is particularly sensitive to mean monthly temperature (Gorham 1974).

Because grass and other herbaceous plant growth is dependent on the amount of solar radiation that reaches the forest floor, greater biomass of summer forage is produced in recent burns, open woodlands and clearcuts (Raup 1933, Chowns 1986, Carbyn *et al.* 1993, Redburn et al. 2008). The availability of these drier habitats is most important when deep water and soft ground in wet meadows preclude bison use in summer and reduce year-round grazing pressure on sedge meadows that are vital in winter.

Warming, evapotranspiration rates, soil moisture deficits, and surface runoff are expected to become more pervasive in wood bison ranges (Bonsal *et al*. 2024), leading to increasing size and frequency of fires (Price *et al*. 2013). Shifting plant communities toward species adapted to dry conditions and rapid postfire recovery may increase forage for wood bison as grasses increase abundance on drier sites and sedges respond positively with adequate soil moisture (Jorgensen *et al.* 2023).

For more information on *Habitat Trends*, refer to *Appendix A2*.

Floodplains

Rivers are powerful forces of disturbance across their floodplains. They continually erode their banks, deposit sediments into island/bar complexes, carve new channels and abandon old ones, scour shoreline areas and occasionally flood the plain. These processes provide new substrates for riparian plant communities and reset succession to early seral stages. The Slave River Lowlands is composed of deltaic deposits that filled the former southern arm of Great Slave Lake after isostatic rebound separated it from Lake Athabasca (Craig 1965). The Slave River advances laterally through the relict portion of the delta (Vanderburgh and Smith 1988), and the new alluvial accumulations support very productive meadows. East of the river, where the deltaic deposits have been re-sorted by abandoned distributary channels, there are hundreds of shallow ephemeral lakes or sloughs containing emergent vegetation (Brock *et al*. 2008). At the outlet of Great Slave Lake, a widening of the Mackenzie River known as Beaver Lake regularly floods into extensive areas of low relief. Many broad former channels extend downstream to the Mills Lake-Horn River delta floodplain complex (Kemper *et al*. 1975).

Low-lying flat land adjacent to these rivers and Great Slave Lake are inundated by small rises in water level that may persist long enough to drown woody plants. Timoney and Argus (2006) determined that pulses of willow establishment coincided with drying periods. Willow die-back depended on species, water depth, duration of flooding, time since flooding, and size and age of the plant. High amplitude flood/drawdown cycles are necessary for retrogression of these habitats to stages favourable to bison. Although the distributary channel network responds to summer flooding, it appears that only spring ice jamming on a massive scale is capable of surpassing the natural levees and recharging the perched stream channels, floodplain lakes and wetlands (Peters *et al*. 2006; Brock *et al*. 2008; Pavelsky and Smith 2008). Low freeze-up levels, followed by rapid melt of a heavy winter snowpack, are conditions necessary for producing a spring flood-wave large enough for ideal massive ice jamming and extensive backwater flooding (Prowse and Conly 2002; Beltaos *et al*. 2006).

The main tributary of the Slave River, the Peace River, has much of its runoff captured by the W.A.C. Bennett Dam and the Williston Reservoir, which were constructed for hydroelectricity and filled between 1968 and 1971. By releasing more water than normal during winter when electricity demand is highest and reducing the flow of the Peace to recharge the reservoir in spring, the dam disrupts the natural amplitude of the flood/drawdown cycle (Peters and Prowse 2001). This could represent a threat given its potential impact on floodplain bison habitats downstream, including the Peace-Athabasca Delta, Slave River Lowlands, Great Slave Lake, and the Mackenzie River (e.g. Carbyn *et al*. 1998). However, river flow monitoring since the dam was completed shows that spring break-up discharge has increased, not decreased, and the greatest effect on daily discharge occurs during summer (Timoney 2021). Timoney (2024) concluded that downstream habitats have been subjected to decadal scale variations in wetness before and after the dam, without long-term unidirectional trends, and there is no evidence that river regulation is associated with declines in bison populations.

Low precipitation is likely to facilitate conversion of high biomass wet meadow to low biomass dry meadow (Smith and La Roi 2005). In the Slave River Lowlands, the presence of sedge to reedgrass was 2:1 in wet meadows and 1:60 in dry meadows (Reynolds *et al*. 1978). Pringle (1987) found the quantity of forage produced annually in the Slave River Lowlands to be highly related to fluctuations in the water table. This may be offset by sedges invading habitats that were normally too wet for them to grow.

From 1942 to 1944 most of the Slave River Lowlands burned, including one continuous fire that stretched between Fort Smith and the Slave River Delta in 1944 (Holman 1944). Between the time of extensive fires in the Hook Lake bison range in 1952 and a generalised lowering of the water table in the 1970s, local residents reported substantial decreases in meadow coverage caused by willow and tree invasion (Jalkotzy and Van Camp 1977). They observed the major effect of fire in meadow habitats to be removal of dead plant material, which comprised over 50% of the standing plant biomass. This fire improved bison range by removing low quality plant material from the diet and increasing the availability of new forage in spring by accelerating green-up. Reynolds (1976) suggested that periodic fire in the Hook Lake area would improve forage production by creating faster nutrient cycling. Although repeated surface burns appeared to reduce willow vigour in Slave River Lowlands meadows studied by Quinlan et al. (2003), survival remained high and less palatable bison forage species became more abundant.

Flood/drawdown cycles in the Slave River Lowlands seem to be correlated to those in the Peace-Athabasca Delta where these events have been more extensively monitored. In 1945, meadow cover was high, and willow cover was low in the delta, both declined by 1970, meadow remained near its multi-decadal median until 2017 while willows increased and remained high until 2017, then both meadow and willow coverage declined significantly between 2017 and 2022 in the wake of flooding (Timoney 2024). A similar period of prolonged flooding in the Slave River Lowlands has reversed willow succession since 2020 (Armstrong pers. comm. 2025). Extensive fires returned to the Slave River Lowlands in 2023 (Figure 27), along with drought conditions and an abundance of dead woody fuel.

Almost three-quarters of the inflow to Great Slave Lake originates from the Slave River, and Great Slave Lake is the source for nearly all the water entering the upper Mackenzie River (Gibson *et al*. 2006a; Prowse *et al*. 2006). If upstream flow regulation can affect seasonal levels in Great Slave Lake, Woo and Thorne (2003) suggested that outflows to the downstream Mackenzie River would also experience some degree of seasonal dampening from regulation. This would affect floodplain bison habitat along the Mackenzie River, particularly Mills Lake and Beaver Lake. However, their analysis also indicated that these effects would likely be partially offset by climate variability.

Ecological changes in the upper Mackenzie River from flow regulation and climatic anomalies are unclear, as no long-term studies are being carried out. Comparison of aerial photos of the Mills Lake-Beaver Lake area from 1970 to 2024 shows encroachment of willows and aspen into former sedge meadows due to drawdown (Chowns pers. comm. 2025), but the extent has never been measured. Flood-drawdown cycles that occur along the Slave and Mackenzie rivers and Great Slave Lake are driven largely by precipitation variability in the Peace-Athabasca basins (Prowse *et al*. 2006). While the nearby inland basins were drying out in 1974, Mills Lake was flooded until autumn and water levels rose to within six inches (15 cm) of the historic high-water mark because the watersheds of the Peace and Athabasca rivers were recharging from heavy precipitation (Kemper *et al*. 1975). This paralleled the 1974 large discharge peak on the Slave River (Brock *et al*. 2008) and the nearly complete inundation of the Peace-Athabasca Delta from spring until autumn that drowned about 3,000 bison that year (Carbyn *et al.* 1993; Peters *et al*. 2006).

In the early 1990s, the flood/drawdown difference between the Mackenzie River and inland areas to the north had reversed from 1974. Most of the high biomass sedge meadows regularly used to sustain this bison population through the winter appeared to be under water. Bison invaded the high and dry shoreline meadows extending from Mills Lake, and Beaver Lake on the Mackenzie River, to Lonely Bay on the west side of Great Slave Lake in great numbers (Gates *et al.* 1992b).

Drying occurred during the mid 2000s, and by 2020, high precipitation levels in the Mackenzie watershed flooded the Slave River Lowlands, Beaver Lake, and Mills Lake (Armstrong pers. comm. 2025).

From the BC-NWT border to Flett Creek, the Liard River is a braided stream with numerous islands, narrow floodplains and follows a relatively straight course. From Flett Creek to its confluence with South Nahanni, and as far as the Blackstone River, the Liard River channel is broad and meandering, and provides some of the most optimal bison habitat (Reynolds *et al*. 1980; Larter and Allaire 2007). The seasonal flooding associated with the meander zones has resulted in the formation of a broad floodplain extending up to 16 km on either side of the river (Jeffrey 1961; Day 1966; Rostad *et al*. (1976). The meadows of the floodplain have their boundaries defined by the channel scars where they are situated (Rostad *et al*. 1976). The herb layer of recent floodplains is usually dominated by reedgrasses and horsetails, but vegetation composition is dependent on flood duration and frequency, and woody plants increase with distance from the river. Wide expanses of wet meadow containing sedges and horsetails occur mainly around the Liard-Netla confluence (Jeffrey 1961). From Blackstone River to Birch River, the channel is straighter between low banks and a narrow band of abandoned floodplains remain (Jeffrey 1961; Day 1966; Rostad *et al*. (1976). Between Birch River and the Mackenzie River, the river channel is narrow, and the banks become higher eroded steep slopes without floodplains (Day 1966).

Hydrological trends in wood bison floodplain habitat in the Mackenzie drainage basin include increasing mean annual flow, higher winter flow, and earlier timing of peak flow, all of which are attributable to warming temperature, increasing precipitation, and decreasing snowpack storage (Shrestha *et al*. 2021). Large rain events and rapid snowmelt runoff resulting in a rapid increase in channel flow may cause an ice jam which raises the river level to flood stage. This process is important for inundating elevated wetlands and maintaining riparian bison habitat. Trend analysis since 1981 indicates that the frequency of ice-induced floods has generally remained stable (Turcotte 2021). Warmer temperatures are expected to moderate floods by reducing the fraction of winter precipitation that is stored as snow and reduce the frequency and intensity of spring ice jam flooding (Beltaos *et al*. 2006; Shrestha *et al*. 2021).

Marl lake basins

Marl lake basins in wood bison range are typically well-defined by ice-shoved shorelines (ramparts) and moraines. They apparently alternate between shallow lakes and relatively dry basins. During the early 1980s, when Mychasiw (1987) conducted his primary range survey in the Mackenzie Bison Sanctuary, only a relatively small part of most lake basins held any water. Because the lake ramparts contained driftwood, he suggested that they were of relatively recent origin and created by shoreward movements of ice. Aerial photos of marl lake basins from 1948 show that they were dry enough to support extensive sedge meadows (Mychasiw 1987).

In preparation for the bison reintroduction north of the Mackenzie River, Novakowski (1959) surveyed potential bison range in the Fort Providence area. He described the area from Falaise Lake to Lonely Bay as having no potential. Weather records suggest that Falaise Lake and the other marl lake beds may have become flooded during the 1950s and high water levels continued into the 1960s (Chowns 2002; Wang *et al*. 2014), which may explain why Novakowski (1959) considered Falaise Lake to be unsuitable for bison.

After the release of 18 animals in 1963, surveys showed that the growing bison population had started using marl lake meadows of the Mackenzie Bison Sanctuary by 1968 (Gates and Larter 1990). Low water levels shown by 1971 aerial photos of the marl lakes (Mychasiw 1987) suggest that a drying trend began around this time. During the 1970s and 1980s, bison remained concentrated primarily at Boulogne, Falaise, Dieppe, Calais and other unnamed large marl lakes where extensive *C. atherodes* meadows were available.

As prolonged drought conditions continued through the 1970s until 1986, low water tables in the Mackenzie Bison Sanctuary led to concerns about loss of wet sedge meadow bison habitat. Jacobson (1976) proposed that a plant succession pathway from sedge-grass meadow to shrubland and forest was occurring in the marl lake basins, related to progressive drying of the soil and organic build-up. The lack of dead drowned forests at the edges of the lakes suggested to him that this was a one-way process, without great amplitude between flooding and drying. He suggested the lakes were draining from beneath because of the karst geomorphology.

Marl lake water tables in the Mackenzie Bison Sanctuary were so low by the 1980s that concerns about willow encroachment into meadows and permanent loss of bison habitat prompted a study. From aerial photos of selected dry lake basins in the Mackenzie Bison Sanctuary, Mychasiw (1987) documented vegetation change since 1948. He also carried out a quantitative assessment of forage production and estimated the amount of coverage of the major vegetation classes using satellite imagery and ground surveys from 1983 to 1985. Compared to 1948, Mychasiw (1987) found that by 1971 (latest aerial photos available for comparison), woody plant cover had encroached 11% into the sedge meadows of selected marl lakes. Based on 1977 estimates, Peden and Reynolds (1981) suggested that the annual forage production in this area could support 14,000 bison. Woody encroachment had also been continuing unabated through to Mychasiw's 1983-1985 study of forage production and coverage of the major vegetation classes, but quantitative changes from 1971 aerial photos to 1980s satellite imagery could not be accurately assessed (Mychasiw 1987).

During the annual waterfowl survey of 1974, Kemper *et al*. (1975) observed that steadily receding water levels had transformed Falaise and Boulogne lakes into mere potholes surrounded by extensive, open sedge-grass meadows. Falaise Lake, once 50 square miles (130 km^2) in area, only had three small permanent wet areas remaining. Boulogne Lake formerly occupied approximately 12 square miles (31 km^2) but was reduced to an intermittent marsh that had become unimportant for waterfowl. Edward Lepine (pers. comm. *in* SARC 2016: 112) stated that at Boulogne Lake, he used to trap muskrats in "four feet of water" in the 1960s, but those sites became "four feet of grass" by the 1970s.

By 1987, precipitation started increasing in the Mackenzie Bison Sanctuary and water levels were rising incrementally (Gates *et al*. 1995). As water levels increased, woody plants were drowned, and dry grassy meadows were transforming into wet sedge meadows.

After high levels had persisted for several years, sedge meadows in deeper parts of the lake basins also began to drown. Studies have shown that *C. atherodes* cannot survive longer than three years in water depths exceeding 76 cm (Harris and Marshall 1963; Millar 1973; Squires and Van der Valk 1992). Flooding was exacerbated by the arrival of beavers (*Castor canadensis*) and their dam building activities when flowing water returned to creek beds that had been dry since the 1960s (Chowns 1988). Water levels in the Mackenzie Bison Sanctuary reached a peak around 1992 (Gates *et al*. 1992a).

Precipitation began relenting in 1992, and by 1994 drought conditions had returned and the water table reached very low levels by 1995 (Chowns *et al*. 1998). However, this period of drying was insufficient to allow the marl lake basins to return to mid-1980s water levels.

Historical reconstructions of marl lake level using proxy data from sediment cores permitted Korosi *et al*. (2017) to demonstrate that post-1986 lake expansion in the Mackenzie Bison Sanctuary has been unprecedented over a multi-century time period. Of notable importance are the water level changes at Falaise Lake, formerly the core of bison habitat and the largest marl lake within the Mackenzie Bison Sanctuary. The surface area of Falaise Lake increased from 6.1 km^2 in 1986 to 43.4 km^2 in 1992, contracted to 21.1 km^2 in 1997, then recharged from 1997, increasing its surface area to 56.4 km^2 by 2011, for a total increase of 824% between 1986 and 2011 (Korosi *et al*. 2017). Satellite imagery from 2020 shows most marl lake basins almost completely flooded. Since the time of optimal moisture levels and peak forage production in the

1970s and 1980s (Peden and Reynolds 1981; Mychasiw 1987; Smith 1990), there has been a net loss of marl lake bison habitat (Armstrong pers. comm. 2024).

In a study by Travers-Smith *et al*. (2022) examining changes in surface area of northern lakes from 1985 to 2020, they found that lakes associated with higher ground ice content were more likely to have increased in area, likely due to the acceleration of permafrost thaw by climate change. However, lakes impacted by wildfire (including those in the 1995 burn that affected part of the Mackenzie bison range) consistently decreased in area. Deeper and faster permafrost thaw driven by fire and loss of organic surface cover seem to have promoted drainage and surface runoff, while trends in precipitation appeared to be less important in directly affecting lake levels.

Northwestern Canada, including NWT wood bison ranges, has undergone a 1.1°C increase in maximum summer temperature from 1965 to 2020, coupled with a 22-mm (17%) increase in average summer precipitation (Dawe *et al*. 2022). Furthermore, climate models predict a 10-30% increase in precipitation for northwestern Canada by the end of this century (Gaboriau *et al*. 2023). The capacity for the atmosphere to hold moisture rises rapidly with rising temperatures which leads to increases in evapotranspiration (Flannigan *et al*. 2016). Higher evapotranspiration in a warming climate is expected to exceed the increases in average precipitation (Price *et al*. 2013). However, flooded marl lake basins currently lack the vegetation conduit for evapotranspiration, leaving only evaporation and limited runoff to reduce water volume and restore bison habitat. Travers-Smith *et al*. (2022) suggested that rising temperatures are not driving widespread evaporative losses in lakes.

Fens

C. atherodes may be very abundant in fens until increasing depth of peat and decreasing pH shifts the competitive advantage to water sedge, *C. aquatilis* (Jeglum 1971), which has less food value for bison in summer and winter (Larter and Gates 1991).

In some areas, plant succession has been offset by severe fire during dry years. In 1973, 1979 and 1980, fires scoured out large wetland complexes in the Mink Lake area and northeast of Fort Providence. Drought conditions allowed fire to penetrate deep into the peat, burning out entire root systems of trees, willows and dwarf birch, which permitted sedges and grasses to invade. Eventually, the burns produced a much greater diversity of herbaceous plants. *C. atherodes* was still favoured where it was encountered, but bison were observed to broaden their diet selection depending on forage availability (Larter and Gates 1991). Perhaps the burned substrate was enriched, rendering marginal forage species more nutritious and palatable (Chowns 1986; Coppedge and Shaw 1998; Fuhlendorf and Engle 2001). Three bison were spotted within the 1980 Mink Lake burn perimeter in early autumn (Forbes pers. comm. 1980). Later in the winter, 11 were observed and numbers continued to increase for many years. The bulldozer road created through the forest to reach this fire for suppression activities became a major thoroughfare for bison travelling between the Mackenzie Bison Sanctuary and Mink Lake.

Only during drought conditions can fire penetrate the rooting layers of peat and cause significant retrogression. In experiments conducted by Hogenbirk and Wein (1991), deep burning reduced *C. atherodes* and *Calamagrostis canadensis* by up to 90%, and fire-scoured plots were often invaded first by pioneering plant species before graminoids returned.

The high precipitation that flooded the marl lake basins from the late 1980s to early 1990s also affected the fens in the Mackenzie bison range. The capacity of peat to absorb moisture buffers flooding, and the water table may fluctuate within the column of peat without producing standing water. Although sedge meadows were not drowned, flooding appeared to temporarily render forage unavailable for bison in the early 1990s (Gates et al. 1992b). Since the 1990s, over 21,000 hectares north of Fort Providence have been affected by flooding. These areas were mapped in 2016 (Olesinski and Brett 2016). Large-scale drowning of aspen, an early successional species, indicates that floods and drawdowns may occur frequently in these fens.

The Bluefish River-Deep Bay area that was recommended for the 1963 Mackenzie bison transplant is dominated by fens and intervening forest. Novakowski (1959) cautioned that because much of this had burned over in 1946, its value in terms of bison forage would be temporary as the trees return. Flooding and tenuous existence of upland meadows underscored the need to return fire to the ecosystem for habitat improvement, especially for bison. To reverse woody shrub invasion that was diminishing bison habitat value, prescribed fires were designed in 1991 for the fens between Fort Providence and Deep Bay (Chowns 1992). The methodology used was to mimic traditional use of fire in historic times. More than 55,600 hectares were treated in this manner (Chowns *et al.* 1998). Water levels in the Mackenzie bison range reached their zenith around 1992 (Gates *et al*. 1992a). Extensive tracts of coniferous forest between the Horn River and Falaise Lake that had survived wet cycles in the past were completely drowned out. Most of these areas were probably treed fens and flooding was enhanced by beaver activity.

Loss of sedge-grass meadow in fens through peat aggradation and woody plant invasion is a relatively slow process measured over decades and centuries, but a single fire can cause significant retrogression (Moss 1953). Post-fire tree recruitment after the 2014 fires in the Mackenzie and Nyarling ranges was lowest in open wetlands (Whitman *et al*. 2018).

If average annual precipitation and temperatures increase across the northern Canadian boreal zone as climate modelling indicates, soil moisture may be impacted by higher rates of evapotranspiration, such that even wetlands such as fens would be exposed to generally drier conditions and more disposed to burning (Price *et al*. 2013).

Because of flooding in the early 1990s, and several large fires in the mid-1990s and mid 2000s that caused retrogression of shrubland to meadow, there has probably been a net gain in fen habitat, particularly in the Mackenzie bison range. Future habitat change depends on the frequency of these events.

Bogs

As peat depth and permafrost prevent roots from reaching the mineral-rich ground water, ericaceous shrubs and other plants adapted to these low-nutrient environments must rely on precipitation for their moisture requirements (National Wetlands Working Group 1997). Such shallow-rooted plants are intolerant to grazing and have developed chemical defences rendering them unpalatable to bison (Guthrie 2001). Other than their use for loafing, wallowing, and travel routes, bogs are marginal providers of cover or forage for bison and are considered relatively poor habitat (Soper 1941).

Fires warm peat surfaces directly, remove organic insulating layers, and reduce surface albedo (solar reflectance), all of which tend to degrade permafrost and may result in flooding events (Olesinski and Brett 2016; Travers-Smith *et al*. 2022). If water-logging occurs, bogs become treeless (Price *et al*. 2013). Because permafrost has been warming continuously since 1970, rapid degradation over extensive areas within the next 50–100 years may be expected (Smith *et al*.2005; O'Donnell *et al*.2010; Price *et al*. 2013; Wu 2023). It remains undetermined whether this trend would improve habitat for wood bison.

Following the intense 2014 wildfires in the Mackenzie Bison range, black spruce survival was higher in wet areas with thick organic soil layers which experienced low fire severity (Walker *et al*. 2018b; Day *et al*. 2023)

Salt Plains

Where salinity levels are not prohibitive, slender reedgrass (*Calamagrostis inexpansa)*, foxtail (*Hordeum jubatum*), Baltic rush (*Juncus balticus*), and other halophytic (salt-loving) plants become established (Raup 1935). Trees are restricted to slight elevations of relief. Low forage biomass precludes much of the Salt Plains as winter bison range, and the availability of fresh drinking water limits use in late summer. Meadows containing dense stands of sedges and grasses extend into the soils of lowest salinity and are the most attractive to bison (Schwarz *et al*. 1986).

Despite heavy precipitation that flushes the highly soluble salts and improves conditions for woody encroachment, and excessive flooding that causes retrogression to meadow, Schwarz *et* *al*. (1986) found no evidence of substantial vegetation change from examination of aerial photos between 1945 and 1982, suggesting that salt plains are very resilient to change.

Karst Terrain

These formations may contain periodic or permanent water, and often support forage preferred by bison, especially in summer (Fuller 1966). Raup (1935) described the development of meadow vegetation in shallow sinkholes. Although they are relatively small food patches, hundreds of them pock-mark the bison ranges, and the sunken valleys are tens of kilometres in length. Karst depressions providing sustenance may be likened to 'oases' for bison in densely forested landscapes where most water is subsurface. In addition, the valleys provide important travel corridors for these animals. Karst terrain in the bison ranges is very unstable and trees tilting haphazardly are signs of recent activity. There is no evidence suggesting any net gain or loss of bison habitat in karst terrain.

Uplands

In wood bison range of the NWT, uplands are generally forested and characterized by coarser soils and greater depths to the water table. Raup (1933) was one of the first to recognize that forests are most valuable as bison feeding habitat when they are at early seral stages, usually as a result of fire. However, fallen dead trees (coarse woody debris) and dense saplings that often characterize regenerating forests impede bison movements (Hecker *et al.* 2023). Timber harvesting has the potential to improve habitat. However, this activity operates at a relatively small scale in the bison range of the NWT (Smith pers. comm. 2024). Clearcuts examined in northern Alberta provided adequate forage for wood bison during the summer, and capacity typically started decreasing eight years after the harvest (Redburn *et al.* 2008). Beaver dams on streams create ponds that flood forested areas until beaver colonies fail (Novakowski 1965a). After dams fall into disrepair, *beaver meadows* appear in former ponds, which are beneficial to bison.

Early travelers in wood bison range in the NWT commented on the extent of treeless prairies that that now seem to be much diminished (Mackenzie 1801; McConnell 1891; Russell 1898; Preble 1908; Seton 1911; Blanchet 1926). During his descent in 1789 of the river that bears his name, Alexander Mackenzie (1801) remarked about hunting bison at Mills Lake and the extensive prairies on both sides of the Horn River abounding with bison. Wentzel (1807) described the banks on both sides of the Mackenzie River as barren because of spring fires set by the Indigenous inhabitants to improve hunting. Blanchet (1926) mentioned large prairies within 50 miles (86 km) of Fort Providence. When leaving that settlement for the winter trail to Fort Rae, travelers were cautioned to allow themselves plenty of time to cross the first three prairies, otherwise they would be unable to find enough wood for a campfire (McConnell 1891; Russell 1898). Today, almost all of this prairie land has been invaded by early successional forest.

Role of fire

To help understand the structure of past and present vegetation communities and natural fire frequency in this area, Chowns (2002) carried out a fire history study of the Mackenzie Bison Range. Over a 200-year time span, the average fire interval was found to be 40 years and appeared to be much shorter in the lowland sector lying below 190 m elevation (33 years), than the upland sector (46 years) above 190 m elevation. Although fires could burn in consecutive years, this was only apparent on soils capable of supporting a grassy ground cover. Fires in forested landscapes usually occurred at least two decades apart.

The average time since the last fire in the study area was 58 years. In the lowland sector, the average time was 48 years, and in the upland sector it was 66 years. In some decades, over half of the lowland sector burned, while in other ten-year spans no large fires occurred in either sector. Over the past two centuries, there has been considerable variability in fire occurrence. This may be explained partly by the annual precipitation levels. Extensive fires occurred during the drought conditions between 1942 and 1949. Relative to the long-term average, the area burned per year after 1950 is considerably less. The 1960s were the wettest on record and experienced the least amount of fire. When soil organic layers are moist, fires are denied this high biomass of fuel and are easily rained out.

The larger, more frequent fires in the lowland sector may be explained by higher fuel connectivity and traditional burning practices. A grassy understory enables fire to spread faster over large areas and recur more frequently than a fuel bed with higher bulk densities. In the Mackenzie bison range, multi-year layers of grass and sedge often accumulate and provide heavy potential fire fuel loads. The lowland sector, which has always attracted the most human activity, showed considerable evidence of fire in years that may not have been subjected to particularly dry weather. According to Petitot (1891), Indigenous people in the Fort Providence area used fire to manage the environment to their advantage. In his rejection of areas at the Horn River and westward as a potential site for bison reintroduction, Novakowski (1959) commented that their value would be temporary as these were burns that would revert back to forest.

Holsworth (1960) described areas of Wood Buffalo National Park where fires had been of adequate frequency to firmly establish grassland for considerable periods of time. He also commented that some of the large grassy meadows described by Raup (1933) and Soper (1941) from the 1930s had almost disappeared by the 1950s.

Holsworth (1960) suggested that after a forest fire, transpiration may be reduced so much that a higher water table hinders tree regeneration. Rowe and Scotter (1973) found that *Calamagostis canadensis* and various sedge species frequently move into recently burned areas of the boreal forest as they are fast growing and capable of rapid invasion by seed and vegetative means, and burning seems to stimulate flowering and seed production. They also noted that a vigorous growth of sedges, grasses and forbs may continue for about ten years.

Studies in Alaska may provide some insight for processes in the wood bison range of the NWT. Lutz (1956) observed that areas that once contained white spruce became treeless as the vigorous early growth of *C. canadensis* and *Artemisia* spp. seemed to present a barrier to tree seed germination and were more stable than shrublands that retrogressed from forests. Similarly, Viereck (1973) described areas repeatedly burned, which became semi-permanent grasslands dominated by *C. canadensis* and many herbaceous species. Campbell and Hinkes (1983) reported that a fire in black spruce forest expanded sedge-grass winter range of the Farewell bison herd in Alaska. The fire also removed belts of dense black spruce allowing insular meadows to become more accessible. Connectivity with summer range was also enhanced.

Following the anthrax outbreak of 2012, the 2013 census survey indicated that the Mackenzie population declined to approximately 714 bison. From 2013 to 2023, approximately 9,066 km^2 (36%) of the Mackenzie bison range burned, with 7,259 km^2 (29%) occurring in 2014 (Figure 27). Since then, many bison have been using burned upland habitat while Falaise Lake and the other marl lake basins remained flooded, and by 2023 the population had rebounded to approximately 1,945 (Armstrong pers. comm. 2024).

In the wake of a prolonged, multi-year drought, extreme fire events in 2014 affected the Mackenzie and Nyarling bison ranges (Day *et al* 2023). According to Kochtubajda *et al*. (2019), the fall of 2013 was very dry in this area and precipitation during the winter through to the next spring were as much as 50% below normal (1961–1990 base period). During the summer months of 2014, precipitation was approximately 30% below normal and temperature was 1.5° to 2.5°C above normal. Many fire hotspots smoldered in deep, dry organic layers over the following winter, then flared up again with rising spring temperatures (Scholten *et al*. 2021).

Key findings from studies carried out in these burns included decline of black spruce dominance while jack pine and trembling aspen gained dominance (Whitman *et al*. 2018; Dawe *et al*. 2022); poor recruitment of all tree species, especially black spruce, after shortened fire return intervals and postfire drought (Whitman *et al*. 2018; Whitman *et al*. 2019; Stevens-Rumann *et al*. 2022; Reid *et al*. 2023); substantial loss of coarse woody debris and lack of replenishment after short interval reburns (Whitman *et al*. 2019); and increased abundance of downy wildrye (*Leymus* *innovates*) after short interval reburns (Whitman *et al*. 2019). Although most of these studies were restricted by access, contained small sample sizes, and were not designed with wood bison ecology in mind, the key findings listed above are all beneficial to bison. Broadleaf dominance over conifers increases browse production, regeneration failure of trees provides more ground level forage and open woodland for unimpeded bison movements, combustion of coarse woody debris removes obstacles to bison movements, and downy wildrye is a preferred graminid for bison in summer (Chowns pers. comm. 2025).

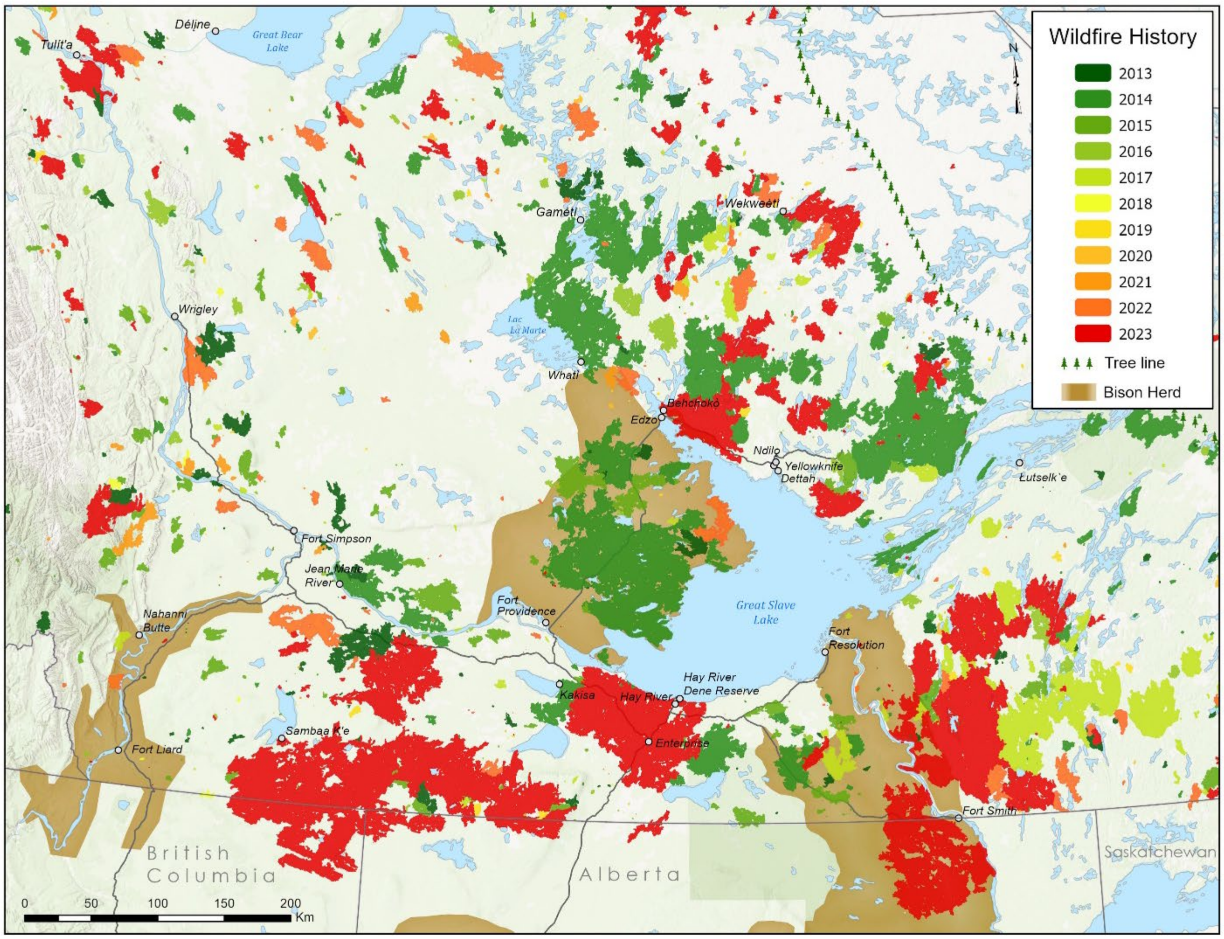


Figure 27. Fire history in NWT wood bison ranges from 2013 to 2023. Fire history data courtesy M. Coyle, GNWT-ECC. Map by B. Fournier.

Since large fires of 1942-1943 (Holman 1944), upland habitat in the Nahanni bison range has been minimally affected by fire compared to the Greater Wood Buffalo and Mackenzie ranges (Coyle 2018; CNFDB 2023).

Tree mortality from causal agents such as drought, insects, disease, flooding, slumping or windfall contributes to the buildup of dry fuel for future wildfire. Most drought- caused mortality involves low-density stands where moisture loss is elevated by greater sunlight, wind exposure, and winter desiccation (Brett and Melnik 2023). Water stress in trees also reduces their capacity to defend against insects and disease (Olesinski and Brett 2016). Although the insect having the greatest impact on NWT forests is the spruce budworm, secondary insect pests have been able to increase their impacts during recent drought conditions (Olesinski and Brett 2016; Huberman *et al*. 2022).

Despite organized fire suppression since the 1940s, periodic large fires in most NWT bison ranges almost every decade have contributed to a net gain in upland bison habitat over the past three generations.

For more information on wildfires, refer to *Appendix A2*.

Habitat Fragmentation

The total population of wood bison in the NWT can be considered severely fragmented (as per IUCN Standards and Petitions Committee 2024). Wood bison in the NWT occur in three relatively small and isolated populations separated by large distances. Of the total NWT population, 63% of bison occur in the Mackenzie range and the remaining 37% in the Nahanni range or the Greater Wood Buffalo metapopulation.

Land Conversion

The clearing of native vegetation for agriculture, rural development, urbanization, mining, fossil fuel exploration, timber harvesting, roads, and hydroelectric reservoirs are the usual forces detrimental to contiguous wildlife habitat. However, wood bison often derive foraging opportunities from disturbances that revert mature forest into early successional vegetation, and these animals readily use roads and seismic lines as travel routes. Although agriculture has probably been an important form of habitat fragmentation for wood bison in the western provinces, this activity is relatively undeveloped in the NWT.

Natural Discontinuities

Extensive tracts of dense forest, muskeg and steep mountains may cause natural habitat fragmentation. Wood bison have a limited ability to overcome some of these physical obstacles by developing trails many kilometres in length through forests, across bogs, and along mountain valleys and passes. Compared to other large mammals, bison appear to be most attracted to paths of least resistance through muskeg and dense forest. They create their own trails as the easiest and shortest routes to favoured habitat patches throughout their range (Graham 1923). Bison now include anthropogenic features such as cutlines and highway corridors for travel routes. They have never been reported swimming across the Mackenzie River and rarely cross it in winter, likely due to obstacles created by rough ice.

Bison Exclusion Zones

The Mackenzie and Nahanni populations are isolated from the Greater Wood Buffalo metapopulation by the Bison Control Area (see Figure 20). Bison that enter this zone are removed to prevent the spread of tuberculosis and brucellosis (Reynolds and Gates 1991). It is connected to Alberta's Northwest Bison Protection Area and the B.C. Bison Management Area where diseases from the Greater Wood Buffalo metapopulation and genetic introgression from feral plains bison from Pink Mountain, B.C., are actively monitored (Harper and Gates 2000; Mitchell and Gates 2002; Nishi 2017; Lewis 2024).

POPULATION

Abundance

The total NWT population of wood bison is estimated at **3,079** (see Table 2). This estimate includes the Nahanni and Mackenzie populations and the three subpopulations of the Greater Wood Buffalo metapopulation that primarily range into the NWT (Nyarling River, Grand Detour/Little Buffalo and Hook Lake).

The proportion of the total population for the NWT that are non-breeding calves and yearlings has not been accurately determined and is expected to vary among populations. Using overall summer herd composition averages (calves 15%, yearlings 8%, bulls 36%, cows 41%) and assuming animals 2+ years of age are capable of reproducing (Armstrong pers. comm. *in* SARC 2016: 93), the number of mature individuals would be approximately **2,371**.

Free-ranging populations outside of the NWT occur in Alberta, Yukon, British Columbia, Manitoba, Alaska and the Republic of Sakha (Yakutia) in Russia, for a combined total of 5,524 (see Table 3). The wood bison herd at Chitek Lake, Manitoba is maintained annually at approximately 300 animals (Myers 2012). The proportion of the global population occurring in the NWT is approximately 36%.

Table 2. Population estimates of NWT wood bison populations/subpopulations as of 2024, with 95% confidence intervals.

Population	Estimate	Year	Reference
Nahanni	544 ± 173	2021	ECC unpubl. data 2024b
Mackenzie	1,945 ± 761	2023	ECC unpubl. data 2024b
Nyarling River	282 ± 223	2024	Parks Canada unpubl. data 2024
Little Buffalo[1]	101 ± 88	2024	Parks Canada unpubl. data 2025
Hook Lake	207 ± 69	2024	ECC unpubl. data 2024b
Total	**3,079**		

[1] As of 2003, the survey area for Little Buffalo (conducted by Parks Canada) also includes the area covered by GNWT surveys of the Grand Detour subpopulation outside of Wood Buffalo National Park. Therefore, as of 2003, Little Buffalo replaces Grand Detour in the total wood bison abundance estimate for the NWT.

Table 3. Population estimates of free-ranging wood bison outside of the NWT, as of 2024 (does not include Elk Island population).

Jurisdiction	No. of Bison	Reference
Alberta	2,800	CPAWS 2024
Yukon	1,951	Jung *et al*. 2023
British Columbia	341	BC-CDC 2023
Manitoba	300	ECCC 2018
Alaska	72	ADFG 2023
Sakha (Yakutia), Russia	60	Sharini *et al*. 2022
Total	**5,524**	

Three subpopulations of the Greater Wood Buffalo metapopulation occur within the NWT: Nyarling, Grand Detour/Little Buffalo, and Hook Lake. Population sizes are estimated by aerial surveys. Total counts were generally carried out in open areas of high density and strip transects are flown to sample secondary ranges. In 2009, the survey method was changed to a sample count that could estimate a confidence interval along with the abundance estimate using transects at fixed intervals (Armstrong 2011). In Wood Buffalo National Park, permanent transect lines have been used in both high-density and low-density areas since 1992.

The change in abundance of NWT wood bison during the **last three generations** from surveys carried out from 2003 to 2024 is displayed in Table 4. Compared to the **prior three generations** (1982 to 2003) (Table 5), the Mackenzie and Nahanni populations appear to be the most stable. Movements among the Nyarling River, Grand Detour/Little Buffalo, and Hook Lake subpopulations may contribute to any apparent instability.

Refer to *Appendix A3 – Population Trends and Fluctuations* and *Appendix 4 – Search Effort* for more detail on population survey methods.

Table 4. Population estimates of NWT wood bison during the last three generations (2003-2024). Estimates are only available for survey years.

Year	Nahanni	Mackenzie	Nyarling River	Little Buffalo[1]	Hook Lake
2003	-	-	355	602	-
2004	511	-	-	-	-
2005	-	-	414	1018	-
2006	-	-	-	-	-
2007	-	-	625	683	-
2008	-	1555	-	-	-
2009	-	-	497	1001	902
2010	-	-	-	-	-
2011	408	-	-	-	-
2012	-	1531	-	-	-
2013	-	714	-	-	-
2014	-	-	326	362	715
2015	-	-	-	-	-
2016	-	851	104	275	399
2017	962	-	-	-	-
2018	-	-	-	-	-
2019	-	1468	276	262	-
2020	-	-	-	-	315
2021	544	-	-	-	-
2022	-	-	-	-	-
2023	-	1945	-	-	-
2024	-	-	282	101	207

[1] As of 2003, Little Buffalo replaces Grand Detour in the total wood bison abundance estimate for the NWT.

Table 5. Population estimates of NWT wood bison during the next-to-last three generations (1982-2003). Estimates are only available for survey years.

Year	Nahanni	Mackenzie	Nyarling River	Grand Detour	Hook Lake
1982	-	712	-	-	-
1983	-	980	48	198	316
1984	-	-	35	144	-
1985	-	-	12	58	-
1986	20	-	-	-	-
1987	25	1,718	145	6	183
1988	-	-	112	56	-
1989	40	2,431	36	118	-
1990	-	-	112	56	-
1991	-	-	144	3	-
1992	55	2,026	236	4	228
1993	-	-	-	-	-
1994	-	-	196	463	212
1995	64	-	174	356	-
1996	78	1,857	173	288	508
1997	107	-	49	282	-
1998	160	1,908	229	148	-
1999	-	-	184	95	-
2000	-	1,998	-	235	283
2001	-	-	-	-	-
2002	-	-	233	-	-
2003	-	-	652	-	-

Density

Environmental conditions from 1930 to 1971 seem to have been favourable for the Greater Wood Buffalo metapopulation to maintain a density consistent with or higher than mean densities of herbivores, scaled to body mass. Since 1971, observed densities have been suppressed, apparently by one or more overwhelming factors that have affected the animals' ability to survive and reproduce.

Immediately prior to dispersal episodes, densities have been reported to exceed 0.70 bison/km^2 for the Mackenzie population (Gates and Larter 1990; Larter *et al*. 2000). Until 1968, the bison population was primarily restricting its distribution to prime habitat on the marl basin of Falaise Lake, and then extended its range to other marl lakes. In 1980, the range expanded to the Mink Lake area. Larter *et al*. (2000) plotted population density against the instantaneous rate of growth from 1963 to 1998 and found a cyclical pattern during the eruptive population increasing phase; both density and population growth rate increased until population density exceeded circa 0.55 bison/ km^2. Once this point was reached, both density and growth rate decreased, and the cycle began again. The cycle was completed twice with both dispersal episodes coming the year following peak population density. During the eruptive phase of population growth, there was pulsed dispersal of animals and an increasing area of occupancy.

Current density is well below allometric projections, which may reflect high quality sedge-grass meadows covering less than six per cent of the range, often separated by tens of kilometres of marginally productive forest (Mychasiw 1987; Larter and Gates 1990; Matthews 1991), and the limited high-quality sedge-grass meadows left in the range after recent increases in the water table (Armstrong pers. comm. *in* SARC 2016: 98).

Refer to *Appendix A3 – Population Trends and Fluctuations* for more detail on population density.

Carrying Capacity

Ecological carrying capacity is defined as the population size at which the population no longer increases (Caughley 1979). This upper limit is reached when removal of forage by herbivores equals the forage produced annually, and juvenile survival equals adult mortality. These may be indicators that the population density is too close to exceeding what the range can support.

Higher animal densities can be supported in environments where nutritious food resources are present in greater abundance and for longer duration. In variable environments, carrying capacity is not a measurement of long-term equilibrium density, but more of a short-term potential density as a function of resource availability (McLeod 1997). The more widely and unpredictably the quantity of vegetation fluctuates, the more difficult it is to determine carrying capacity.

Fuller (1966) suggested that the ideal situation for bison was to have a stable population below the ecological carrying capacity. Estimates of wood bison carrying capacity based on standing crop and productivity of the forage (e.g., Townsend 1972; Reynolds *et al.* 1978; Reynolds *et al.* 1980; Peden and Reynolds 1981) have been much higher than levels ever attained by the real populations.

A population surpassing 400 approaches an acceptable level for the long-term retention of genetic diversity (McFarlane (Zittlau) et al. 2006). A population greater than 1,000 would give a 90% probability of retaining 90% of allelic diversity for 200 years (Gross and Wang 2005) and satisfy the recommendations from the Bison Conservation Initiative (Dratch and Gogan 2010).

Population Dynamics

Population dynamics typically show considerable annual variation; therefore, long term averages are required for an accurate assessment at the population level. Parameters used here to describe population dynamics (natality, recruitment, adult survival, and immigration/emigration) have not been measured consistently among all wood bison populations, or during comparable time intervals. Recent time periods are the most important for evaluating the current status of wood bison in the NWT. Fortunately, the methodology among jurisdictions has become standardized.

Natality

Estimation of calf crop in a population is very sensitive to the timing of the census. Early counts miss later births and late counts fail to detect the calves lost during the intense neonatal predation period. A series of counts through the duration of the calving season determines when peak calving occurs and provides the most accurate estimate of birth rate.

From Wood Buffalo National Park slaughters between 1950 and 1953, Fuller (1961, 1966) estimated the pregnancy rate of adult females to be over 50%, but the observed calf crop from aerial surveys was only 20-25% of the total number of animals counted. With adult cows apparently outnumbering bulls, Fuller expected the observed calf crop to be higher at 35-40%. He considered abortion in late pregnancy and post-partum mortality as explanations for this discrepancy.

Because of the difficulty in accurately accounting for the adult male component of the population, it has become conventional for the birth rate to be expressed in terms of the number of calves per 100 adult cows. In Wood Buffalo National Park, the natal trajectory trended from approximately 28 calves: 100 cows (1986-1989), upward to 38 calves: 100 cows (1989-2003) (Bradley and Wilmshurst 2005; see Table 6). The last sample obtained in the Slave River

Lowlands was 2020 and the ratio that year was 30 calves: 100 cows, with the long-term average being 35 calves: 100 cows (Armstrong pers. comm. 2025).

Table 6. Birth rates for each NWT bison population expressed as number of calves per 100 cows. Data from Armstrong pers. comm. 2025 unless otherwise indicated.

Population	Birth Rate (calves: 100 cows)			
	Low	High	Average	Recent (Year)
Greater Wood Buffalo	**28: 100**[1] (1986-1989)	**38: 100**[1] (1989-2003)	**35: 100**	**30: 100** (2020)
Mackenzie	**11: 100** (2013)	**57: 100** (2024)	**39: 100** (1999-2024)	**57: 100** (2024)
Nahanni	**20: 100**[2]	**88: 100**	**43: 100** (1999-2024)	**88: 100**[3] (2024)

[1] From Bradley and Wilmshurst 2005.

[2] From Larter pers. comm. *in* SARC 2016: 104.

[3] Estimate based on small sample size of only 32 cows.

Larter *et al*. (2000) estimated the average birth rate for the Mackenzie Bison Sanctuary from 1984 to 1998 at 41 calves: 100 cows. As expected, the average for the expanding number of bison in the Mink Lake area (Mackenzie population) from 1989 to 1998 was higher at 51 calves: 100 cows. In 2013, the Mackenzie birth rate was 11 calves: 100 cows, which is the lowest ever reported for this population, while the 2024 ratio was the highest at 57 calves: 100 cows. Since 1999, the birth rate has averaged 39 calves: 100 cows (Armstrong pers. comm. 2025).

The mean birth rate for the Nahanni population was 42 calves: 100 cows for 2002-2013; there are little comparative data prior to 2002 (Larter pers. comm. *in* SARC 2016: 104). If the only other data point from 1999 is added, 41 calves: 100 cows would be the mean, with a range of 20-65 calves: 100 cows (Larter pers. comm. *in* SARC 2016: 104). In 2024, the birth rate was 88 calves: 100 cows, but this was based on a quite small sample size of only 32 cows. The average of 23 years sampled since 1999 for the Nahanni population was 43 calves: 100 cows (Armstrong pers. comm. 2025).

Recruitment

Recruitment is generally defined as the percentage of juveniles entering the reproductive segment of the population. Although this does not usually occur in bison until after the second year, bison in this age class are difficult to segregate. Recruitment has been considered synonymous with survival to the age of one year, partly because high calf mortality levels do not continue into the yearling and older age classes (Fuller 1961, 1966). Ideal recruitment rates for wood bison populations depend on mortality rates, as both would be equal in a stable population. Recruitment must exceed mortality for populations to grow.

When Gaillard *et al*. (1998) reviewed long-term population studies of large herbivores in contrasting environments, they found that juvenile survival typically shows high yearly variability and may play a dominant role in population dynamics. Predation, drought, rainfall, harsh winters, low birth weight, low early growth rates, late parturition, poor calving areas, lack of suitable bedding sites, genetic factors, and altered immunocompetence of neonates were reported as causes that decrease juvenile survival in ungulates.

From slaughtered animals (1950 to 1953) in Wood Buffalo National Park, yearlings averaged 7.6% of the total population (Fuller 1961, 1966). This figure was from a time when the bison population was fairly stable at relatively high numbers. Since then, expressing recruitment in terms of the number of yearlings per 100 adult cows (instead of percentage of the total population) has become standard. For all of Wood Buffalo National Park, the recruitment trajectory has risen from about 5 yearlings: 100 cows (approx. 1991) to about 20 yearlings: 100 cows in 2004 (Bradley and Wilmshurst 2005). From 15 surveys in the Slave River Lowlands between 1999 and 2024, composition estimates were 14.3% calves, 6.8% yearlings, 38.4% bulls, and 40.5% cows (Armstrong pers. comm. 2025).

The estimated recruitment for the Mackenzie Bison Sanctuary from 1984 to 1998 was 22 yearlings: 100 cows and the expanding number of Mackenzie population bison located near Mink Lake produced 30 yearlings: 100 cows from 1989 to 1998 (Larter *et al*. 2000). In 2013, the Mackenzie recruitment rate was 9 yearlings: 100 cows, which is one yearling more than the lowest ever reported for this population in 2003. From 17 surveys between 1999 and 2024, recruitment has averaged 19 yearlings: 100 cows and ranged between 8 and 31 yearlings: 100 cows. Composition estimates averaged 15.85 calves, 8.6% yearlings, 35.2% bulls, and 40.55 cows. (Armstrong pers. comm. 2025).

For the Nahanni population, the estimated recruitment was 21 yearlings: 100 cows with a range between 10 and 31 yearlings: 100 cows from 2002 to 2013 (Larter pers. comm. *in* SARC 2016: 105). Larter and Allaire (2007) estimated an overwinter survival of calves by dividing the ratio of yearlings: 100 cows determined in a given year by the ratio of calves: 100 cows from the previous year. If recruitment is synonymous with survival to the age year one, then the mean overwinter survival of calves since 2002/03 has been 56% (range 22.8-88.5%) (Larter pers. comm. *in* SARC 2016: 105; Armstrong pers. comm. 2025).

Adult Survival

The review by Gaillard *et al*. (1998) also indicated that survival of prime-aged, large mammal females varies little from year to year, or across populations. Adult female survival appeared to be buffered against temporal variation regardless of the causes of mortality, except for disease. The calculation of meaningful survival rates for adult wood bison in the NWT is hampered by several factors, such as small sample sizes, short collection periods, and a paucity of data from marked individuals. Survival rates are most sensitive to the age structure of the adults.

In Wood Buffalo National Park, Joly and Messier (2005) found that annual survival of adult bison varied from a low of 77% in the Delta subpopulation (1998/99) to nearly 100% in the Nyarling River subpopulation from 1997-2000. For the Mackenzie population, the probability of annual adult survival was 92.9% between 1986 and 1991 (Larter *et al.* 2000).

Immigration and Emigration

There has been no evidence of immigration or emigration other than among the subpopulations of the Greater Wood Buffalo metapopulation. Wilson and Strobeck (1999) detected significant gene flow throughout the Greater Wood Buffalo metapopulation, but not enough to totally obscure genetic differences. Joly (2001) did not discover any significant trends regarding interchange among any subpopulations. Calef and Van Camp (1987) found that the ratio of bison numbers east (Hook Lake) and west (Grand Detour) of the Slave River remained constant at 4:1 between 1966 and 1977 and none of the animals collared at Hook Lake were ever relocated west of the Slave River. None of the thousands of tagged animals at the Hook Lake anthrax round-ups reappeared at any Wood Buffalo National Park round-ups, or vice-versa (Calef 1976). An anomaly was reported by Calef and Van Camp (1987) when the Hook Lake subpopulation appeared to lose about 50 bison in 1978 to the west side of the Slave River, then regained the same number in 1979.

Although it has yet to be observed, there is potential for movement between the Nahanni and Mackenzie populations.

Possibility of Rescue

Rescue effect is the process by which a species may move through its range in a way that would mitigate an NWT extirpation or population decline. Some wood bison herds in the NWT share distributions with Alberta, British Columbia and the Yukon. Because tuberculosis and brucellosis present in the bison in the Greater Wood Buffalo metapopulation pose a threat to wood bison recovery (Gates *et al*. 1992b), bison exclusion zones are maintained in northern Canada that deny wood bison from using much of their historic range (Reynolds and Gates 1991). The NWT Bison Control Area enforces an anthropogenic separation of the Nahanni and Mackenzie populations from the Greater Wood Buffalo metapopulation. Although this stifles gene flow and rescue, exclusion zones are presently the only protection available against infection of disease-free herds.

If the Nyarling River, Grand Detour/Little Buffalo or Hook Lake subpopulations should disappear or experience a decline, the likelihood of rescue from other subpopulations in the Greater Wood Buffalo metapopulation is high. There is virtually no probability that dispersal from elsewhere could re-establish the Mackenzie population because of the Bison Control Area, and the Mackenzie range is too remote from any others for immigration to be a factor.

The likelihood of the Nahanni population being rescued by dispersal from elsewhere is also remote even though it is not far from the Nordquist herd in northern British Columbia. The relatively small Nordquist herd has the poorest projected population viability analysis of any wood bison herds and there has been no known or reported movement between the two populations (McFarlane (Zittlau) *et al*. 2006; BC-CDC 2023). As the Aishihik population in southwestern Yukon is more than 700 km from the Nahanni population with intervening mountain barriers, it provides virtually no potential for rescue.

Population Trends and Fluctuations

Historical Decline

The introduction of firearms and advances in breech-loading rifle technology led to excessive human predation and reduced the continental bison population from millions, or perhaps tens of millions in the mid-1860s, to a few hundred by the late 1880s (Hornaday 1889; Shaw 1995). More specifically for wood bison, their numbers dropped from thousands to a few hundred (Ogilvie 1893). From the testimony of R. Hardisty and W. Christie, Hornaday (1889) attributed the lesser decline of wood bison to habitat factors which prevented hunting them on horseback. Both plains and wood bison have slowly started to recover from these severe reductions through protection and reintroductions.

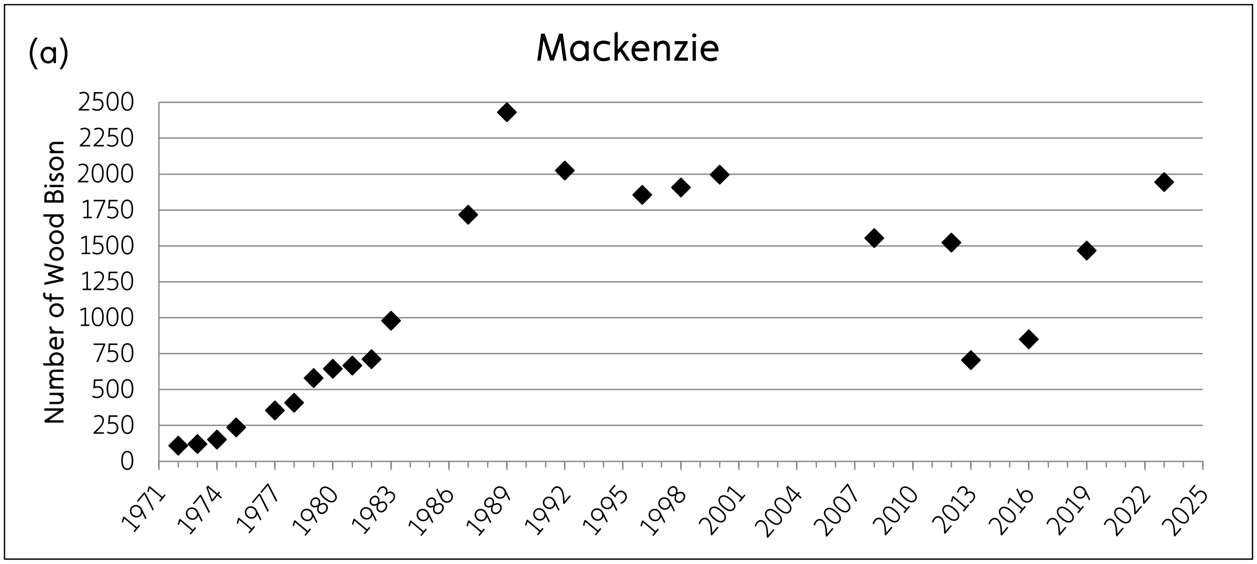
Table 7 shows the approximate timeline of wood bison disappearance from its historical distribution. Although oral history says that bison persisted from at least the 1700s to the early 1900s in parts of the lower Mackenzie region, Yukon, and Alaska (Stephenson *et al*. 2001), evidence from written accounts and radiocarbon dates from that time is currently lacking. The total number of wood bison probably stopped declining between 1896 and 1900 (Soper 1941), even as isolated herds continued to vanish.

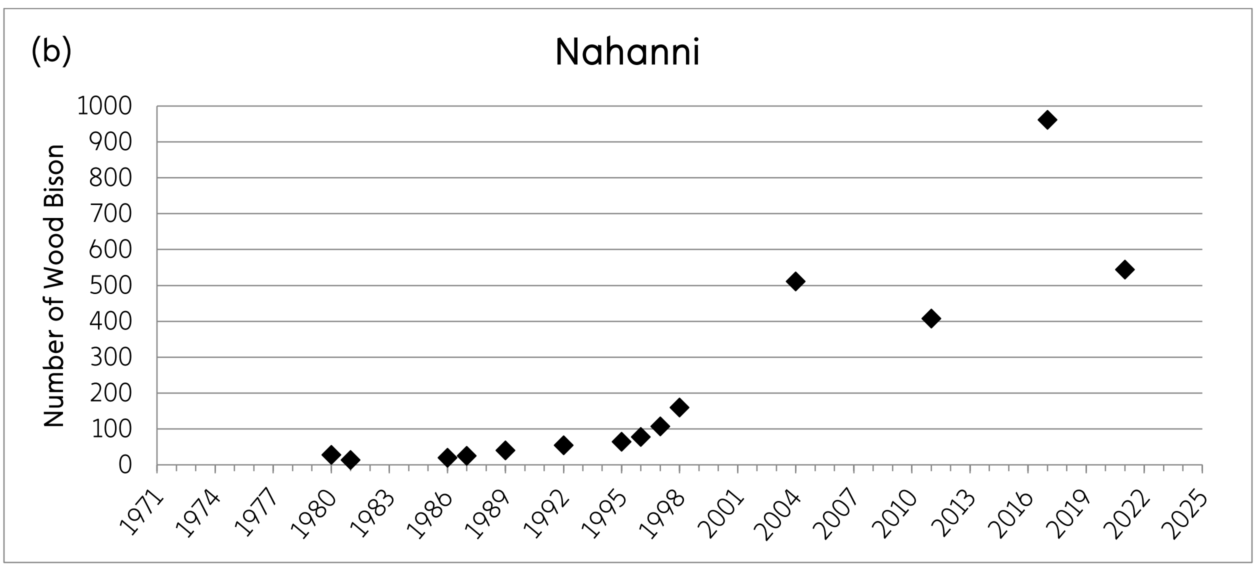
Table 7. Wood bison sequence of disappearance from historical distribution. For further details, refer to *Appendix A4 – Search Effort*.

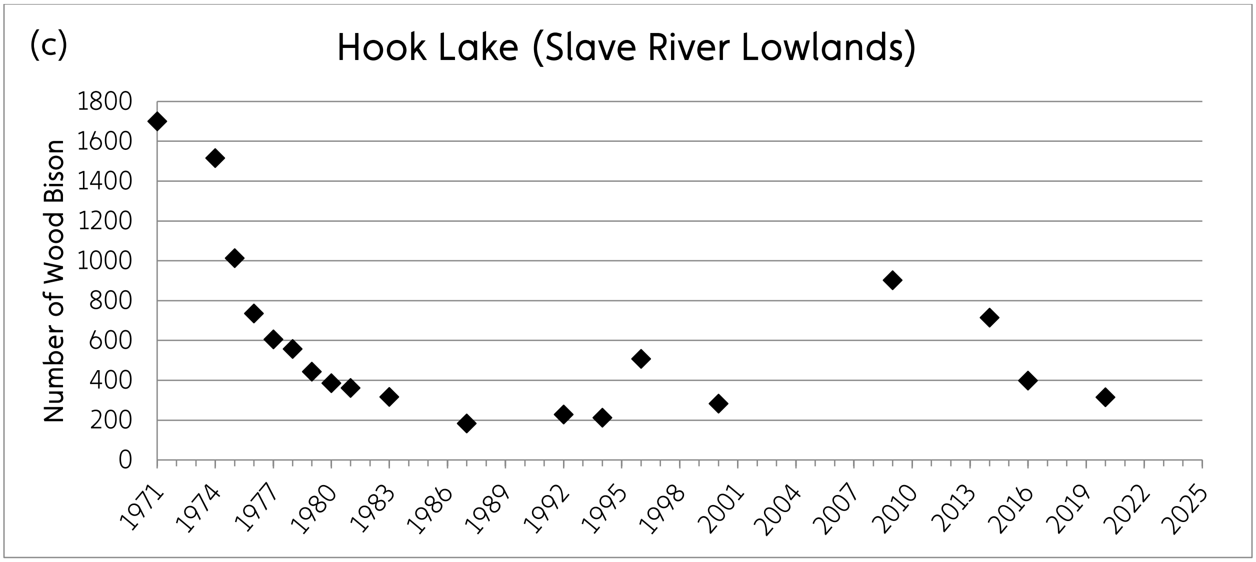
Area	Date	Reference
East of Little Buffalo River	1911-1916	Mulloy 1912; Camsell 1917
Fort St. John district	1906	MacGregor 1952
South of lower Peace River	1898	Radford 1911
Liard-Nahanni rivers	late 1890s	Rhoads 1897
Lower Athabasca River	1896	Jarvis 1897
Upper Hay River	1893	McLeod 1908
Clearwater River	1888	Seton 1927
West of Great Slave Lake	early 1880s	Blanchet 1926
Great Slave Lake south shore	early 1880s	Blanchet 1926
East of Slave River	1880	Radford 1911
Grande Prairie district	1870s	Dawson 1881
Middle Peace River	1870	Butler 1873
Lower Mackenzie River	undetermined	Stephenson *et al*. 2001
Yukon	undetermined	Lotenberg 1996
Alaska	undetermined	Stephenson *et al*. 2001

Population Changes

Data for population abundance for the Mackenzie, Nahanni, Hook Lake and Grand Detour populations/subpopulations (surveyed by GNWT-ECC; Figure 28) and Little Buffalo and Nyarling River subpopulations (surveyed by Parks Canada; Figure 29) were obtained from several sources. Complete citations and references for 1971-2014 estimates can be found in SARC 2016. Nyarling River estimates from 2016-2024 and Little Buffalo estimates from 2003-2024 are from Parks Canada unpubl. data 2024 and 2025. Due to variable historical survey methods, population estimates for Little Buffalo prior to 2003 may be unreliable. Estimates for other NWT populations, 2016-2024, are from Armstrong and Boulanger 2016, Larter 2021, and ECC unpubl. data 2024b (2018-2024 estimates). Original references should be used for accessing confidence intervals associated with these estimates.







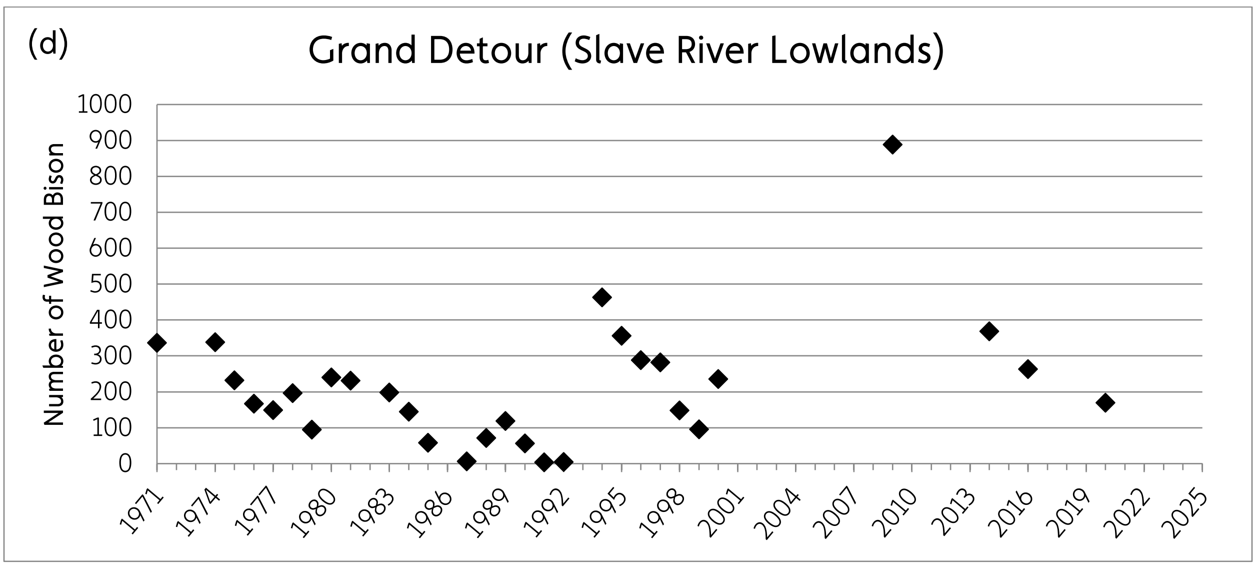


Figure 28. Wood bison abundance for the (a) Mackenzie, (b) Nahanni, (c) Hook Lake and (d) Grand Detour populations since 1971.

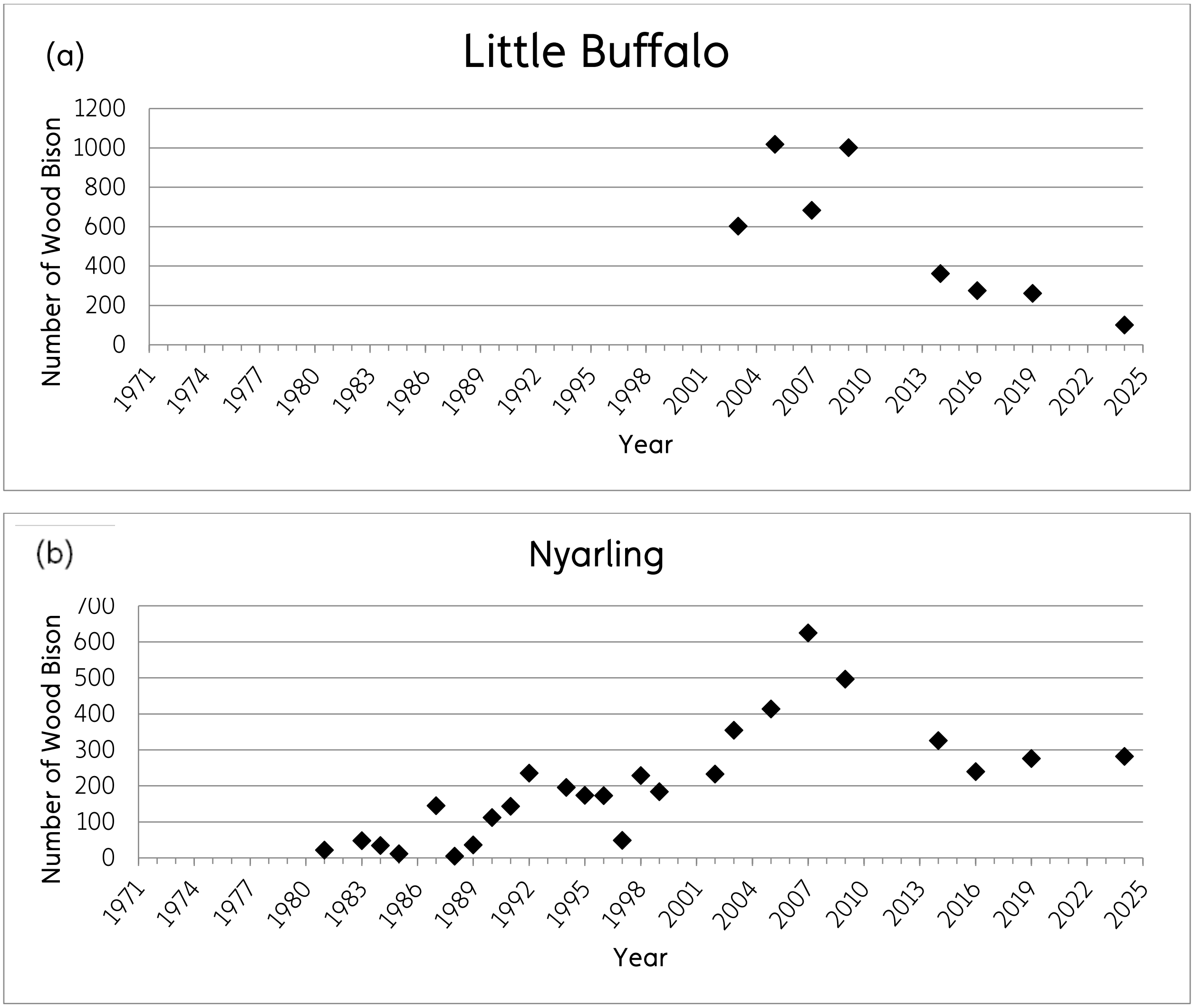


Figure 29. Wood bison abundance for the (a) Little Buffalo and (b) Nyarling River subpopulations. Surveys for Little Buffalo include bison inside and outside Wood Buffalo National Park (survey area overlaps with Grand Detour; refer to Figure 21).

With respect to the estimate of population trends for all NWT wood bison, the data in Table 8 was used to assess the number of wood bison in all populations, and how that has changed over different bison generations. Survey estimates over a six-generation period (1982-2024) were collected for all populations/subpopulations; these are the bold values in the table.

For years where census data were not available, an estimate was derived by calculating the annual linear growth rate between successive population estimates and projecting that forward. These estimates are shown in unbolded font on the table. For example, the Nahanni population size was estimated as 511 in 2004 and 408 in 2011. The estimated annual change was a subtraction of 14.7 animals per year over seven years, as shown in Table 8. With population estimates for all populations/subpopulations and all years, the annual summed total of bison was used to provide a population dynamic of all bison, in all populations.

Table 8. Census numbers from surveys between 1982 and 2024 in bold text with projected numbers estimated from rate of growth for non-census years (unbolded). Data were derived from Calef (1984); Chowns and Graf (1984); Gates and Larter (1990); Graf *et al*. (1990); Gates *et al*. (1991); Larter *et al*. (2000); Gates *et al*. (2001b); Joly and Messier (2004b); Larter *et al*. (2007); Vassal and Kindopp (2010); Armstrong (2011); Armstrong (2013b); Armstrong (pers. comm. *in* SARC 2016: 101); Larter and Allaire (2013); Armstrong (2014); Cortese and McKinnin (2015); Armstrong and Boulanger (2016); Larter (2021); Parks Canada unpubl. data (2024 and 2025); ECC unpubl. data (2024b).

Year	Nahanni	Mackenzie	Nyarling	Grand Detour/ Little Buffalo*t	Hook Lake	Total
1982	15	**712**	35	215	339	1316
1983	16	**980**	**48**	**198**	**316**	1558
1984	17	1165	**35**	**144**	283	1644
1985	19	1349	**12**	**58**	250	1688
1986	**20**	1534	79	32	216	1881
1987	**25**	**1718**	**145**	**6**	**183**	**2077**
1988	38	2075	**5**	**71**	192	2381
1989	**40**	**2431**	**36**	**118**	201	2826
1990	45	2296	**112**	**56**	210	2719
1991	50	2161	**144**	**3**	219	2577
1992	**55**	**2026**	**236**	**4**	**228**	**2549**
1993	58	1984	216	234	220	2712
1994	61	1942	**196**	**463**	**212**	2874
1995	**64**	1899	**174**	**356**	360	2853
1996	**78**	**1857**	**173**	**288**	**508**	**2904**
1997	**107**	1883	**49**	**282**	452	2773

1998	**160**	**1908**	**229**	**148**	396	2841
1999	219	1953	**184**	**95**	339	2790
2000	277	**1998**	200	**235**	**283**	2993
2001	336	1943	217	357	352	3205
2002	394	1887	**233**	479	421	3414
2003	453	1832	**355**	**602**	489	3731
2004	**511**	1776	385	810	558	4040
2005	496	1721	**414**	**1018**	627	4276
2006	482	1666	520	851	696	4215
2007	467	1610	**625**	**683**	764	4149
2008	452	**1555**	561	842	833	4243
2009	437	1548	**497**	**1001**	**902**	4385
2010	423	1540	463	874	865	4165
2011	**408**	1533	429	746	827	3943
2012	500	**1525**	394	618	790	3827
2013	593	**706**	360	490	752	2901
2014	685	754	**326**	**362**	**715**	2842
2015	777	803	265	319	557	2721
2016	870	**851**	**240**	**275**	**399**	2599
2017	**962**	1057	228	271	378	2896
2018	858	1262	252	266	357	2995
2019	753	**1468**	**276**	**262**	336	3095
2020	649	1587	277	230	**315**	3058

2021	**544**	1707	279	198	288	3016
2022	440	1826	280	165	261	2972
2023	335	**1945**	281	133	234	2928
2024	231	2064	**282**	**101**	**207**	2885

* As of 2003, Little Buffalo replaces Grand Detour in the total wood bison abundance estimate for the NWT.

[t] Population estimates for the Little Buffalo subpopulation are unverified.

Figure 30 provides for an examination of overall NWT bison populations trends, broken down by generation (7-year periods). Estimated total NWT bison numbers from Table 8 are stacked by population/subpopulation (NA = Nahanni population, NY = Nyarling River subpopulation, GD = Grand Detour subpopulation, LB = Little Buffalo subpopulation, HL = Hook Lake subpopulation, and MB = Mackenzie population). Numbers from surveys are shown with solid fill and extrapolated numbers are shown with hatched fill. The 7-year periods shown with arrows indicate *bison generations*.

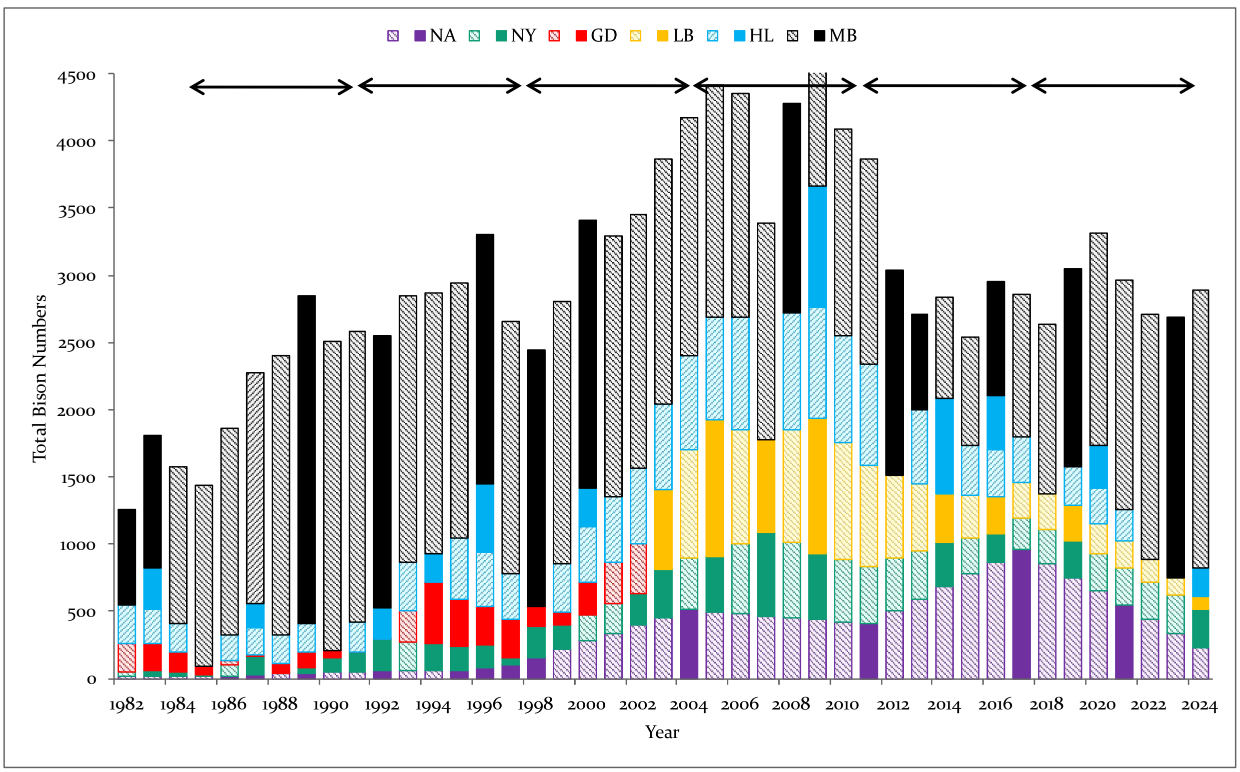


Figure 30. Estimated total NWT bison numbers, stacked by population/subpopulation (1982-2024).

Rate of Growth or Decline

Instantaneous rate of growth (*r*) is a measure of the per capita rate of change in population size for a particular period of time. In a closed population it equals the birth rate minus the death rate. A stable population has $r = 0$. Instantaneous rate of growth was calculated using the formula $r = (\ln N_{(t+n)} - \ln N_{(t)})/n$; where t is the initial time (year), n is the number of years from the initial time, and N is the population estimate for each time period.

Hook Lake and Mackenzie numbers have undergone the greatest increases and decreases over time. The Hook Lake subpopulation increased from 350 animals in 1949 (Fuller 1950) to 1,701 in 1971 ($r = 0.072$). This was followed by a decline for the next similar period ($r = -0.096$), and then regrowth to 902 animals in 2009 ($r = 0.081$). Since then, numbers declined to 207 in 2024 ($r = -0.098$).

From its establishment in 1963, the Mackenzie population began exponential growth from 18 animals (Novakowski 1963b) to 111 animals by 1972 ($r = 0.202$), then continued increasing to 2,431 animals to 1989 ($r = 0.182$). Since achieving peak numbers in 1989, it slowly declined to 1,525 by 2012 ($r = -0.020$), then dropped precipitously after the 2012 anthrax outbreak ($r = -0.770$) to 706. From its 2013 low, the Mackenzie population rebounded to 1,945 by 2023 ($r = 0.101$).

Instantaneous rate of growth (*r*) estimates in Table 9 (derived from Table 8) show all populations/subpopulations, except the Mackenzie herd, to be in decline over the last three generations (2003-2024). However, no herds have been in continuous decline from the previous three generations (1982-2003). Overall, NWT bison underwent negative population growth ($r = -0.011$) during the last three generations, following positive population growth ($r = 0.048$) during the prior three generations.

Table 9. Instantaneous rate of growth (*r*) for NWT bison herds during the last three generations and the prior three generations.

Population/ Subpopulation	Last 3 Generations (2003-2024)	Prior 3 Generations (1982-2003)
Nahanni	**-0.032**	**0.163**
Mackenzie	**0.006**	**0.045**
Nyarling	**-0.041**	**0.017**
Grand Detour/ Little Buffalo	**-0.085**	**0.040**
Hook Lake	**-0.041**	**0.017**
Total	**-0.012**	**0.050**

The International Union for the Conservation of Nature (IUCN) provides a calculator to determine the three-generational rate of change under criterion A. The calculations assume that population changes are exponential and incorporate information from multiple subpopulations based on two data points for each population (census or surveys). Using the available census data from 2003 and 2024, or the closest census year, the rate of change over three generations (2003-2024) is provided in Figure 31. An overall wood bison decline was estimated at approximately **17.5%** over the last three generations.

Calculating 3 generation decline with exponential assumption and only 2 years of data for each subpopulation													
Generation time (years)=	7		Assessment period=		21	years							
Assessment year=	2024		3 generations ago=		2003								
Subpopulation name	**Year 1**	**Population in year 1**	**Year 2**	**Population in year 2**	# years between 3-gen ago and Year1	# years btw Year2 and present	**Annual change**	Change btw 3-gen ago & Yr1	Change btw Yr2 & present	**Population 3 gen ago**	**Population current**	**3-gen change**	
Nahanni	2004	511	2021	544	1	-3	100.37%	100%	99%	509	538	5.7%	(increase)
Nyarling	2003	355	2024	282	0	0	98.91%	100%	100%	355	282	-20.6%	(reduction)
Little Buffalo	2003	602	2024	101	0	0	91.85%	100%	100%	602	101	-83.2%	(reduction)
Hook Lake	2000	283	2024	207	-3	0	98.71%	104%	100%	272	207	-23.9%	(reduction)
Mackenzie	2000	1,998	2023	1,945	-3	-1	99.88%	100%	100%	1,991	1,947	-2.2%	(reduction)
									Total:	3,729	3,075	-17.5%	(reduction)

Figure 31. NWT bison population/subpopulation trends using IUCN Criterion A, exponential assumption, two data point calculator.

Population Viability Analysis

Although metapopulations may be large, subpopulations colonizing new areas are usually small and face significant risks. Stochastic events are capable of causing extinctions in small numbers of individuals haphazardly that would otherwise be buffered against in large populations. An example of demographic stochasticity might be the death of every male during an anthrax outbreak. An example of environmental stochasticity might be the loss of an entire population to a drowning event. In small populations, loss of genetic diversity in these types of instances may be particularly acute.

Feedback between demographic and genetic decline that leads rapidly toward extinction is called an 'extinction vortex' (Gilpin and Soule 1986). The threshold below which a population is likely to be drawn into an extinction vortex is its 'minimum viable population' or MVP. Using a simulation model, Gross and Wang (2005) demonstrated that an MVP of about 400 bison was needed to retain 90% of selectively neutral variation with a 90% probability for 200 years. Longer generation times allow older animals to eventually or continually contribute to the gene pool. As population sizes approach 1,000, the simulated effects of population management on genetic variation become small. Gross and Wang (2005) concluded that bison populations exceeding 1,000 should be more resilient than smaller populations. A target population size of 1,000 animals was chosen by Sanderson et al. (2007), based on modeling studies performed to estimate the loss of genetic diversity in wood bison populations over time.

Recognizing that few bison herds in North America play the significant roles they once did in the ecosystems when they competed with other grazers, interacted with predators, shaped landscapes, and roamed without impediment, Sanderson *et al.* (2007) questioned whether bison restoration should ideally encompass the interactions between bison and their environment. A statement jointly written by scientists and stakeholders from throughout North America, known as the *Vermejo Statement* reads as follows: "Over the next century, the ecological recovery of the North American bison will occur when multiple large herds move freely across extensive landscapes within all major habitats of their historic range, interacting in ecologically significant ways with the fullest possible set of other native species, and inspiring, sustaining and connecting human cultures." (Sanderson *et al*. 2008: 254). They defined the following population size classes as a scorecard for ranking contributions of bison herds to the concept of ecological restoration:

- small contribution – fewer than 400 animals
- modest contribution – 400 to 1,000 animals
- large contribution – 1,000 to 5,000 animals
- exceptional contribution – more than 5,000 animals

Accordingly, the Mackenzie population would be ranked as a **large contributor**, and the Nahanni population as a **modest contributor** to ecological restoration of bison herds. The Greater Wood Buffalo metapopulation would be ranked as a **large contributor**, and the only wood bison population that can be considered ecologically restored (thousands of individuals).

Eruptive Oscillation

Riney (1964) and Caughley (1970) described a four-stage eruptive oscillation in ungulate populations that occurs when there is a great discrepancy between how many animals the environment can support and the numbers present. This scenario usually unfolds after a population has been significantly reduced, or has been introduced, and predators may be present. Ford (1931) suggested that natural selection is relaxed during population increases, allowing inferior genotypes to survive. When conditions deteriorate, inferior individuals are eliminated through increased natural selection causing the population to decline.

Since the turn of the last century, all wood bison populations appear to have undergone eruptive oscillations that are somewhat analogous to the Riney (1964) and Caughley (1970) predictions. Although there are many information gaps, the most intensively documented population dynamics have been for the herds within Wood Buffalo National Park, plus the Hook Lake and Mackenzie herds.

For information on instances of eruptive oscillation in wood bison populations, which typically occur after a population has been significantly reduced or has been introduced, refer to *Appendix A3*.

THREATS AND LIMITING FACTORS

Overhunting and disease management actions, such as vaccination round-ups and culls for disease control, represent important historical threats to wood bison, from which they are still recovering. Today, infectious disease, human-caused mortality, vehicle collisions, habitat loss (e.g., through diminishing flood/drawdown cycles), low genetic diversity, fire management, predation, and episodic catastrophes (e.g., drowning) are considered the most important threats to wood bison in the NWT. These are discussed in more detail in the following pages.

Human-caused Mortality

Overharvesting

Humans are very efficient predators of large mammals, and even before firearms, subsistence use may have influenced bison abundance and distribution (e.g. Van Vuren 1987).

The long-term decline in wood bison was exacerbated by the advent of the fur trade, which relied heavily on the meat provided by wood bison (Chowns 1990; Ferguson 1993). Commercial exploitation for hides was not a contributing factor. After witnessing the tragedy of plains bison, the Hudson Bay Company refused to trade in wood bison hides (Russell 1898; MacFarlane 1908).

Ferguson's (1993) analysis shows that the use of bison meat during the fur trade may have initiated the great decline of wood bison between 1800 and 1820 when rivalry between competing trading companies was most intense and creation of new posts was prolific.

By 1830, it was evident that bison populations were depleted and were not recovering. Posts closed or changed location repeatedly because of difficulties in procuring sustenance (Simpson 1843). Archery persisted as the principal hunting method in the wood bison range north of the Mackenzie River until at least the 1860s (Petitot 1891).

The changes to a fur harvesting lifestyle that led to greater mobility, more dogs to feed, and the earnings to acquire firearms meant greater pressure on bison that were already in serious decline. By the late 1800s, ever increasing distances to find bison were seen as warning signs of imminent extermination (e.g. McConnell 1891, Pike 1892, Russell 1898, Whitney 1898, MacFarlane 1908, Radford 1911).

Hornaday (1889) chronicled the demise of plains bison across North America and predicted the demise of wood bison in the same manner if conservation measures were not taken. The *Unorganized Territories Game Preservation Act* of 1894 banned the hunting of bison, but it was not publicized or enforced north of 60° latitude until Royal North-West Mounted Police officers came to Fort Smith (Jarvis 1897). The creation of Wood Buffalo National Park in 1922, along with hunting and trapping restrictions, was a further measure to discourage human access to the bison range.

As bison appeared in the Slave River Lowlands from Wood Buffalo National Park during the 1930s and 1940s, the Slave River Preserve was in effect (Robinson and Robinson 1946, Ogilvie 1979). This protected the game and fur harvesting rights of General Hunting Licence (GHL) holders who were mainly Indigenous. After the Slave River Preserve was abolished in 1955, harvest of the newly founded Hook Lake and Grand Detour subpopulations was permitted for non-native residents (Van Camp 1987). In 1959 and 1970, outfitters were licensed to guide non-resident hunters. When meat was no longer available from slaughters in Wood Buffalo National Park, northern residents turned more attention to hunting the animals that had moved outside of the park.

Harvest of the Hook Lake and Grand Detour subpopulations exceeded 165 per year from 1968 to 1974 (Calef 1976). As the Hook Lake subpopulation declined drastically between 1974 and 1976, the absolute numbers killed by hunters also dropped, but the hunter harvest rate continued at 8-10% of the subpopulation per year, as it had since 1969 (Van Camp 1987). After harvest by resident and non-resident hunters was terminated in 1977, General Hunting Licence holders continued to harvest 4-8% of the Slave River Lowlands population, which, without the additive effects of predation and other sources of mortality, was still higher than the 3.9% recruitment rate (Van Camp 1987). Calef (1976) suggested that overhunting may have been a contributing factor to the 1974-1976 decline, which was aggravated by the preference of hunters for young cows, the most productive segment of the subpopulation. Because Slave River Lowlands bison were considered surplus from Wood Buffalo National Park, and wood X plains bison hybrids of unvalidated taxonomic status, they were thought as unworthy of effective conservation, and more restrictive legislation for General Hunting Licence holders was never introduced. During the Hook Lake decline in the 1970s and 1980s, the territorial government sought a voluntary reduction in General Hunting Licence harvest (Van Camp 1987), but this effort was unsuccessful. This endeavour failed to achieve its objectives.

Management Actions

Management actions are also a source of human-caused bison mortality. Between 1929 and 1950, slaughters were carried out in Wood Buffalo National Park to provide meat for the Catholic missions and other residents of the NWT. By the 1950s, a program of tuberculosis testing and slaughtering bison that tested positive was implemented for disease control, and meat was salvaged for commercial local consumption and commercial purposes (Fuller 1966). Meat was also sent north to Inuit communities (Beck pers. comm. *in* SARC 2016: 120). Up to 1,000 bison were killed per year and this continued until 1967 (Carbyn *et al*. 1993). Additional slaughters for local consumption were conducted in 1971 and 1974.

After anthrax outbreaks on the Slave River Lowlands, 522 bison of the Grand Detour/Little Buffalo herd were slaughtered from November 1964 to March 1965 in a futile attempt to prevent the disease from spreading through Wood Buffalo National Park (Novakowski 1965b). At Hook Lake and Wood Buffalo National Park, large scale annual round-ups were carried out for vaccinations from 1965 to 1977. This was very disruptive to the herds at a critical time when calves were young, and the average mortality from these round-ups was estimated at 2% of the animals handled (Millette and Sturko 1977).

Present-day management includes destroying bison that cannot be deterred from entering communities. Removals from the Mackenzie population in Fort Providence have ranged from 0-8 annually in recent years, and 0-5 annually from the Nahanni population in Fort Liard (Armstrong pers. comm. *in* SARC 2016: 121; Larter pers. comm. 2025). Over the years, bison have occasionally been killed in the Bison Control Area (e.g., three bison between 2020-2024; CMA 2025). It is unlikely these removals have had any significant effect on the population (Chowns pers. comm. 2025).

Vehicle Collisions

Wood bison are frequently found along roads and use them for grazing and movement. Collisions between bison and vehicles are an important cause of mortality for wood bison populations in the NWT (CMA 2019) and have been a problem on all NWT highways that traverse bison ranges. The annual mortality rate is probably less than 1% for each population, including the Mackenzie range where about 89% of vehicle-bison collisions in the NWT occur (CMA 2025). On average, about 12 vehicle-bison collisions are reported to the GNWT Department of ECC every year, with 2020 representing the most collisions on record in a single year (31 collisions reported) (CMA 2025). Although many accidents involve a single animal, sometimes multiple animals are involved. Those most frequently killed are adult females, followed by calves, then adult males (Wildlife Collision Prevention Program 2016). Collisions have been most frequent from August to December (CMA 2019).

Increasing incidents per annum in the Mackenzie bison range may be attributable to increased speed of vehicles, volume of traffic, expansion of the bison population and movements, and improvement of the highway. Most collisions occur from dusk till dawn and an increase in night-time traffic because of the new Deh Cho Bridge may have become a contributing factor (Armstrong pers. comm. *in* SARC 2016: 127; Wildlife Collision Prevention Program 2016).

Bison are also expected to continue to move northward along the Tłįchǫ Highway, increasing the number of vehicle-bison collisions, which is already a substantial cause of mortality on Highway 3 (INF 2023b). Aerial surveys designed to monitor moose relative abundance and trend in the Tłįchǫ Highway study region can be used to monitor bison occurrence in the area, track any northward expansion, and inform the need for more targeted mitigation to minimize bison-vehicle collisions (INF 2023b).

Disease

Of the nine diseases listed by the American Bison Specialist Group that are currently of concern to the conservation of wood bison, the American Bison Specialist Group considered anthrax and bovine tuberculosis to have the most serious disease implications (Aune and Gates 2010). Bovine brucellosis was ranked as a significant impediment and Johne's disease as a medium impediment for bison restoration (Aune and Wallen 2010). Endoparasites and ectoparasites could become a local concern for wood bison (Aune and Wallen 2010). Although highly effective vaccines are not yet available for preventing diseases in free-roaming bison, research into vaccines to combat tuberculosis and brucellosis is being carried out (Niroula *et al.* 2025). The Greater Wood Buffalo metapopulation has a legacy of at least 14 generations with these two exotic diseases, but it requires considerable time to build significant heritable resistance, and all other populations are pathogen-naïve. If the pathogens were introduced into Mackenzie or Nahanni populations, they may have a greater impact than in the Greater Wood Buffalo metapopulation.

Anthrax

Anthrax is a disease caused by the bacterium *Bacillus anthracis*, which is found naturally in the soil. Outbreaks of varying proportions have arisen periodically in the Greater Wood Buffalo metapopulation and Mackenzie bison population, and many years may elapse between epidemics of high mortality (Gates *et al.* 1995; Elkin *et al.* 2020; Table 10).

There is uncertainty about how and when anthrax became endemic (Dragon *et al*. 1999; Turnbull *et al*. 2008b). The initial diagnosis of anthrax in wood bison was from the Slave River Lowlands on July 28, 1962 (Novakowski *et al.* 1963), although ten years earlier, two wardens experienced a cutaneous infection after they handled a bison carcass in Wood Buffalo National Park (Hugh-Jones and de Vos 2002). Ferguson and Laviolette (1992) also provided historical accounts from the 1800s of wood bison die-offs that resembled anthrax outbreaks.

Between 1962 and 2024, there have been 15 recorded outbreaks in Wood Buffalo National Park, nine in the Slave River Lowlands (outside of the park), and three in the Mackenzie bison range. These events have killed at least 2,372 bison in total; additional outbreaks and anthrax cases may have gone undetected (Elkin *et al.* 2020; New *et al.* 2017; CMA 2025). The first documented case of anthrax in the Mackenzie population was in July 1993 (Gates *et al.* 1995), but retrospective blood serum analysis of anthrax antibodies showed that Mackenzie bison had been exposed to this pathogen at least as far back as the 1980s (Turnbull *et al.* 2001). No cases of anthrax have been found in the Nahanni population.

Transmission pathways of the disease include inhalation, hematophagous (blood-eating) insects, and ingestion. Determining how bison acquire enough spores to trigger new epidemics and spread the disease has been problematic (Elkin *et al.* 2013). High densities of flies can spread an infection many kilometres from the initial focus and potentially transform isolated cases into epizootics (Bakhteeva and Timofeev 2022).

The natural prevalence of infection, exposure and resistance in animal populations is not well known (Bagamian *et al*. 2013). After the spores germinate into the vegetative form of the bacterium inside its host, replication in the bloodstream occurs intensively within a few days, and massive release of toxins causes septicaemia and often rapid death (Novakowski *et al.* 1963; Dragon and Rennie 1995; Keim *et al*. 1997; Gates *et al*. 2001b). During subacute infections, the host immune defences prevent the disease from becoming established, but such protective immune responses wane rapidly, seldom lasting more than a year in large herbivores (Cizauskas *et al*. 2014). Little opportunity exists for evolving innate genetic immunity in bison due to the high lethality of anthrax and absence of chronically diseased individuals with any heritable resistance (Keim *et al*. 1997).

To complete its life cycle, some of the anthrax microbes must leave the carcass and enter the soil where warm temperatures, oxygen and desiccation stimulate the organism to develop into highly resistant spores (Minett 1950; Choquette and Broughton 1981; Titball and Manchee 1987; Hugh-Jones and de Vos 2002; Bakhteeva and Timofeev 2022). The epidemiological impact may also be amplified by necrophagous insects (e.g. blowflies) which feed on and reproduce in the body fluids of anthrax victims, then contaminate surrounding areas by regurgitating and defecating *B. anthracis* onto nearby vegetation (Braack and De Vos. 1990; Turnbull *et al.* 2008b). Although predators and scavengers are quite resistant to the disease, they become important agents for anthrax dissemination by tearing into and dismembering carcasses which releases contaminated blood and tissue into the environment (Bakhteeva and Timofeev 2022).

The survival of anthrax spores is usually limited to no more than three years, and viability and virulence may be further reduced by acidity or microbial competition (Hugh-Jones and de Vos 2002). However, spores can remain viable for decades if they are buried in soil with high calcium levels and a pH exceeding 6.1 (Turnbull 1996; Hugh-Jones and Blackburn 2009). Dragon and Rennie (1995) hypothesized that water movement may concentrate spores into wallows that become storage sites for anthrax. Furthermore, Hugh-Jones and Blackburn (2009) found that pot-hole depressions accumulated calcium, phosphorus, magnesium, and sodium from surrounding soils, creating a locus favourable to spore survival in an otherwise hostile environment. Decaying carcasses provide a pulse of nutrients supporting higher quality forage that may attract herbivores into localized infectious zones (Turner *et al*. 2014).

Anthrax epidemics have always impacted more mature males in bison populations, and this age and gender susceptibility is also apparent among other large herbivores (Bakhteeva and Timofeev 2022). Turnbull *et al*. (2001) found evidence of maternal antibodies being passed on to young calves through the colostrum. Calves feeding on milk also reduces the risk of infection from soil-borne spores. In addition, their gastrointestinal tract may be too hostile for the survival of the vegetative form with its smaller volume, shorter length, lower pH, greater digestive enzyme activity, and a higher rate of digestion compared to adults (Bakhteeva and Timofeev 2022). Mature males may have a higher likelihood of infection than smaller females by consuming more food, ingesting coarser vegetation that increase micro-lesion entry points in upper parts of the digestive system, and retaining contaminated food longer in larger rumens having a higher pH and less hostile digestive environment for spore survival (Gates *et al*. 1995; Bakhteeva and Timofeev 2022). Bison bulls often gore and stomp on fallen or dead bulls, and display-wallowing in a dead competitor's wallow may also contribute to excessive mature male mortality (Hugh-Jones and de Vos (2002).

The first documentation of yearling and calf losses to the disease was at the Salt Plains of Wood Buffalo National Park in 1991, when 9 of the 34 bison that died were female (Broughton 1992). A narrower gender spread between deaths was a 3:2 bull to cow ratio after the 2001 outbreak in Wood Buffalo National Park. The 2012 outbreak in the Mackenzie bison range also claimed juveniles and an unusually high number of females (Armstrong pers. comm. in SARC 2016: 127). This outbreak was the most serious to date, killing an estimated 30% of the population, across all age groups, with 40% of these being mature females (Armstrong pers. comm. in SARC 2016: 123). A risky behaviour that male and female bison often engage in unwittingly is gathering around a fallen comrade using various forms of bodily contact to rouse the animal onto its feet, and it may be three or four days before the fallen bison is abandoned (Hugh-Jones and de Vos 2002).

Anthrax has generally been perceived as an extremely lethal pathogen, possibly because the subacute form of the disease often goes undetected (Bagamian *et al*. 2013). Hugh-Jones and de Vos (2002) suggested that a wildlife population may suffer high initial losses of its most susceptible animals, and then the losses become self-limiting as more survivors respond with protective immunity. In seroepidemiological studies of the Mackenzie bison and Greater Wood Buffalo metapopulation, Turnbull *et al*. (2001) found high antibody titres to the anthrax toxin after and between epidemics, suggesting that a significant proportion of animals survive outbreaks and develop a protective immune response. Since hematophagous insects often transmit sub-lethal doses of the pathogen, they could dampen epizootics by contributing to adaptive immunity (Hugh-Jones and Blackburn 2009).

Table 10. Number of wood bison carcasses found during documented anthrax outbreaks in the Slave River Lowlands, Wood Buffalo National Park and Mackenzie bison range from 1962 to 2024 (Elkin *et al*. 2013; New *et al*. 2017; Elkin pers. comm. *in* SARC 2016; CMA 2025).

Year	Slave River Lowlands	Wood Buffalo National Park	Mackenzie Bison Range	Total
1962	281	-	-	281
1963	257	47	-	304
1964	303	60	-	363
1967	-	120	-	120
1968	-	1	-	1
1971	33	-	-	33
1978	39	47	-	86
1991	-	32	-	32
1993	-	-	172	172
2000	-	106	-	106
2001	12	91	-	103
2006	26	3	-	29
2007	-	64	-	64
2010	46	7	9	62
2012	-	-	451	451
2013	-	1	-	1
2015	-	58	-	58
2022	-	50[1]	-	-
2023	30	11	-	41
2024	-	-	-	-
Total	**1027**	**698**	**632**	**2357**

[1] Additional mortalities from 2022 were discovered in spring 2023 in the southwest portion of Wood Buffalo National Park. Due to intense fire in the area, cause of death could not be confirmed.

Brucellosis

Bovine brucellosis arrived in North America with European cattle. Infected plains bison from Wainwright likely brought the disease to Wood Buffalo National Park, as they were exposed to diseases infecting cattle, and although brucellosis was not discovered there until 1956, it has surely been present since the 1920s (Fuller 2002).

Among NWT wood bison, the disease is present only in the Greater Wood Buffalo metapopulation. It mainly impacts female bison reproduction by causing abortion of the foetus by the third trimester of pregnancy (Tessaro 1989). Most animals abort during the first pregnancy following infection but will carry subsequent pregnancies to term (Canadian Food Inspection Agency [CFIA] 2012). Both sexes are susceptible to inflammation of the reproductive tract, and sterility in advanced cases. Bursitis and arthritis caused by concentrations of *B. abortus* in the joints results in lameness (Tessaro 1989, 1992). The disease may be transmitted through oral contact with aborted foetuses, infected placentas, uterine discharges and contaminated forage (Tessaro 1989). Although bulls may excrete large numbers of *B. abortus* in their semen, no evidence of venereal transmission of the disease has been found (Robison *et al*. 1998).

Although the pathology of brucellosis in bison is fairly well understood, the effects at the population level have only been investigated in Yellowstone National Park. Dobson and Meagher (1996) suggested that brucellosis needs a population threshold of 200 bison to persist. In Wood Buffalo National Park, Joly and Messier (2004a) did not detect any decrease in prevalence rates since the 1950s, despite a major decline in population size. This observation included the Nyarling River subpopulation, which maintained numbers below 200 bison. Since brucellosis appears endemic in this subpopulation, the threshold number may be lower than what Dobson and Meagher (1996) suggested.

Brucellosis can be difficult to diagnose, as a bison that tests seropositive does not necessarily have the disease. Serology testing also detects the presence of antibodies in animals that have acquired resistance or immunity. Infection can only be proven if the disease organism is cultured from the animal's tissues. Bison in Yellowstone National Park have a seropositive prevalence of approximately 50% (Rhyan *et al*. 2009) and modeling simulations by Fuller *et al.* (2007) suggested that brucellosis eradication would result in a 29% increase in population growth rate for that bison population because of higher birth rates.

In a serological survey of 2,365 bison in and around Wood Buffalo National Park, sampled from 1959 to 1974, Choquette *et al.* (1978) found that 31.2% were seropositive for brucellosis. A similar result of 30.9% for 342 bison surveyed from 1997 to 1999 (Joly and Messier 2004a) suggests the seropositive rate has been fairly constant over a 50-year time span. Comparing these effects with Yellowstone National Park bison is complicated by the fact that 10% of these animals test positive for both brucellosis and tuberculosis (Joly and Messier 2001) and the two populations have a much different relationship with predators.

Tuberculosis

Bovine tuberculosis is caused by the bacterium *Mycobacterium bovis*. Like brucellosis, it arrived in North America with imported cattle during European settlement and has been endemic in the Greater Wood Buffalo metapopulation since the introduction of plains bison from Wainwright in the 1920s. It has not been found in either the Mackenzie or Nahanni populations. Almost all modes of infection are through the respiratory and digestive systems (Tessaro *et al.* 1990) and it occasionally passes from mother to offspring via the placenta or milk (Tessaro 1992).

In 1996, the Hook Lake Wood Bison Recovery Project was launched by the Deninu Kų́ę́ First Nation, the Fort Resolution Aboriginal Wildlife Harvesters Committee and the GNWT as an experimental attempt to salvage healthy, genetically robust bison from a diseased population for release into the Slave River Lowlands, after the gradual elimination of infected wild herds (Himsworth et al. 2010). The detection of latent tuberculosis in some of the animals after nearly ten years of quarantine demonstrated the incubation capacity of this pathogen. The project ended in 2006 as there was no process in place to continue after such a setback.

Based on the condition of carcasses from the 1952-1956 Wood Buffalo National Park slaughters, Fuller (1961, 1966) estimated the annual mortality of bison from tuberculosis at 5%. The small sample size examined by Tessaro (1987) indicated 6%, but how many animals near death from the disease would succumb to other causes such as predation is unknown. Joly and Messier (2001) estimated the combined effects of tuberculosis and brucellosis on adult mortality at the population level to be much lower at about 1% per annum. Their number was derived from a 10% decrease in survival for the 10% of the bison that have both diseases. Carbyn *et al*. (1993) estimated from a sample size of 3,412 that 1% exhibited moderate to severe lameness, and that a further 1% showed various degrees of emaciation and debilitation.

From 1,508 bison examined at Hay Camp, Fuller (1961, 1966) noted the incidence of tuberculosis to be 39%, but it was significantly lower in the Delta subpopulation. Fuller did not indicate whether tubercular bison were showing clinical signs or merely testing positive for tuberculosis. Since brucellosis was not discovered in Wood Buffalo National Park until 1956, the interactive effect of both diseases could not be taken into account. Tuberculosis tends to rise rapidly in younger animals until about three years of age, and then more slowly in the older age classes. Fuller (1961, 1966) suggested a possibility that this observation is the result of lethal removal of the most infected animals, and higher survival of those with genetic resistance.

Among subpopulations in Wood Buffalo National Park, Joly and Messier (2004a) found an overall incidence of 49%. Males showed a higher prevalence than females, and prevalence increased at a higher rate with age in males (1.26 times for each additional year of age) than females (1.1 times with each year of age).

From a sample size of 205 bison collected from 1997 to 1999, Joly and Messier (2005) found a reduced probability of pregnancy for tuberculosis-positive females only in the Nyarling River subpopulation. However, they discovered in all Wood Buffalo National Park subpopulations that the probability of pregnancy was 30% less likely for females with both brucellosis and tuberculosis, compared to females with one or neither disease. Joly and Messier (2005) could not account for the difference in pregnancy rates of diseased females between the 1950s and the 1990s data. One suggestion was that their February-March sampling results were more impacted by late gestation brucellosis-induced abortion, than the December-January slaughters.

As with brucellosis, tuberculosis levels have not decreased over time despite a major decline in population size, and prevalence rates were no different between high- and low-density populations (Joly and Messier 2004a). This stability in relative prevalence suggests that any decline in transmission does not occur until very low densities. The only feasible method for eradicating tuberculosis from a herd seems to be the removal of all infected animals, as well as all exposed susceptible animals (Northern Diseased Bison Environmental Assessment Panel 1990; Animal and Plant Health Inspection Unit – United States Department of Agriculture [APHIS USDA] 2005; CFIA 2012). In the Greater Wood Buffalo metapopulation, we can assume that all bison have been potentially exposed and are susceptible to infection.

Johne's Disease

Clinical cases of Johne's disease have never been documented in any free-ranging wood bison even though the causal organism is evident in all NWT populations (Elkin *et al*. 2006; Forde *et al*. 2013). It is mainly a chronic disease of domestic ruminants and clinical signs may lead to diarrhoea, weight loss, decreased milk production, and mortality (Buergelt *et al.* 2000). The origin of infections in wood bison is uncertain (Elkin *et al.* 2006). Forde *et al*. (2013) suggested that weakened animals might be quickly culled from the population through predation, and otherwise go undetected by wildlife managers. They also stated that it is unlikely that Johne's disease causes a high level of mortality in wood bison.

Disease Synergy

Disease synergy may be best described as an interaction between diseases where one enhances the pathological effects of another, or the immune response is too overwhelming for the host

(Joly and Messier 2005). Although no brucellar lesions were reported among 1,000 bison slaughtered outside of Yellowstone National Park in 1996-97, these clinical signs are common among Wood Buffalo National Park bison where tuberculosis is also present (Tessaro *et al*. 1990). Compared to bison with one or neither disease, Joly and Messier (2005) found that bison testing positive for tuberculosis and showing a high titre for brucellosis, were 2.5 times more likely to die during the early winter season and 3.7 times more likely to die during the late winter season than bison testing negative for either or both diseases.

Habitat Loss and Deterioration

Agriculture

Most wood bison habitat loss in Canada has occurred in northern Alberta and northeastern British Columbia where fertile lacustrine and alluvial soils have been converted into farmland (Strong and Gates 2009).

In the NWT, agriculture began in the Mills Lake-Horn River delta meadows in the late 1960s and involved cattle ranching, haying and crop cultivation (Kemper *et al.* 1975). By 1974, there were three operations near the Horn River delta on the northeast shore of Mills Lake, and lease applications had been filed for the entire remaining area. Although agricultural activities halted after the 1974 flooding and the end of government assistance, the leases were still in place. By 1981, they were all acquired by an enterprising rancher from the United States hoping to start a beef cattle operation. After his endeavour failed, the leases again went dormant, waiting for a buyer. In the mid-1980s bison started to invade the Mills Lake-Horn River delta and this area has since become one of the most important core habitats for the Mackenzie bison population. This area is now part of the Edéhzhíe Dehcho Protected Area and National Wildlife Area.

Agricultural interests have been apparent in the Liard Valley and Slave River Lowlands since the 1960s and comprehensive soil surveys were carried out (Day 1966, 1972; Rostad et al. 1976). However, to date, no large-scale initiatives have been deemed feasible.

Fire Suppression

As described in the section on *Habitat Trends*, frequent fire is a component of wood bison habitat maintenance. Anthropogenic burning has been well-documented in North America by Pyne (1997) as a means of improving bison habitat by transforming large areas from forest to grassland. Until the 20th century, lightning fires burned unchecked across the range of wood bison in summers of low precipitation, and Indigenous people added to the burn pattern on the landscape by intentionally using fires to modify vegetation or fuel buildup in the spring, fall, and wet summers, as needed (Lewis 1977; Lewis 1982; Lewis and Ferguson 1988).

The Dominion Forestry Branch emerged at the turn of the 20th century with the responsibility of protecting all natural resources in western Canada, including the last wild wood bison. There was a pervasive belief among the foresters in charge that fire was destructive to bison and threatening their range. As *buffalo patrols* found little evidence that wolves or Indigenous people were affecting populations, locating and extinguishing fires throughout bison range became a top priority (Janzen 1990). This may have contributed to the bison conservation problem that the government was trying to remedy, and the unintended consequence was that upland habitats may have started to deteriorate in the 1910s (McCormack 1992).

Forest expansion due to fire control after the middle of the 20th century likely contributed to a regional reduction in carrying capacity of wood bison in northern Alberta (Strong and Gates 2009). Suppression included fires caused by both lightning and humans. Consequently, northern sedge-grass habitat diminished in this century, replaced by forests resulting from fire suppression programs and new European-based land use patterns such as agriculture and timber harvesting (McCormack 1992). This is problematic from a bison management perspective, given their reliance on sedge-grass meadows. Holsworth (1960) stated that, at that time, the Wood Buffalo National Park forest management policy of total fire suppression conflicted with bison habitat objectives.

The North American tree-ring fire-scar network (NAFSN) is a multi-century record of fire activity comprised of 10,000-km^2 hexagonal polygon sample sites spanning the continent to investigate contemporary fire surplus or deficit and compare recent fire years with historical fire regimes (Margolis *et al*. 2022; Parks *et al*. 2025). The Taiga and Hudson Plain ecoregion contains two NWT sample sites located west of Fort Smith and north of Fort Providence (Margolis *et al*. 2022). In this ecoregion, an NAFSN analysis carried out by Parks *et al*. (2025) indicated that a statistically significant fire surplus occurred from 1984 to 2022. Although they were unable to evaluate contemporary vs. historical fire activity, Parks *et al*. (2025) provided evidence that any previous fire deficit from fire suppression that may have existed in the Greater Wood Buffalo and Mackenzie bison ranges has possibly been eliminated by a fire surplus from large burns that have occurred in recent years.

The historical fire regime was characterized by frequent, low severity fires that cumulatively burned large areas stabilizing feedback for sustaining fire tolerant vegetation types (Coppoletta *et al*. 2016; Teply *et al*. 2018). Conversely, contemporary fires are often characterized by infrequent, high severity fires that individually burn large areas because they generally escape suppression efforts during severe droughts and tend to destabilize feedback for sustaining fire tolerant vegetation types and driving vegetation transformation (Coppoletta *et al*. 2016; Teply *et al*. 2018; Falk *et al*. 2022). Even if large contemporary fires eliminate fire deficit, reduced stability of vegetation types relative to historical regimes is likely to reduce stability of wood bison habitat and populations.

Holman (1944) mapped 1942-43 burns east of the Liard River from Fort Liard to Fort Simpson Liard River, and as far east as Trout Lake and Jean Marie River, that exceeded 1.9 million hectares. After that, fires larger than 200 hectares in the Nahanni bison range have been rare, with only one reaching 10,000 hectares since 1965 (Coyle 2018; CNFDB 2023).

Low Genetic Diversity

For every gene locus, there is at least one allele, and the more alleles carried by members of a population, the greater the genetic diversity. When a new population is established, it contains only a subset of the total alleles available from the parent population. If the number of founders is small, the subset of alleles will be a smaller fraction. The reduction in population size for wood bison from thousands to hundreds (Soper 1941) would have reduced the number of founders and thus genetic integrity of wood bison. All bison herds have been derived from remnants of much larger populations and the original gene pools may be poorly represented (Boyd *et al*. 2010a). Further loss of genetic diversity is exacerbated if new parent populations are already genetically impoverished.

Wilson and Strobeck (1999) examined several bison herds and confirmed a positive correlation between the number of founders and the average number of alleles. The founder effect can foster genetic divergence in populations as shown by the genetic distance between the Mackenzie Bison Sanctuary and the Elk Island National Park Isolation Area wood bison populations. In the early 1960s, these two wood bison populations were founded from 18 and 11 individuals respectively, from the same Nyarling River area of Wood Buffalo National Park. However, their genetic distances show that their gene pools are quite distinct (Wilson and Strobeck 1999). Consequently, genetic diversity has not been well distributed among disease-free wood bison herds in Canada, especially herds started from the Elk Island National Park Isolation Area.

Continuing studies by McFarlane (Zittlau) *et al*. (2006) found that the average number of alleles was highest for Wood Buffalo National Park and Hook Lake subpopulations, indicating that they are the most genetically variable populations. Even though their founder number was probably the highest in North America (> 200 animals), Pertoldi *et al*. (2009) detected long chromosomal regions fixed for one allele in Wood Buffalo National Park samples, demonstrating that Greater Wood Buffalo metapopulation bison are not very rich by normal genetic standards.

The disease problem and the lack of genetic diversity among populations are "co-exacerbating" (Genome Prairie 2022). While the Greater Wood Buffalo metapopulation has been co-evolving with tuberculosis and brucellosis for several generations and has a broader genetic diversity to draw upon for pathogen resistance, the Mackenzie and Nahanni wood bison populations, relatively unexposed to these diseases and with less genetic diversity, may be more vulnerable to the lethal effects of the two diseases.

Inbreeding Depression

Keller and Waller (2002) reviewed inbreeding effects in wild populations. Inbreeding, the mating among closely related individuals, causes a higher probability of recessive deleterious alleles being expressed in the progeny. The resulting decreased fitness, known as inbreeding depression, is often manifested by under-weight births, low survival, and poor reproduction, as well as reduced resistance to disease, predation and environmental stress. These ill-effects may be sudden and severe on a population. Theoretically, recessive deleterious traits can be purged by natural selection acting against them, but the process often has low efficacy in small populations.

In the large ancestral bison population, recessive detrimental genetic traits would have been masked by dominant favourable alleles (Hedrick 2009). Hedrick (2009) suggested the rapid reduction in population size of the late 1800s may have resulted in some detrimental alleles becoming fixed, or increasing in frequency by chance, resulting in lowered population fitness. The reproductive success of European bison has declined with inbreeding (Olech 1987). In North America, inbreeding depression has only been documented in the Goodnight plains bison herd in Texas, but is suspected in the Badlands National Park herd of South Dakota (Berger and Cunningham 1994).

Because all re-established wood bison populations were founded by very low numbers from the Greater Wood Buffalo metapopulation, some inbreeding would have been inevitable. Although there is no evidence of inbreeding depression in any wood bison populations, it is difficult to demonstrate without comparison to a control group.

Genetic Drift

Genetic drift is the loss of alleles by chance and is intensified when populations remain small and isolated for many generations. The number of alleles available for each gene locus is limited by those present in the parental generation and can only decrease. Restoration of variation by mutation is too rare in small populations to be significant (Lacy 1987). The lower the frequency of an allele in the parent generation, the more likely it will be lost in the offspring generation.

Most of the U.S. federal bison herds have independently undergone genetic drift over a number of generations resulting in substantial differentiation among them (Halbert and Derr 2008). Even though the Mackenzie and Elk Island National Park Isolation Area wood bison both originated from the Nyarling River subpopulation, differences between allele frequencies have already developed over the past 50 years and these two populations contain less variation than their founding herd (Wilson and Strobeck 1999). Both the founder effect and genetic drift are probably responsible for the genetic status of these two herds.

As a population becomes more homogenous, it has fewer individuals with unique resistance traits to certain pathogens. Thriving populations with little genetic variation can be reduced to endangered levels by a single disease outbreak (O'Brien and Evermann 1988). Major histocompatibility complex genes play a crucial role in pathogen recognition and are the most polymorphic genes in vertebrates (Borghans *et al.* 2004; Piertney and Oliver 2006). Loss of variation in these genes is a particular risk to the survival of some species (Radwan *et al.* 2007). Population bottlenecks are the most likely explanation for the low major histocompatibility complex diversity observed in moose, muskoxen, roe deer, fallow deer (Mikko *et al*. 1999) and mountain goats (Mainguy *et al*. 2007). Compared to those species, a significant amount of major histocompatibility complex polymorphism has been retained through the population bottleneck that bison experienced in the late 19th century (Mikko *et al*. 1997). Nevertheless, the number of major histocompatibility complex alleles has doubtlessly been reduced to a small fraction of the alleles present before the bottlenecks.

Outbreeding Depression

This is a genetic condition manifested by interbreeding of two genetically distant populations, resulting in a loss of fitness of the progeny from the disruption of selective advantage of adapted gene complexes in the parental forms (Frankham *et al*. 2011). Outbreeding depression may become particularly acute when the populations are separate species, experienced no gene flow in the last 500 years, or inhabit different environments (Frankham *et al*. 2011). Interbreeding of wood bison with cattle and plains bison (either of pure lineage or carrying some cattle heritage from past breeding experiments) potentially threaten the genetic integrity, fitness and evolutionary pathway of wood bison. For example, cattle genes in bison have some deleterious effects such as reduced body size and fitness (Hedrick 2010; Derr *et al.* 2012) and if forced mating between cattle and bison does occur, fertility of the offspring is compromised and restoration of fecundity of hybrids in future generations requires backcrosses with either bison or cattle (Hedrick 2009; Boyd *et al.* 2010a). At present, there are no privately owned herds of mixed lineage bison within the range of wood bison in the NWT.

Hybridization with Plains Bison

Presently, the most imminent hybridization threat is between the expanding Nahanni wood bison population and feral plains bison in British Columbia. Originating as a private herd that escaped into the wild, the Pink Mountain plains bison population occupies historic wood bison range in northern British Columbia. The growing commercial plains bison ranching industry in this province has also resulted in an increased number of escapees (Harper and Gates 2000). Genetic introgression from the plains subspecies may weaken naturally selected heritable adaptations wood bison have acquired for their unique environment. The genetic integrity of every wood bison herd existing today is already compromised by some plains bison introgression (Van Zyll de Jong 1986; Polziehn *et al.* 1996; Wilson and Strobeck 1999).

Drowning

In cases where bison break through lake or river ice, they are generally unable to climb out (Carbyn *et al.* 1993). Mortality of large herds of plains bison that fell through thin ice in the past was summarised by Roe (1970). In the late 1870s, about 90 wood bison drowned in a small lake adjacent to the Athabasca River during early winter when the ice was too thin (Preble 1908). More recently in the Peace-Athabasca Delta, 500 bison drowned during spring 1958 (Fuller 1966), 1703-3,000 bison drowned from fall to winter of 1969 Carbyn *et al*. 1993), and in the spring/summer/fall of 1974 about 3,000 bison perished (Carbyn *et al.* 1993).

In the NWT, Gates *et al.* (1991) documented the 1989 drowning of 177 bison through spring ice on Falaise Lake in the Mackenzie Bison Sanctuary. In winter 2008-09, thin ice likely caused the loss of 13 bison of the Nahanni population, and an additional 15 individuals drowned between 2004 and 2015 (Larter and Allaire 2013; Larter pers. comm. 2025). In 2017, a bison was found drowned in a roadside ditch full of water that the animal had slipped into (Larter unpubl. data 2017). Fourteen bison died in the ice on the Horn River in March 2011 and three more fell through the ice on that river in November 2012 (Armstrong pers. comm. *in* SARC 2016: 134). Since then, there has been the occasional drowning (Armstrong pers. comm. 2025).

Boat and barge traffic also represents a potential threat to wood bison in the NWT. Wood bison, especially calves and mature males, which sit lower in the water than other age classes, are vulnerable to waves and wakes created by these vehicles (Larter *et al.* 2003; Larter and Allaire 2007). A group of bison was swept under a fully loaded barge on the Liard River with few spotted afterwards (Larter unpubl. data 2010).

Adverse Snow Conditions

In the late 1800s, there was an apparent mass mortality of bison near the Peace River after heavy snowfall was followed by rain and refreezing (Ogilvie 1893; Whitney 1898). The ensuing thick crust impaired foraging and mobility of bison and allowed hunters easy access to the herds. MacFarlane (1908) heard testimony about wood bison herds perishing in the Peace River region because of excessively deep snow, and how vulnerable they were to wolves and hunters under these conditions. Before wolves were reintroduced to Yellowstone National Park, Meagher

(1973) considered harsh winters to be the greatest source of bison mortality, and spring calf to adult ratios were negatively correlated with snowpack (Fuller *et al.* 2007).

In 2013, the Hay-Zama wood bison suffered from harsh winter conditions with estimates of calf survival at only 5%. This reduced herd numbers to the lower range of the population objective, prompting a temporary suspension of hunting to allow recovery (Government of Alberta 2013).

Wood bison in Alaska's Lower Yukon/Innoko area suffered major population setbacks in 2018, 2020, and 2023 resulting from the onset of deep snow early in the fall, a temporary thawing and refreezing, then heavy snowfall persisting late into spring (Alaska Department of Fish and Game 2023).

Such episodic snow events have also occurred in the NWT. A November snowstorm followed by freezing rain led to the loss of approximately 33% of the Hook Lake subpopulation during the winter of 1974-75. An extreme late winter 2016 freeze-thaw event in the Nahanni range coincided with the lowest overwinter calf survival yet recorded as only two yearlings were observed during the 2016 classification survey (Larter 2021).

The snow in the Fort Liard area was particularly deep in the winter of 2021-22 and some bison were found dead near the community. The animals all were in very poor condition and no causal agent was identified from the samples analysed. They were deemed to have starved (Armstrong pers. comm. 2025).

Snowpack is projected to deepen across NWT bison ranges in later decades, but it is expected to be offset by rising temperatures that shorten the period of snow accumulation during spring and fall (Derksen *et al*. 2019). The worst-case scenario for bison would be more frequent extreme snowfall events coupled with thawing or rain. Winter precipitation in the NWT has been modelled to be 50-60% higher by the 2080s, and a warming climate increases the probability of precipitation falling as rain rather than snow (Wu 2023).

Predation

Predation has never become a wildlife management issue regarding the welfare of the Mackenzie herd (Calef 1976, Gates 1988, Environment and Natural Resources 2010). Larter *et al.* (2000) stated that this population appears to be regulated by food supply, despite considerable wolf predation on calves. When the Greater Wood Buffalo metapopulation was in decline after the mid-1970s, food shortage was considered dubious, and predation was identified as the prominent factor (Van Camp and Calef 1987, Gates 1988, Carbyn *et al.* 1993). More specifically, it was attributed to excessive predation on calves resulting in low recruitment. No information sources were available on predation of the Nahanni bison.

Wolves do not attack large prey indiscriminately because of the risk of injury. As selective foragers, wolves must capitalise on vulnerable prey and be risk averse (Smith *et al.* 2004, MacNulty 2002).

For more information on predation, refer to *Appendix A5*, which contains *Case History: Impacts on an Increasing Mackenzie Bison Population (1963-1992)*, and *Case History: Impacts on a Decreasing GWBE Bison Population (1971-1999)*.

Season

Bison may be less vulnerable to wolf predation in summer compared to other seasons (Mech 1970; Simon *et al*. 2019; Mech and Boitani 2003). As is typical for wolf-ungulate relationships (Mech and Peterson 2003), bison of all ages become more vulnerable with the onset of deep snow. Food consumption among wolves in Wood Buffalo National Park was estimated by Carbyn *et al.* (1993) to average 2.5 kg/day/wolf in early winter, rising to an average of 4.3 kg/day/wolf by mid-winter and reaching 6.2 kg/day/wolf during the severe winter of 1978-1979 (Carbyn *et al.* 1993).

Calef and Van Camp (1987) suggested the severe snow conditions of 1974-75 in the Hook Lake range (discussed above under *Adverse Snow Conditions*) may have caused bison to become nutritionally stressed and more vulnerable to wolf predation. After taking advantage of the weakened bison, the wolves may have increased in numbers and exerted additional predation pressure on the surviving bison.

Age Structure

Age-dependent predation may be more important than is generally recognized in wolf-ungulate systems (Vucetich and Peterson 2004). In a wolf-bison system, bison calves are expected to be the preferred prey because they are smaller and usually easier to kill than adults. Since numbers of calves are limited and their prey biomass is low, bison calves alone are not enough to sustain robust wolf populations without a broader prey base.

Winter radio-tracking data of several wolf packs in Wood Buffalo National Park indicated that wolves selected calves and old bison greater than 11 years of age (Carbyn *et al.* 1993). Calves were always killed at a disproportionately higher rate (24%) than they occurred in the population (11%), except in 1978-1979 when it was suspected that fewer calves were available to wolves in the study area. Carbyn *et al.* (1993) and Larter *et al*. (1994) observed that after high early mortality rates, vulnerability of calves gradually decreased through their first year of life. Two- to five-year old bison seemed to be relatively immune to predation. Animals greater than 11 years of age were also killed at a disproportionately higher rate (14-20.8%) than they occurred in the population (10.8%). Unlike the impact calf predation can have on recruitment into the herd, Fuller (1966: 37) stated, "Very old animals are generally considered to be a biological surplus, and the loss of individuals in that class to predators or from any other cause is not usually detrimental to the herd welfare." Whether predation of older animals bolsters the wolf population and thus increases predation pressure on calves was considered by Vucetich and Peterson (2004) and is discussed below.

When examining reasons why the bison of Wood Buffalo National Park had stabilized by the 1940s, Fuller (1966: 40) stated that the growing population from 1890 to 1925 must have been essentially a young population which was less vulnerable to predation.

The more than 6,000 plains bison imported during 1925-29 were also young animals, and Soper's (1941, 1942) 1932-34 faunal studies in Wood Buffalo National Park indicated that wolf predation was having little impact on bison. The geriatric cohorts arrived in the 1940s and continued to represent large age classes in a stable population until the end of the 1960s when wolf control ceased.

In the Mackenzie population, predation was not observed on calves until 1983 (Chowns and Graf 1987) and was much later for adult bison (Larter *et al.* 1994). Figure 32 shows the Mackenzie population kill ratio of calves to yearlings to adults, calculated from a 1989 to 1992 study period, to be much higher than Wood Buffalo National Park and Hook Lake kill ratios that were calculated from late 1970 study periods. Of the wolf-killed bison documented in the Mackenzie population by Larter *et al.* (1994), the calf to yearling to adult ratio was 26:5:10. Larter *et al.* (2000) stated that this bison population appeared to be regulated by food supply, despite considerable wolf predation on calves. The 17:3:28 kill ratio in Wood Buffalo National Park (Carbyn *et al.* 1993) was remarkably similar to the 16:2:28 Hook Lake kill ratio (Van Camp 1987). In contrast to the Mackenzie population of 1989-1992 when its age structure was dominated by younger animals, few juveniles were being recruited into the Wood Buffalo National Park and Hook Lake herds during the late 1970s, resulting in their age structures being dominated by older animals. Carbyn *et al.* (1993) believed that wolves maintained a strong search image for calves and the pressure on them would be relentless, as long as they remained available. Switching to adults only occurred when calf encounter rates dropped below a profitability threshold, and apparently this threshold had not been reached in the Mackenzie range. Carbyn *et al*. (1993) suggested that in Wood Buffalo National Park, wolf predation of adult bison may have equalled recruitment in some years. In the snow-free period, they observed that wolves killed calf bison opportunistically, and largely ignored adult bison as long as calves were available.

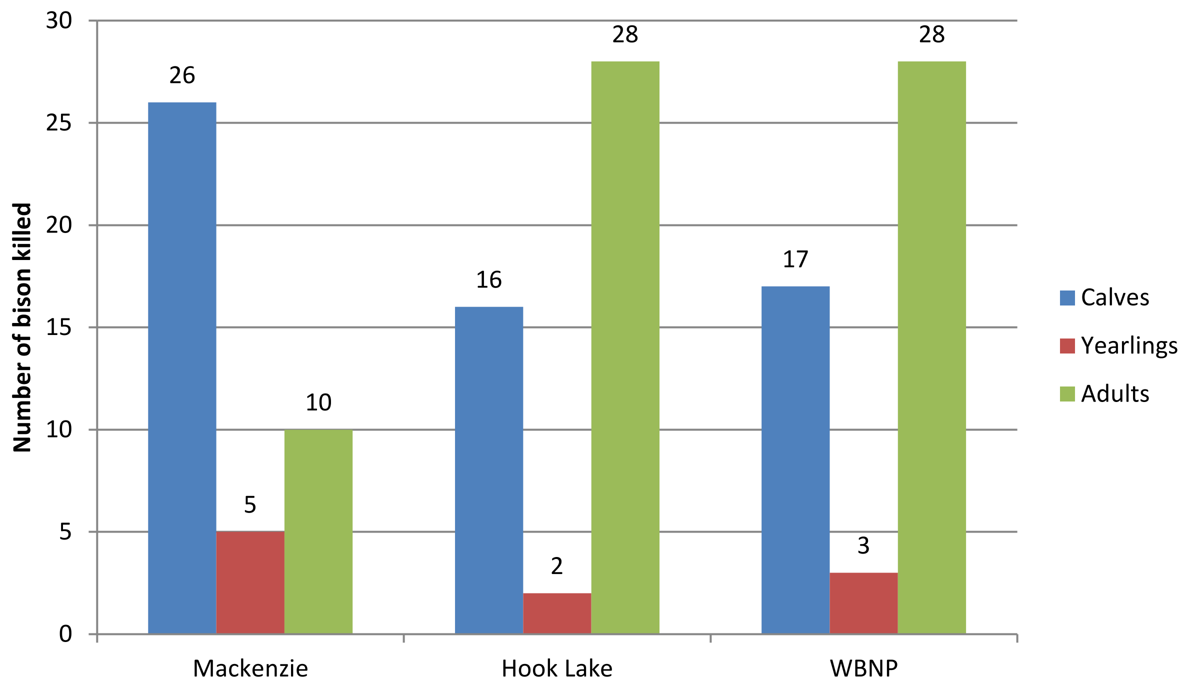


Figure 32. Predation and age class. Data for Mackenzie population from Larter *et al.* (1994); data for Hook Lake from Van Camp (1987); data for Wood Buffalo National Park (WBNP) from Carbyn et al. (1993).

Large scale anthrax outbreaks may interrupt the progression of an aging population structure of bison, as older animals are much more susceptible to the disease (Elkin *et al*. 2020). In African ruminants, where susceptibility is also age-linked, Hugh-Jones and de Vos (2002) found that high proportions of young animals can be left in the wake of an epidemic.

Habitat Heterogeneity

Spatial irregularity on the landscape introduces a difference between the total prey population density and the proportion that is actually available to the predator (Gorini *et al*. 2012). Sinclair (1979) hypothesized that in heterogeneous environments where prey have opportunities to avoid encounters with predators, prey populations would fluctuate and become food limited. However, in more homogeneous environments where they are in closer association, predators could have a stronger impact on prey. Gates *et al*. (2005) reviewed the various ways that ungulates find refuge from predators during the critical time when calves were most vulnerable, and found that ungulate populations that employed this strategy outnumbered conspecific populations that did not seek refuge.

Carbyn *et al*. (1993) proposed the 'habitat dispersion hypothesis' to account for the decline of bison in Wood Buffalo National Park between 1971 and 1991, whereby this decline was unique to the Peace-Athabasca Delta and did not occur north of the Peace River. Bison use forest patches for escape as an anti-predator strategy (Fuller 1960). Carbyn *et al*. (1993) suggested that bison have a greater predation risk in the large meadow complexes of the delta, compared to other areas north of the Peace River where forest and meadow habitats are more interspersed. The expansive open habitats of the delta lack escape cover, contain highly predictable bison concentrations for wolves, and provide fewer moose as alternate prey. Carbyn *et al*. (1998) stated that extensive delta foraging areas have been underutilized by bison, and Carbyn *et al*. (1993) raised the possibility that bison may not have been abundant in the Peace-Athabasca Delta in historic times even if the forage base could support higher numbers.

During their study from 1997 to 2001, Joly and Messier (2004b) stated that the Nyarling River subpopulation never exceeded 230 bison, and no wolf predation was observed. They suggested that moose were the main prey, and bison density was too low to maintain wolf densities high enough to be a significant source of bison mortality for this subpopulation. In the Greater Wood Buffalo metapopulation, wolf predation was highest in the Delta subpopulation (9-10%); however, they expected this rate to eventually drop as it did with the Hay Camp and Garden River subpopulations. Joly and Messier (2004b) rejected the 'habitat dispersion hypothesis' because their interpretation of population trends demonstrated that the 1976 to 1999 Hay Camp decline was indistinguishable from the 1981 to 1999 Delta decline.

Consequently, the negative trend in the Peace-Athabasca Delta was not unique within Wood Buffalo National Park. The interpretations differ primarily with regards to the validity of the Peace River as the boundary between the two main bison populations. North of the Peace River, Joly and Messier (2004b) recognized a zone of overlap between the Hay Camp and Delta subpopulations. They suggested that the Carbyn *et al*. (1993) demarcation based on the Peace River has not been adequately tested and may have obscured the dynamics of the Hay Camp subpopulation.

Calef (1976) noted that bison in the Mackenzie population were more likely to run from danger than those in the Slave River Lowlands. This behavioural difference may be because the marl lake meadows occupied by Mackenzie bison were surrounded by heavily forested escape cover, whereas the Slave River Lowlands contain more extensive meadows and less intervening forest. Alternately in the early 1970s bison in the Mackenzie were relatively naïve and new to the system and may have been more risk averse than bison in the Slave River Lowlands who had been present in the system for generations (Larter pers. comm. 2025).

Disease Vulnerability

During his disease survey in and around Wood Buffalo National Park between 1983 and 1985, Tessaro (1987) found that four out of five wolf-killed bison he examined exhibited extensive tuberculosis. Tessaro *et al.* (1990) proposed that advanced diseases predispose bison to predation, and that this should be considered when considering proportional mortality due to wolves. This was termed the 'disease-predation hypothesis' by Gates (1993). Until the 1970s, the Greater Wood Buffalo metapopulation grew in the presence of exotic diseases, but in the absence of substantial wolf predation (Joly and Messier 2004b). Decline of this population occurred in the presence of disease and predation from 1970 to 1999 (Van Camp and Calef 1987; Carbyn *et al.* 1993; Joly and Messier 2004b).

Joly and Messier (2004b) supported the 'disease-predation hypothesis,' whereby the presence of bovine tuberculosis and bovine brucellosis would likely reduce productivity of the bison population by suppressing birth rate and survival, and as a consequence, bison densities would be relatively low and regulated by wolf predation. The 'disease-predation hypothesis' also predicts that in the absence of wolf predation, bison populations would grow to high density in the presence of exotic disease.

Stochastic population simulations by Joly and Messier (2004b) showed that growth of bison populations in the absence of exotic disease exceeded the maximum wolf predation rate at all densities. Disease-free bison populations, regardless of anthrax or drowning episodes, were highly likely to persist at high densities that would be regulated by food competition. In contrast, simulations predicted that a bison population with tuberculosis and brucellosis was likely to decline to low densities, regulated by wolf predation, particularly when drowning and anthrax were added to the model. Joly and Messier (2004b) also stated that the difference between the simulated growth of bison populations with and without tuberculosis and brucellosis likely underestimated the true impact of exotic disease on bison productivity. These simulations implied that an interaction between tuberculosis, brucellosis, and predation may account for the decline in the abundance of bison in Wood Buffalo National Park from 1970 to 1999. Joly and Messier (2004b) acknowledged that surveys since the 1990s in Wood Buffalo National Park showed substantial bison population growth and interpreted this as indicating that the wolf population had declined, possibly because of disease or reduced prey availability. When heavy predation on the highly preferred calves results in scarcity, wolves need to rely on aged or other vulnerable adults as their primary prey. Low recruitment levels from the 1980s may not have provided enough geriatric prey to maintain high wolf populations. As a result, calf predation is relaxed, and recruitment may be increasing.

Bradley and Wilmshurst (2005) discounted the 'disease-predation hypothesis' on the grounds that all subpopulations did not decline, even though all were diseased. They disagreed with Joly and Messier (2004b) that the 1976 to 1999 Hay Camp decline was indistinguishable from the 1981 to 1999 Delta decline, because in concurrence with Carbyn *et al.* (1993), they assigned the overlap area north of the Peace River to the Hay Camp subpopulation. Their analysis indicated that the population decline was highest and juvenile survival was lowest in the Delta subpopulation, despite evidence that disease incidence was lower in the Delta subpopulation than in the rest Wood Buffalo National Park. Bradley and Wilmshurst (2005) used the same model and a similar data set as Joly and Messier (2004b) but chose different juvenile survival rates. Joly and Messier (2004b) proposed a 20% difference in juvenile survival rates between diseased and healthy populations based on the differences in recruitment data between Wood Buffalo National Park and the non-diseased Mackenzie bison of the Mink Lake area. This difference was assumed to be equivalent to the loss from brucellosis-induced abortion. Bradley and Wilmshurst (2005) questioned that assumption because the effects of brucellosis-induced abortion at the population level had not yet been studied, and juveniles were the age class least susceptible to disease effects. They also stated that the Wood Buffalo National Park juvenile survival rate in recent years had increased to a level equivalent to the Mink Lake rate reported by Larter *et al*. (2000), and even if it had not, the reason would not necessarily be related to disease. More recently, Fuller *et al.* (2007) has studied abortion effects at the population level for the Yellowstone National Park bison and calculated negative impacts on birth rate and population growth rate. In this case, study results showed that *Brucella*-exposed three-year-old bison have lower pregnancy and birth rates than older individuals and suggested that the elimination of brucellosis could affect an increase of 29% in population growth rates (Fuller *et al.* 2007).

Bradley and Wilmshurst (2005) believed that population data collected after Joly and Messier's (2004b) study altered change points and weightings in the bison population trajectories in such a way that validated the original proposal by Carbyn *et al.* (1993) that the decline of the Delta subpopulation was unique. Bradley and Wilmshurst (2005) also claimed that the decline between the 1970s and the 1990s would have occurred regardless of the disease status of the Wood Buffalo National Park population. They suggested that mortality due to predation was not strongly exacerbated by disease, since the Delta subpopulation had the highest predation rate, as well as the lowest disease prevalence. Survival of juveniles was likely an important determining factor affecting changes in population size.

Tessaro *et al.* (1990) suggested that availability of substantial numbers of debilitated bison maintains larger numbers of wolves, which would intensify the problem of poor recruitment of juveniles into the bison population. If a substantial proportion of the adult bison segment is more vulnerable to predation because of debilitating disease, wolf populations will increase and would, in turn, result in greater losses of calves because they are the most vulnerable to predation.

Alternate Prey

Summer is the critical season for survival of wolves (Mech 1970). This is when any form of alternate prey becomes most important (e.g., Kuyt 1972; Stahler *et al*. 2006) as adult ungulates are in peak physical condition and at lowest vulnerability.

Bison east of the Slave River (Hook Lake subpopulation) and south of the Peace River (Delta subpopulation) experience the most intense wolf predation in the Greater Wood Buffalo metapopulation (Van Camp 1987, Joly and Messier 2004b). This may be the result of higher summer survival rates of wolves due to the availability of alternate prey species unique to these two areas. Year-round food studies of wolves carried out east of the Slave River (Van Camp 1987) and in Wood Buffalo National Park (Carbyn *et al.* 1993) indicate that moose and muskrat are important alternate prey species. Of the four wolf packs studied by Van Camp (1987) from 1975-78 in the Hook Lake bison range, only two consumed a substantial about of bison during summer, and muskrat, hare and duck were more important than moose among all of the packs. Remains of muskrat and other aquatic species were also present much more frequently than moose in scats from the Peace-Athabasca Delta portion of the survey area (Carbyn *et al.* 1993). If muskrats provide a critical subsidy that improves summer wolf survival east of the Slave River and in the Peace-Athabasca Delta, the Hook Lake and Delta bison subpopulations may be inherently prone to higher predation than other herds.

For the Nyarling River subpopulation from 1997-2000, Joly and Messier (2005) found that annual survival of adult bison was nearly 100% and suggested that wolves relying on moose would incorporate bison into their diet when profitable. Although predation rates on bison may be low where smaller and less dangerous prey are available, In Prince Albert National Park, Simon *et al*. (2019) observed that wolves still selected areas intensively used by bison in all seasons even if attacking healthy adult bison was probably relatively costly for wolves. Simon *et al*. (2019) suggested that wolves in multi-prey systems could be monitoring areas intensively used by bison for the opportunity to encounter senescent, injured or very young individuals which are vulnerable to attack.

In the multi-prey system of the Ronald Lake bison range, Dewart (2023) discovered wolf diets in summer to be 77% beaver, and in winter to be 70% moose and white-tailed deer. Although predation on bison was relatively low, wolves spent more time in areas frequented by bison in late winter when they were most vulnerable.

Surplus Carrion

Periodic mass mortality events in bison populations, such as anthrax outbreaks, drownings, or harsh winter starvation, provide a massive food subsidy to predators. High wolf populations may persist and continue to exert heavy predation pressure asynchronously for many years after the mortality event because as George Calef stated "wolves did not just roll over and die" after the carrion disappears (Calef pers. comm. 1980). Availability of bison carcasses after an anthrax outbreak benefits wolves at the time of year when sufficient nourishment for their pups is most critical. The flooding of the Peace-Athabasca Delta from spring until autumn of 1974 that drowned about 3,000 bison probably boosted the wolf population, and a spillover effect may have contributed to the rapid increase in the Slave River Lowlands wolf population in the following years (Calef 1976). Bison killed on highways are another source of carrion, and this subsidy can be substantial in some years along Hwy 3 between Fort Providence and Behchokǫ̀ (Armstrong pers. comm. 2025).

POSITIVE INFLUENCES

Efforts to Reduce Human-caused Mortality

The most effective management intervention influencing the recovery of wood bison herds in the NWT was the introduction of hunting restrictions, which removed the most devastating source of mortality for these animals (Radford 1911, Hewitt 1921). After a recovery from the 1964-65 depopulation, the Grand Detour/Little Buffalo herd quickly re-established and has remained viable. Vaccination rounds-ups have also been discontinued, due to the disruptive effects of these programs.

Today, harvest is prohibited inside Wood Buffalo National Park (*Canada National Parks Act* 2018). Because wood bison in the NWT were designated as a species in danger of becoming extinct under regulation (*Game Declared in Danger of Becoming Extinct*, C.R.C., c. 1236, enabled by the *Northwest Territories Act*), the reintroduced Mackenzie and Nahanni populations were also granted special protection. These measures were carried over in the regulations when the new NWT *Wildlife Act* (SNWT 2014, c 31) came into force in November 2014.

Harvest levels of Mackenzie and Nahanni bison are managed through adaptable quotas (Big Game Hunting Regulations, R-019-92; ENR 2018; ENR 2019). The Nahanni population has a quota of seven bulls. Quotas for the Mackenzie population were adjusted after the 2012 anthrax outbreak, when all hunting of the Mackenzie population was halted to allow the population to recover (except for 4-5 males harvested annually by the Deh Gáh Got'ı̨ę First Nation under a Wildlife Permit). With population recovery well underway by 2021, the quota for the Mackenzie population was raised to 40 bulls (Armstrong pers. comm. 2025; CMA 2025).

General Hunting Licence harvest from the Slave River Lowlands subpopulations outside of Wood Buffalo National Park (Hook Lake and Grand Detour) is unregulated, and other NWT residents may purchase one bison tag per year for hunting. Resident hunters must report on their bison hunts but data on Indigenous harvest of bison in the Slave River Lowlands are not collected (Armstrong pers. comm. 2025). The current co-management approach with the Mackenzie, Nahanni, and Slave River Lowlands bison working groups and management plans shares the commitment for appropriate conservation measures. In accordance with management plans and working group recommendations, harvest quotas for Mackenzie and Nahanni populations are formulated as a percentage of total population size with consideration of recent trends (ENR 2018; ENR 2019).

To help reduce vehicle collisions with bison, the GNWT Department of Environment and Climate Change (ECC) and Department of Infrastructure (INF) carry out an annual awareness campaign every September-November (when most collisions occur) to remind drivers to be cautious where bison frequent highways. Highway signage is also displayed on Highway 3 between Fort Providence and Yellowknife where bison are often encountered. Also, ECC and INF produced and distributed a brochure on 'Safety in Bison Country' to address safety for drivers, cyclists and pedestrians. Ecology North developed a wood bison education and awareness project, funded by the NWT Species Conservation and Recovery Fund (SCARF).

To help mitigate the risk of bison drownings from boat and barge traffic on the Liard River, animals were collared to identify when and where they have highest probability of swimming across the river (Thomas *et al*. 2022b).

Habitat Conservation

In the late 1990s, the issue regarding agriculture in the Mills Lake-Horn River Delta was finally resolved when Ducks Unlimited Canada bought out the leases. This area was transferred to the federal government upon establishment of the Edéhzhíe Dehcho Protected Area and National Wildlife Area (ECCC 2022). This initiative effectively removed a major threat to wood bison habitat.

From a continental perspective, the Wildlife Conservation Society set a vision for the ecological future of the North American bison (Redford and Fern 2006). In 2008, ecologists, experts and stakeholders from across North America released the *Vermejo Statement* which articulated this vision of multiple large herds within extensive landscapes (Sanderson *et al.* 2008).

Wildfire

Frequent wildfires in bison range seem to have produced the greatest results for habitat restoration (Chowns pers. comm. 2025). However, ignitions are impossible to predict, and spread is driven by weather. In recent years, the natural role of fire in ecosystems has become better understood and is recognized in the NWT's *Forest Fire Management Policy* (GNWT 2005), and the Parks Canada policy on ecosystem-based management (Parks Canada 2015). As resource managers and the public develop a better understanding of the natural role of fire in the ecosystem, and how to use it safely for resource management, there may be greater confidence in using fire as a bison habitat improvement tool. The NWT *Forest Act* provides for defined burning prescriptions to achieve forest management and other land use objectives (GNWT 2023). In a study that included Wood Buffalo National Park, Parks *et al*. (2018) investigated how burning reduces the probability of subsequent fire within the footprint of previously burned areas. They concluded that this self-limiting feedback is a fundamental ecosystem process and will help maintain landscapes in a state that is resilient to excessively large fires in future years.

If fire is to be an effective tool for improving bison habitat, resource managers would also need to consider the risk to other values (e.g. boreal caribou habitat; human life and property). The number of wildfires and the area burned each year in the NWT fluctuate dramatically (ENR 2015a). Management actions depend on the location of the fire, availability of resources, fire behaviour and the potential to affect human life, property, natural resource values and cultural resource values (GNWT 2005). A fire management strategy accommodating both caribou and bison is possible if the two species are partitioning the landscape. Large tracts of habitat preferred by caribou maintained by low fire frequency would be compatible with smaller tracts of habitat occupied by bison maintained at higher fire frequencies.

Managing Genetic Diversity

One of the most profound management decisions for bison was to follow the recommendation of Van Zyll de Jong *et al.* (1995) that all wild populations of bison in northern Canada be considered wood bison. A minimum standard based on science has now become established for starting new wood bison populations. To retain 99% of genetic variation, Wilson (2001) recommended an effective population size of 50, but because few males breed every year, a reasonable sex ratio would be 25% males and 75% females. For that reason, at least 67 animals is the new standard for founding herds.

McFarlane (Zittlau) *et al*. (2006) developed a simulation modeling approach to evaluate genetic management strategies and the relative effects of wood bison population size, number of populations, movement of animals between populations, and harvesting or culling regimens on genetic diversity. Their recommendations included conducting additional genetic salvage from diseased bison in and around Wood Buffalo National Park to ensure that diversity of the wood bison genome was well represented and conserved in disease-free populations. Each salvage effort was based on a large number of founding individuals, using the most genetically important disease-free populations as the primary source for creating new disease-free populations, and managing individual wood bison herds above a minimum population size (i.e., census size > 400 individuals). They also recommended gene flow via movement of animals among all herds to reduce the rate at which diversity is lost, but giving population growth precedence over gene flow when populations are below carrying capacity.

Advances in reproductive technology are continuing to find ways to salvage valuable genetic material from diseased populations. Developments in assisted reproductive technologies conserve genetic diversity from infected herds (e.g., Robison *et al.* 1998; Thundathil *et al.* 2007; Aurini *et al.* 2009).

The Bison Integrated Genomics (BIG) project was launched in 2022 as a three-year project funded by Genome Canada in collaboration with Parks Canada and the University of

Saskatchewan. Its goal is to ensure the existence of healthy, genetically diverse bison populations that includes long-term sustainability (BIG Project 2022). The Nahanni and Mackenzie populations were founded with low numbers of animals with reduced genetic diversity and are particularly vulnerable to genetic drift. These effects increase probability of extirpation without gene flow between isolated populations (Frankham *et al*. 2011). Through advances in the integrated use of genomics, the BIG Project hopes to produce disease-free gametes and embryos from genetically isolated bison herds to restore genetic connectedness among existing populations. Using germplasm to increase genetic diversity in isolated disease-free herds may be the most appropriate way to increase genetic diversity without the risk of disease transfer (Shury pers. comm. 2025).

Safeguarding Genetic Integrity

The federal (Canadian) *Species at Risk Act* (2002) includes any "subspecies, varieties or geographically or genetically distinct population" in its definition of wildlife species, and the *Species at Risk (NWT) Act* (2009) allows a distinct population (defined as "a geographically or biologically distinct population of a species or a distinct population identified by the Conference of Management Authorities") to be assessed. These measures affirm that taxonomic entities below the species level also need protection for conservation of biological diversity. Subsequently developed *Guidelines for Recognizing Designatable Units* approved by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in November 2020 clearly deem wood bison in northern Canada to be a discrete population that requires its own management plan (COSEWIC 2022).

Such decisive actions recognize that wood bison and plains bison are on different evolutionary pathways that must not be impeded by undue human interference. Accordingly, federal, territorial and provincial wood bison management and recovery plans contain goals and objectives that conform to this position. The *Recovery Strategy for Wood Bison in the Northwest Territories* (CMA 2019) calls for the prevention of hybridization of wood bison with plains bison, domestic bison and cattle by not allowing domestic bison or plains bison to enter wood bison range in the NWT.

Managing Disease

The Greater Wood Buffalo metapopulation persists with tuberculosis and brucellosis at population numbers that have never dropped below 2,200 animals (Joly and Messier 2004a). This level is safely above 1,000, the number considered for a bison population to be ecologically restored (Sanderson *et al.* 2007). Generations of natural selection ought to be providing some measure of inherent disease resistance. Natural immunity to bacterial diseases has been known for centuries, but the genetic implications are only recently being understood; new tools are now providing a better understanding of the genetic basis for innate resistance or susceptibility (Adams and Schutta 2010).

Considering a 31.2% seropositive rate for brucellosis (Choquette *et al.* 1978), and tuberculosis incidence at less than 39% (Fuller 1961, 1966), Carbyn *et al.* (1993) suggested that such low rates of disease amongst gregarious bison could be a measure of acquired resistance.

Monitoring and removal of bison in the Bison Control Area between Wood Buffalo National Park and the Mackenzie River has continued since 1987 to reduce the risk of contact between infected and non-infected wild bison populations (CMA 2025).

Promoting natural resistance to bacterial infection in domestic cattle is an attractive alternative for disease control. When unvaccinated cattle were inoculated with *Brucella abortus* in a study by Templeton *et al*. (1990), 18% of the animals exhibited natural resistance to brucellosis. Westhusin *et al*. (2007) have reported the rescue of a genome providing natural disease resistance to brucellosis, tuberculosis, and *Salmonella* in cattle.

The Bison Integrated Genomics (BIG) Project, launched in 2022, aims to reduce the prevalence of tuberculosis and brucellosis and protect bison that are disease-free by developing new strategies to rapidly diagnose these two diseases. Although preliminary trials with vaccines for tuberculosis have not demonstrated a complete cure, they have shown a reduction in lesion severity in lungs and lymph nodes, and a lower bacterial burden (Niroula *et al.* 2025). The project team is also working to develop a combined tuberculosis and brucellosis vaccine that could be delivered orally to wild bison populations, as oral vaccines are much more feasible for vaccine delivery on a landscape scale. (BIG Project 2024; Shury pers. comm. 2025).

Routine aerial anthrax surveillance flights are conducted each summer, supplemented by observations during departmental fieldwork. An enhanced surveillance program follows the detection of a suspected outbreak, and the Anthrax Emergency Response Plan is implemented when an anthrax outbreak is confirmed (Elkin *et al*. 2020). The plan includes surveillance, testing, scavenger prevention, disposal of carcasses, decontamination of sites, and human health protection. The Anthrax Emergency Response Plan is continually reviewed and updated using the best available information and experience from previous outbreaks.

Range Expansion

Catastrophic events causing mass mortality are generally sudden, while climatic oscillations often follow multi-decadal trends before they shift. Both have localized effects on wood bison populations. The most effective protection against them is dilution of risk by population dispersal over wide areas. The Greater Wood Buffalo metapopulation has essentially reached its limits of distribution in the NWT, bounded by the Precambrian Shield, Great Slave Lake and the Bison Control Area, but the Nahanni and Mackenzie populations still have potential area for range expansion where there are no major ecological barriers. As this proceeds, the risk of a significant proportion of the population falling victim to a local catastrophe or adverse climate diminishes.

Interagency Cooperation and Co-management Partnerships

In the past, northern bison were managed in accordance with federal, territorial and provincial government mandates which did not always share the same objectives. Now that the Greater Wood Buffalo metapopulation has been recognised as a distinct entity, subpopulations inside Wood Buffalo National Park are managed cooperatively with those subpopulations ranging outside of the park (either in Alberta or the NWT). Wood bison occurring in Alberta are now provincially listed as *Threatened*, whereas before 2021 they were not designated as wildlife in that province and offered no protection from hunting outside of protected areas (Government of Alberta 2021). The Nahanni population also extends across several jurisdictions and is managed collaboratively by the governments of Canada (Parks Canada, Nahanni National Park Preserve), the NWT, Yukon and British Columbia.

The Conference of Management Authorities on Species at Risk (CMA) was established under the *Species at Risk (NWT) Act* to partner the Government of the Northwest Territories and the Government of Canada with wildlife co-management boards and Indigenous governments in the NWT. These Management Authorities share responsibility for the listing, conservation, and recovery of wood bison and other species at risk in the NWT (CMA 2025). Under these terms, the Recovery Strategy for Wood Bison *(Bison bison athabascae)* in the Northwest Territories was developed (CMA 2019), followed by the Progress Report for the Recovery Strategy for Wood Bison (*Bison bison athabascae*) in the Northwest Territories (2020-2024) (CMA 2025).

In addition, working groups have been established to provide direction and perspectives for managing NWT wood bison populations, consisting of the Mackenzie Bison Working Group, the Nahanni Bison Working Group, and the Slave River Lowlands Bison Working Group. Membership extends to the community organizations that are stakeholders in the management and recovery of wood bison. Through collaborative efforts, the Mackenzie Bison Management Plan, Nahanni Bison Management Plan, and the Slave River Lowlands Bison Management Plan have been completed and implementation is underway through the working groups.

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AUTHORITIES CONTACTED

2026 Update

Indigenous Organizations, Resource Management, and Wildlife Advisory Boards

Stephanie Behrens	Wildlife Biologist, Tłı̨chǫ Government, Behchokǫ̀
John Nishi	Biologist Consultant, Tłı̨chǫ Government, Millarville, AB

Territorial Government Contacts

Dr. Terry Armstrong	Bison Ecologist, Fort Smith
Dr. Naima Jutha	Wildlife Veterinarian, Yellowknife
Dr. James Hodson	Regional Biologist, North Slave Region, Yellowknife
Michael Gast	Wildlife Technician II, Dehcho Region, Fort Simpson
Dr. Brad Woodworth	Climate Change Ecologist, Yellowknife
Robin Abernethy	Climate Change Ecologist (former), Yellowknife
Robert Gau	Manager, Biodiversity Conservation
Joanna Wilson	Wildlife Biologist (Species at Risk), Yellowknife
Claire Singer	Wildlife Biologist (Biodiversity) (former), Yellowknife
Allicia Kelly	Biologist (Environmental Assessment) (former), Yellowknife
Lisa Smith	Manager, Forest Resources, Hay River Reserve

Federal Government Contacts

Jenna Rabley	Ecologist Team Lead, Parks Canada, Fort Smith
Dr. Todd Shury	Manager, Wildlife Health and Management, Parks Canada, Saskatoon, Saskatchewan

Other Species Experts

Dr. Nicholas (Nic) Larter	Wildlife Biologist (ret.), Grande Prairie, AB

2016 (past) SARC Report

Indigenous Organizations, Resource Management, and Wildlife Advisory Boards

Jody Pellissey	Executive Director, Wek'èezhìı Renewable Resources Board, Yellowknife, NT

Territorial Government Contacts

Allicia Kelly	Regional Biologist, South Slave Region, Environment and Natural Resources, Fort Smith, NT
Dr. Brett Elkin	Disease/Contaminants Specialist, Environment and Natural Resources, Yellowknife, NT
Dean Cluff	Biologist, North Slave Region, Environment and Natural Resources, Yellowknife, NT
Dr. Nic Larter	Manager, Wildlife Research and Monitoring, Dehcho Region, Environment and Natural Resources, Fort Simpson, NT
Rob Gau	Manager, Biodiversity Conservation, Environment and Natural Resources, Yellowknife, NT
Dr. Terry Armstrong	Wildlife Biologist – Bison, Environment and Natural Resources, Fort Smith, NT
Troy Ellsworth	Regional Superintendent, South Slave Region, Environment and Natural Resources, Fort Smith, NT

Federal Government Contacts

Donna Bigelow	Species at Risk Biologist, Environment Canada, Yellowknife, NT
Dr. Greg Wilson	Species at Risk Biologist, SAR Recovery Unit, Environment Canada, Edmonton, AB
Robert Kent	Southwest NWT Field Unit Superintendent, Parks Canada, Fort Smith, NT
Stuart MacMillan	Manager, Resource Conservation, Parks Canada, Fort Smith, NT

Other Species Experts

Dr. Cormack Gates	Dean, Faculty of Environmental Design, University of Calgary, Calgary, AB
Dr. Damian Joly	Associate Director, Wildlife Health Monitoring and Epidemiology, Wildlife Conservation Society Canada, Toronto, ON
Jack Van Camp	Biologist, self-employed, Fort Smith, NT
John Nishi	Biologist, EcoBorealis Consulting Inc., Millarville, AB

Keith Aune	Senior Conservationist and Bison Coordinator, Wildlife Conservation Society, Boseman, Montana
Dr. Ludwig Carbyn	Adjunct Professor, Wolf-Bison Biologist, University of Alberta, Edmonton, AB
Sonja Leverkus	PhD Candidate, Oklahoma State University, Stillwater, Oklahoma
Wes Olson	Wildlife Specialist, Bison Consulting Services, Val Marie, SK

BIOGRAPHY OF PREPARER

Tom Chowns received his Bachelor of Science degree, majoring in Wildlife Biology, from the University of Guelph in 1975. His first introduction to the status of wood bison in the NWT was from Dr. Nick Novakowski (Canadian Wildlife Service) who visited the university in 1974 as a guest speaker. Tom was employed by the Government of the Northwest Territories Department of Environment and Natural Resources from 1975 to 2002, and since then, he has been an environmental consultant.

For most of his career, he was a field officer in Hay River where wood bison management was a prime responsibility. Field experience included assisting Regional Biologists and Bison Ecologists with studies of bison populations using ground and aerial census techniques, age and sex segregation surveys, radio telemetry, collection of biological samples, monitoring the Bison Control Area, prey selection among wolf populations, seasonal changes in forage selection, and habitat assessment using satellite imagery, ground truthing and GIS. As a nationally-certified Wildland Fire Behaviour Specialist, he supervised the prescribed burning program for bison habitat improvement.

Tom was also very involved with the Fort Providence Integrated Resource Management Plan, the species management plan for wood bison, the Ten-Year Prescribed Burn Plan for the Wood Bison range, the forest fire history of the Fort Providence land base, a study of the historic range of wood bison, ecosystem-based forest policy, departmental input into species at risk legislation, and the Protected Areas Strategy.

Presentations and technical papers were contributed to proceedings of the Interior West Fire Council, and North American Bison Symposium regarding prescribed burning in bison habitat. Writing also included internal manuscript reports on bison, and co-authoring the chapter entitled "Wood Bison at the Crossroads" in the publication "Buffalo."

Cooperative and advisory roles with other groups included Parks Canada and Alberta Environmental Protection regarding inter-jurisdictional bison issues, the Wood Bison Recovery Team, the U.S. Fish and Wildlife Service with their proposed reintroduction of wood bison into Alaska, World Wildlife Fund (WWF) and the Canadian Parks and Wilderness Society (CPAWS) regarding bison habitat protection. Tom has been a member of the IUCN/SSC Bison Specialist Group/North America and the Bison Centre of Excellence.

Since becoming an environmental consultant, Tom has compiled reports entitled State of the Knowledge of Woodland Caribou in Ontario – 2003 for the Forestry Research Partnership (industry and government), and Ecological Interactions among Caribou, Moose, and Wolves: Literature Review for the National Council of Air and Stream Improvement (NCASI). He has also been an invited observer to a series of Northeast Region Caribou Task Team meetings attended by representatives of all stakeholders from Ontario. Tom authored the chapter "Review of Literature on Ungulate Movements" in The Ecology of Bison Movements and Distribution In and Beyond Yellowstone National Park submitted to Yellowstone National Park. He has been the primary author of wildlife sections in Ecological Regions of the Northwest Territories series of reports (Taiga Plains, Taiga Shield, Cordillera, Southern Arctic, and Northern Arctic), and conducted a literature review for distribution and abundance for all mammals and birds found in the NWT for the wildlife species range mapping project.

Tom is a Managed Forest Tax Incentive Plan approver for a program that rewards Ontario landowners for good forest stewardship. He is also working on a multi-year research project on the history of caribou in North America as related to their current status.

STATUS AND RANKS

Wood Bison (*Bison bison athabascae*)

Region	Coarse Filter (Ranks)[3] To prioritize	Fine Filter (Status) To provide advice	Legal Listings (Status) To protect under species at risk legislation
Global	T3 – Vulnerable (NatureServe 2018)	NT – Near Threatened (IUCN Red List 2016)	Appendix II (CITES 2006)
Canada	N3 – Vulnerable (NatureServe 2024)	Special Concern (COSEWIC 2013)	Threatened (SARA 2003)
Northwest Territories	**At Risk (NWT General Status Ranking Program 2020)** **S2 – Imperiled (NatureServe 2024)**	**To be determined**	**Threatened (SARA NWT 2017)**
Adjacent Jurisdictions			
British Columbia	S2 – Imperiled (NatureServe 2024)		Red List
Alberta	S2 – Imperiled (NatureServe 2024)		Threatened (*Wildlife Act* 2021)
Saskatchewan	SX – Presumed Extirpated (NatureServe 2024)		
Manitoba	SNA – Not Applicable (NatureServe 2024)		

[3] All NatureServe codes are as defined in Definitions of NatureServe Conservation Status Ranks: http://help.natureserve.org/biotics/Content/Record_Management/Element_Files/Element_Tracking/ETRACK_Definitions_of_Heritage_Conservation_Status_Ranks.htm#NatureSe

Yukon	S3S4 – Vulnerable to Apparently Secure (NatureServe 2024)		

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APPENDIX A1 – NAMES AND CLASSIFICATION

The concept of species is based on the premise that for an interbreeding group of individuals to maintain itself in nature, the unit must be reproductively isolated from its close relatives (Van Gelder 1977). The criteria for defining higher and lower taxonomic levels (e.g. genus and subspecies) are much more subjective. Classification of wood bison at the genus level is not without controversy. There is debate about whether *Bison* is a valid genus or should be united with *Bos,* and whether the genus *Bos* should be further subdivided (e.g., Nijman *et al*. 2008). Much of the disagreement stems from how the concept of species is applied. Van Gelder (1977) maintains that if reproductive incompatibility is accepted as the upper limit to species differentiation, then it should at least be the lower limit in the definition of genus, and hybridization between different genera at a higher taxonomic level should not be achievable. Van Gelder (1977) advocated the union of *Bison* with *Bos* arguing that *Bison* are able to produce viable offspring with several (if not all) species of *Bos*, thereby exceeding the lower limit in the definition of genus. Subsequent calls to combine *Bison* and *Bos* into one genus based on phylogenetics have followed (e.g. Groves 1981; Baccus *et al.* 1983; Miyamoto *et al.* 1989; Wall *et al*. 1992; Modi *et al.* 1996; Ghassemi-Khademi *et al*. 2021). Acknowledging the ongoing research and debate by taxonomists and the bison conservation community, the American Bison Specialist Group (ABSG) has not supported a change in nomenclature from *Bison* to *Bos* (Boyd *et al*. 2010a; Plumb *et al*. 2024).

The American bison (*B. bison*) and the European bison (*B. bonasus* Linnaeus 1758) are recognized as the two extant species of bison (Boyd *et al*. 2010a; Plumb *et al*. 2024). Some proponents (e.g., Van Zyll de Jong 1986; Corbet and Hill 1991) have suggested that because of morphological similarity between American bison and European bison and their capacity to interbreed, their taxonomic relationship should be at the subspecies level. Studies of the taxonomic position of American and European bison have not led to a definite conclusion (Prusak *et al*. 2004). Nucleotide sequencing of a mitochondrial cytochrome gene by Janecek *et al.* (1996) was indicative of the genus *Bison* being paraphyletic, with American bison being more closely related to species of *Bos* than to European bison. Amplified fragment length polymorphism (AFLP) fingerprinting by Buntjer *et al*. (2002) placed American and European bison in one of the three bovine clusters, and the technique could not assign a consistent placement for yak. Phylogeny of bovine species based on three mitochondrial DNA (mtDNA) sequences studied by Verkaar *et al.* (2004) showed a closer affinity of American bison to yak, whereas European bison were closer to cattle. In contrast, their Y chromosomal analysis supported closer association between American and European bison. As an explanation for this discrepancy, Verkaar *et al.* (2004) proposed 'transpatry,' whereby the European bison could be the result of an ancient Eurasian cattle-like population that was changed by repeated introgression of genes from dominating bison bulls. Hypothetically, this hybridization eventually created a new species with bison-like appearances, autosomal genes and Y chromosomes, but with the original mtDNA from the maternal cattle-like ancestors. The idea would also explain the sudden paleontological appearance of the European bison without clearly identifiable ancestors. With the advent of genetic analysis, hybridization between closely related species and subspecies has proven to be more common than previously supposed, and may actually have important effects on the dynamics of hybrid zones, speciation, and adaptive radiation (Grant *et al*. 2005). To account for uncertainty around phylogenetic reconstruction of the two species of bison and yak, MacEachern *et al*. (2009) considered double mutations and introgressive hybridization, but found more support for lineage sorting from an ancestral species with a large polymorphic population.

Bison Evolution

Because the small, isolated populations of *B. bison* (modern bison) are poor representatives of the dynamic ecosystems they were once part of, Cannon (2001) suggested that the long prehistoric baseline of conditions that bison endured can provide insights for future management decisions. The progression from the ancestral bovine progenitor to modern wood bison has been punctuated by a series of profound environmental events. In the Late Miocene epoch, ancestral bovines developed robust dentition for grazing fibrous, gritty grasses that were evolving together on the subcontinent of India. Climate changes led to the expansion of grasslands and bovine invasions of Africa, Asia and Europe (Agustí *et al*. 2001; Bibi 2007). Bovina (cattle, bison and yak) invaded cooler temperate habitats, splitting from Bubalina (African and Asian buffaloes), which invaded tropical regions. Climate changes in the Pliocene epoch also favoured grasslands, thus permitting the ancestral Bovina to become much more widely distributed (MacEachern *et al*. 2009).

The Pleistocene epoch followed from about 2.6 million to 11.7 thousand years before present (ka) and was characterized by repeated glaciations. Ecological changes associated with the earliest severe glacial advance probably caused Bovina to split very rapidly into taurine cattle, Indochinese cattle, and bison/yak. *Bison sivalensis* (Lydeckker 1878), the earliest identifiable form of bison, probably originated in the Himalayan foothills of northern India (Flerov 1979).

According to Guthrie (1970), the large bovid grazing niche in northern Eurasia was occupied primarily by bison. They were competitively excluded from the warmer south (including tropical regions) as this large bovid grazing niche was claimed by wild cattle species such as auroch (*Bos primigenius*), zebu (*B. indicus*), banteng (*B. banteng*), kouprey (*B. sauveli*), gaur (*B. gaurus*); and the true buffalo genera *Syncerus* and *Bubalus*. Steppe bison (*Bison priscus*) evolved as changing climatic conditions extended cool grasslands across northern Eurasia.

When Ice Ages advanced, lower sea levels exposed 1,600-kilometre-wide plains from the Bering and Chukchi seafloors between Asia and North America (Creager and McManus 1967). This formed a continuous unglaciated refugium (Beringia), too arid for ice to accumulate, that extended from eastern Siberia to most of Alaska, northern Yukon, and reached as far east as the southern Arctic coast of the NWT. This land bridge allowed *B. priscus* to enter North America. Although bison did not penetrate southern Eurasia because of competitive exclusion – Guthrie (1970) hypothesized that *Bison* and *Bos* acted as biotic barriers to each other due to having similar diets – there was no such limitation in North America. The earliest wave of bison 195-130 ka underwent considerable range expansion and phylogenetic change in the New World that was unparalleled in the Old World (Guthrie 1970; Froese *et al*. 2017). Younger mtDNA sequences of bison specimens from Beringia identified a later wave of *B. priscus* to North America 45-21 ka that did not invade the mid latitudes (Shapiro *et al*. 2004; Froese *et al*. 2017).

The Ice Ages of the Pleistocene created unprecedented evolutionary turmoil in mammals, producing giant ungulates with enormous horns, antlers, ossicones and tusks (Geist 1971). According to Geist's (1971) *dispersal theory*, pioneering populations of *B. priscus* encountered a superabundance of high-quality forage in the vacant habitat of Beringia, leading to high growth rate and rigorous social interactions. Strong selection for large body and horn size, especially on the dispersing fringe, did not subside until the habitat became saturated. The first waves of steppe bison across the land bridge were able to penetrate midcontinent North America during deglaciations and evolve into giant forms with massively spreading horns such as broad-headed bison (*Bison latifrons* Harlan 1825) and large-horned bison (*Bison crassicornis* Richardson 1854). The return of the Ice Ages blocked gene flow between Beringia and the rest of North America.

McDonald (1981) described bison evolution as rapid morphological, behavioural and ecological adaptations to new environments, followed by relative stability, until the next environmental change displaced the old selection regime. Rapid evolution over compressed time periods suggests that all bison, living and extinct, were very closely related. Although many forms have been named as separate species, limited coexistence among extinct bison suggests that there may have been a continuum of evolution within one variable chronospecies (Guthrie 1970; Van Zyll de Jong 1986; Hill *et al*. 2008; Wilson *et al.* 2008; Martin *et al*. 2018).

According to Shapiro *et al*. (2004), the early cold periods of the last glaciation provided arid conditions most favourable for the expansion of grasslands in Beringia. Consequently, its bison population grew large and diverse, represented by three distinct genetic lineages (*clades*). Saiga antelope (*Saiga tatarica*), now restricted to Eurasia, were widespread in Beringia, and remains have been found as far east as the Baillie Islands on the southern Arctic coast of the NWT (Harington and Cinq-Mars 1995). Harington (1981) described saiga as an environmental indicator species of arid, level, low-lying steppe grassland, warm summers, and severe winters with thin snow cover. There are many theories to account for the unique character of these grasslands in Beringia, so different from the tundra vegetation of today (e.g., Zimov *et al*. 1995; Guthrie 2001; Walker *et al*. 2001; Hu *et al*. 2002; Williams *et al*. 2004; Swanson 2006; Kienast *et al*. 2008; Doughty *et al*. 2010). In his analysis of plant tissue samples taken from molars of fossil Beringian bison, Guthrie (2001) found that grasses were overwhelmingly represented, compared to sedges and other forages. A brief interval of warmer and wetter climate 37,000 years ago initiated a dramatic reduction of the bison population, as tree cover replaced much of the grassland (Drummond *et al*. 2005).

While full glacial aridity expanded bison habitat in Beringia, moister conditions south of the ice sheets in North America created an opposite effect. Most of the Great Plains became forested, restricting bison mainly to enclaves of savannah woodland in southern parts of the continent, and steering morphological evolution in *latifrons* and *crassicornis* towards browsing adaptations (McDonald 1981).

When the ice began rapidly retreating about 14,000 years ago, Beringian bison expanded eastward into the NWT, and a partially preserved *priscus* carcass was discovered at Tsiigehtchic in the upper Mackenzie Delta, dated to a radiocarbon age of 11.8 ka (Zazula *et al*. 2009). This period was dominated by birch, with considerable representation of willow, buffaloberry, sagebrush, grasses and sedges (MacDonald and Ritchie 1986).

Routes followed by people into North America were free of ice, and a severe population bottleneck in Beringian bison coincided with the arrival of humans (Drummond *et al*. 2005). Much of Beringia disappeared under rising seas, and moister conditions resulted in the conversion of grassland habitats (which supported bison and the other grassland specialists such as mammoth, horse, camel and saiga) to forest habitats utilized by browsers such as moose (Guthrie 2001). Some Beringian bison began to evolve into the smaller *B. occidentalis* about 13 ka to 12 ka (Guthrie 1980; Stephenson *et al*. 2001; Boyd 2003). Indeed, *B. occidentalis* persisted in Alaska until about 1730 BP (Wilson *et al.* 2008).

In contrast to Beringia, southerly latitudes of North America experienced drier climate patterns after deglaciation, allowing grassland to replace forest. Following a gradual tendency toward smaller size and advanced adaptations to grazing, ancient bison (*B. antiquus* Leidy 1852) evolved from *B. latifrons*, and advanced across the Great Plains (Schultz and Hillerud 1977; McDonald 1981).

Around 13 ka, a western corridor emerged between Beringia and the mid latitudes of North America after the cordilleran and continental ice sheets separated, proglacial lakes subsided, and open vegetation became established on recently exposed substrates (MacDonald and McLeod 1996; Heintzman *et al*. 2016). This offered an opportunity for Beringian and southern bison populations to remix, before forest expansion into the corridor diminished their habitat. Although bison from the south penetrated the corridor at least as far north as the Liard River, there is no maternally inherited mitochondrial DNA (mtDNA) evidence of further dispersal into Alaska or the Yukon (Heintzman *et al*. 2016). Also, Beringian bison appear to have accomplished only a minor southern advance before they became extinct and contributed no mtDNA to modern bison (Shapiro *et al*. 2004; Douglas 2006).

In addition to the north-south ice-free corridor, bison remains from Tsiigehtchic, NWT provided evidence of a west to east expansion pathway from Beringia (Heintzman 2016).

The southern ice margins rapidly receded 13 ka to 11 ka (Dyke 2004), and during this time stated that *antiquus* underwent a rapid evolution to the smaller-sized, highly variable American bison (*Bison bison*) in the mid-latitude grasslands of North America (McDonald 1981; Shapiro *et al*. 2004; Wilson *et al*. 2008). Human predation, extinction of megacarnivores and many competitors (e.g. horses, camels, mammoths), and/or a warming climate that altered metabolic demands and reduced forage quality may have been factors in this bison size diminution (Hill *et al*. 2008; Martin *et al*. 2018). Mid latitude bison also increased in abundance at this time, which could represent a demographic release from competition with other large grazers (Wendt IV 2023).

Following the Pleistocene, the Holocene epoch commenced about 11.7 ka and continues to this day. The *Holocene Climatic Optimum* was a west to east time-transgressive warming trend that maximized in Alaska and northwestern Canada 11 ka to 9 ka (Kaufman *et al*. 2004). Spruce forest expanded rapidly northward into the NWT (Ritchie and MacDonald 1986). Along with drier conditions, the spread of the Grassland biome accelerated across the Great Plains and extended north into what is now the boreal forest biome (Ritchie 1976; Vance *et al*. 1995). Excessive aridity resulted in bison advances towards wetter and cooler ranges at higher latitudes and elevations (Wendt IV 2023).

After the Early Holocene period of rising temperatures, the Middle Holocene emerged at the onset of the greatest drop in temperatures of the entire epoch, occurring around 8.2 ka (Walker *et al*. 2018a). Bison centres of distribution retreated southward as arid conditions eased, allowing increased forage production and improved water availability, while northerly latitudes received greater snowfall (Wendt IV 2023). Increases in vegetation cover induced a warming trend that peaked around 6 ka (Thompson *et al*. 2022). Although Wilson (1969) and McDonald

(1981) suggested that the smaller modern American bison (*B. bison*) began differentiating from western bison (*B. occidentalis* Lucas 1899) in this period, Wilson *et al.* (2008) identified a taxonomic inconsistency with *B. occidentalis.* The type specimen from Alaska represents a lineage now known to have become extinct, consequently, bison resembling *B. occidentalis* from south of the ice sheet required an appropriate name. Because it developed into modern *B. bison* from *B*. *antiquus* over such a short time span, Wilson *et al.* (2008) described this bison of "*occidentalis* character" as a chronomorph (rapidly evolving organism) rather than a biologically discrete species.

All three clades of Beringian bison eventually went extinct, leaving only bison from the single clade south of the ice sheet to repopulate the continent (Shapiro *et al*. 2004; Wilson *et al*. 2008; Heintzman *et al*. 2016). However, a late-surviving clade of Beringian bison occupied southern Yukon and interior Alaska as recently as ~325–490 years before present (Heintzman *et al*. 2016). Forest expansion and paludification during postglacial times (Dyke 2005) was suggested by Heintzman *et al*. (2016) to have isolated bison populations.

Cooler, wetter conditions that progressed as the late Holocene Climatic Optimum began to ebb 6,000 to 5,000 years ago also led to forest expansion and peatland development in the boreal region of northwestern Canada (Zoltai and Tarnocai 1975; MacDonald 1987; Cwynar and Spear 1995; Hebda 1995; MacDonald 1995; Szeicz et al. 1995; Vance et al. 1995; Bigelow et al. 2003). As previously stated, McDonald (1981) selected 5,000 years before present as the separation date of *B. bison* from their ancestral stock on the basis that typical specimens older than this time resembled extinct phenotypes, while younger specimens strongly resembled modern bison. He also suggested that the unique lineage of wood bison originated 5,000 to 4,000 years ago. This would have occurred during the mid Holocene to late Holocene transition, punctuated by a major cold event 4,200 years ago (Walker *et al*. 2018a). A considerable amount of skeletal material less than 5,000 years of age resembling wood bison has been found in Alaska, northern Yukon, and the Arctic coast of the NWT (Gardner and DeGange 2003). However, the ancient DNA currently available shows that Beringian bison lingered at least until the late 16th century, and evidence is lacking that southern lineage wood bison ever occurred in those areas (Heintzman *et al.* 2016).

Throughout the course of bison evolution, the habitat of these grazers has declined when forests expanded, but this time a distinctive graminoid niche was created by the emerging peatlands. Accumulation of incompletely decomposed plant material (peat) is triggered when climatic conditions allow annual precipitation to exceed evapotranspiration (Gignac and Vitt 1994). Fens are wetlands underlain by shallow peat, and their vegetation cover is dominated by sedges (Zoltai and Vitt 1990). Northwestern Canada is where the unique lineage of wood bison originated (Wilson 1969; Van Zyll de Jong 1986). Wood bison have adapted to foraging on sedges as their main source of food. However, peat aggradation may eventually transform fens into poorly productive bogs, diminishing habitat quality for these animals. The evolution of wood bison into 'sedge meadow specialists' is a departure from other forms of bison that have largely been 'grassland specialists.' Even when Beringia supported bison, soils were underlain with ice-rich permafrost, but were generally not peaty or waterlogged and its soils maintained a rich variety of productive grasses (Guthrie 2001; Swanson 2006).

Larger-sized bison may have been extirpated by advancing hunting societies (Guthrie 1970; Shapiro et al. 2004; Drummond et al. 2005), and like people everywhere, the first North Americans became most populous in environments rich in biodiversity (Meyer et al. 2011). The more recently evolved modern bison developed several adaptations to cope more effectively with human predation such as exploitation of less productive ecosystems, earlier maturation leading to higher reproduction, and seasonal migration (McDonald 1981; Isenberg 2000; Lott 2002; Wilson *et al*. 2008).

Based on morphometric comparisons to *B. occidentalis* and *occidentalis*-like bison, wood bison appear to be a more primitive form than plains bison (Skinner and Kaisen 1947; McDonald 1981; Van Zyll de Jong 1986). The fossil and ancient DNA record has yet to clarify whether wood bison evolved directly from its *occidentalis*-like ancestor, or from an early plains bison intermediary that remained in the northwest after the grasslands were replaced by boreal forest and peatland. McDonald (1981) suggested that these evolutionary pathways are not necessarily mutually exclusive, and there may have been regular gene flow from northern plains bison into wood bison populations. He also stated that wood bison are the largest bison in North America and historically, plains bison followed a north-south cline of decreasing body size. While wood bison continued to evolve physical adaptations to exploit the forest opening/woodland environment, southern plains bison were being subjected to different selective forces in the new short-grass prairies (Guthrie 1980; McDonald 1981; Isenberg 2000). The most recent body size diminutions up to 2,000 years ago balanced energy demands with environmental conditions and were most pronounced in the populations south of 40 degrees latitude (Hill *et al.* 2008).

During this time period, significant vegetation change occurred in the Mackenzie River basin from an herb/shrub dominated landscape that became widely replaced by muskeg (MacDonald 1987). The Beringian lineages disappeared (Shapiro et al. 2004), and the range of wood bison has since contracted to its more recent historical proportions (Van Zyll de Jong 1986).

Bork *et al.* (1991) described the first step of the speciation process as the geographic isolation of populations, whereupon each population accumulates unique genetic differences. They suggested that prior to human intervention, wood and plains bison had at least reached this step in their evolutionary divergence. The geographic centre of wood bison abundance has been the boreal forest biome where wet meadows produce sedges, particularly awned sedge (*Carex atherodes*), as the most important food for these bison. True grasslands are restricted to very few sites in this biome (Schwarz and Wein 1997). In contrast, the geographic centre of plains bison abundance was the grassland biome that provided drought resistant short-grasses such as blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*) as their most important food. Sedge fens are nearly absent in this biome (Zoltai and Vitt 1990). McDonald (1981) suggested that aboriginal hunting patterns may also have contributed to the separation of the two bison gene pools.

In his account of bison subspeciation, Van Zyll de Jong (1986) referred to a heavily forested transition zone between wood bison in the upper Peace River and plains bison of the prairies. He also considered the aspen parkland of eastern British Columba, Alberta and western Saskatchewan as a transition zone between wood and plains bison, and this ecotone between the boreal forest and grassland biomes is also the approximate southern limit of sedge fens (Zoltai 1975). Further east, no historical geographic separation between the two varieties of bison has been defined. Van Zyll de Jong (1986) was unable to acquire bison samples for comparative analysis from anywhere north of Saskatchewan's aspen parkland. In 1969, a herd of plains bison was established in the Prince Albert National Park area, located in the southern boreal region of Saskatchewan. As described by Fortin and Fortin (2009), these animals have adopted a behavioural and feeding ecology that is very similar to wood bison. As part of the Wood Bison Rehabilitation Program and the expectation that historical wood bison range extended into Manitoba, a herd was established in the Interlake District near Waterhen and Chitek Lake in 1981 (Reynolds 1987). However, Van Zyll de Jong (1986) scored the few skeletal samples available from the interlake and other boreal regions north of the Manitoba aspen parkland as plains bison.

Wood Bison Genotype

Classification of wood bison as a subspecies has been controversial ever since Rhoads (1897) described it. Skinner and Kaisen (1947) concluded that the number of wood bison specimens available for identifying the subspecies was too small to present a comprehensive understanding of the amount of variation possible. Based mainly on pelage characteristics, Krumbiegel and Sehm (1989) proposed two extant North American bison subspecies consisting of a northern plains bison, which included wood bison, and a southern plains bison.

Bison that formerly occupied mountainous habitats may have constituted a third modern subspecies known as the mountain bison (Christman 1971; Meagher 1973). From skeletal analysis, northern cordilleran specimens have basically been classed as wood bison type, and southern counterparts as plains bison type (McDonald 1981; Van Zyll de Jong 1986; Stephenson *et al*. 2001), but there are inconsistencies (e.g., Skinner and Kaisen 1947; Peach 2002; Cannon 2007).

The International Code of Zoological Nomenclature (1999) accepts only one taxonomic rank below species, namely the rank of subspecies. Accepting the definition of Mayr (1969) that a subspecies inhabits a geographic subdivision of the range of the species and differs taxonomically from other populations of the species, Van Zyll de Jong (1986) concluded from his multivariate morphometric analysis of skeletal and external character data that there was a geographic and phenotypic discontinuity sufficient to distinguish wood bison as a subspecies. However, phylogenetical analyses indicated to Douglas *et al*. (2011) and Cronin *et al*. (2013) that extant plains bison and wood bison are not distinct subspecies.

Van Zyll de Jong *et al.* (1995), Wilson and Strobeck (1999) demonstrated that external characteristics of bison are genetically based.

The arrival of firearms led to excessive human predation and reduced the plains bison population from millions, or even tens of millions in the mid-1860s (Shaw 1995), to a few hundred by the late 1880s (Hornaday 1889). During approximately the same period, wood bison dropped from thousands to a few hundred (Ogilvie 1893). After the wood bison population in Wood Buffalo National Park had risen to 1,500-2,000 animals (Seibert 1925), more than 6,000 plains bison from Buffalo National Park near Wainwright, Alberta were released into Wood Buffalo National Park and subsequently hybridized with wood bison (Raup 1933). As recovering herds of wood bison and plains bison are polyphyletic (derived from several lineages) neither subspecies is a well-defined taxon (Polziehn *et al.* 1996). Wood bison and plains bison exhibit many differences in morphological, molecular and genetic characters, but the debate has centred on the degree of distinctiveness.

All extant wood bison herds originated from Wood Buffalo National Park. From its growing population, bison began to appear in former range outside the Park (Fuller 1950). Animals that moved into the Slave River Lowlands west of the Slave River have become known as the Grand Detour subpopulation (may also be referred to as Little Buffalo by Parks Canada), and those that started occupying the area immediately east of the Slave River have become known as the Hook Lake subpopulation.

There had been speculation that small groups of pure wood bison existed in the northwestern part of Wood Buffalo National Park, too remote to mix with descendants of Wainwright plains bison (Raup 1933; Soper 1941; Fuller 1951). During an aerial survey by Novakowski (1957a), bison were found in the upper Nyarling River area, which appeared to be far removed from the main herds of Wood Buffalo National Park. In 1959, specimens were procured from this area for comparison to the wood bison type, and field investigations were carried out in the Fort

Providence area to evaluate the feasibility of bison reintroduction (Novakowski 1959). Based on large size, dark pelage and most skull measurements falling within the wood bison parameters developed by Skinner and Kaisen (1947), Banfield and Novakowski (1960) concluded that the specimens collected represented an isolated population of the wood bison subspecies, and that any contact with hybrid animals would have been minimal.

Novakowski (1963a) reported on the subsequent rescue. Although the question of genetic purity was not completely clarified, animals were captured from the Nyarling River area as breeding stock for establishing new herds of wood bison able to avoid hybridization and debilitating cattle diseases. The presence of tuberculosis and brucellosis in some of the captured animals indicated that isolation was not as complete as anticipated, but it was hoped that the purity of the subspecies was not obviated. After diseased animals were removed, 18 were reintroduced in 1963 to an area near Fort Providence (Novakowski 1963b) which became the Mackenzie Bison Sanctuary. As this population expanded beyond the boundaries of the sanctuary, protection was extended, and the herd became more appropriately known as the Mackenzie population.

In 1965, an additional 23 bison from Nyarling River were transported to Elk Island National Park when anthrax outbreaks in bison along the Slave River were perceived as a threat to the survival of the Nyarling River subpopulation (Novakowski and Stevens 1965). The Elk Island National Park Isolation Area, south of the Yellowhead Highway, was set aside to hold representatives of this population in semi-captivity, specifically for good bison recovery (Babbage 1969). Plains bison roam separately in the portion of Elk Island National Park north of the Yellowhead Highway.

Many factors seem to have prevented genetic swamping by the plains genotype, perhaps including lower fitness by hybrids (Armstrong pers. comm. *in* SARC 2016: 218), and studies have shown wood bison characteristics of northern populations to be more intact than expected. Geist and Karsten (1977) documented physical differences between plains and wood bison held in Elk Island National Park. McDonald (1981) found the skeletal morphometrics of post-1929 Wood Buffalo National Park bison to be closer to wood bison and suggested that evolutionary selection for adaptive traits in this environment (such as larger size) is ongoing. After weighing all the phenotypic evidence, Van Zyll de Jong *et al*. (1995) classed all bison in the NWT as wood bison, including those in and around Wood Buffalo National Park.

While there appears to be little or no variation between wood bison and plains bison by blood characteristics (Peden and Kraay 1979) or at the chromosomal level (Ying and Peden 1977; Cronin and Cockett 1993; Stormont 1993), more polymorphism has been revealed in mitochondrial DNA (mtDNA). Of the 12 mtDNA haplotypes Polziehn *et al.* (1996) identified among three wood bison and six plains bison populations, one is universal and three are widespread. This raises the possibility that prior to the elimination of bison in the sympatric ranges of the late 1800s, some gene flow had occurred between adjacent plains and wood bison populations. From sampling in Wood Buffalo National Park, the Mackenzie Bison Sanctuary, and the Elk Island National Park Isolation Area, Polziehn *et al.* (1996) found four haplotypes to be unique to these wood bison, indicators that they shared a common gene pool. It is not known whether these haplotypes were limited to wood bison, or if they were present in lower frequencies in plains bison herds. Any evidence of a cline would have been lost during the severe depopulation in the late 1800s. Five haplotypes are shared between the two subspecies. These may have been present in the original population of wood bison or introduced along with the plains bison from Wainwright. Unfortunately, the magnitude of population reduction likely removed many more haplotypes, both shared and unique. Genetic distances measured by Polziehn *et al.* (1996) indicated that bison from Wood Buffalo National Park, the Mackenzie Bison Sanctuary and the Elk Island National Park Isolation Area are more related to each other than to the plains populations sampled.

Douglas *et al*. (2011) sequenced complete mtDNA genomes from 43 bison and bison-cattle hybrids, including two wood bison from the Elk Island National Park Isolation Area. Two of the 17 bison haplotypes discovered were unique to these two wood bison, but they did not form a clade separate from the plains bison haplotypes.

Whereas mtDNA is maternally inherited, nuclear DNA is passed on from both parents. Bork *et al*. (1991) studied the genetic relationship of wood and plains bison based on restriction fragment length polymorphism from nuclear DNA. Results were indicative of a recent divergence similar to geographically isolated populations of other species such as red deer (*Cervus elaphus*).

DNA microsatellites, highly polymorphic nuclear markers that are more sensitive in detection of genetic variation, were used by Wilson and Strobeck (1999) to test genetic diversity and heterogeneity among several bison populations. Their analysis of 11 microsatellite loci revealed some evidence for the existence of subpopulations in Wood Buffalo National Park; however, very small genetic distances between them suggest that nuclear material from the introduced plains bison has diffused throughout the Park. They also determined that genetic distances between sampled populations of wood and plains bison are generally larger between than within the two subspecies. In addition, genetic distances between wood bison populations are low, relative to other bison populations.

Could some distinguishing morphological traits of wood bison be unrelated to DNA? Epigenetics is a relatively new field of biology referring to modifications of the genome that do not involve a change in the underlying DNA sequence of the organism (Richards *et al*. 2010). Instead, nongenetic factors such as environmental variation cause the organism's genes to express themselves differently, and these changes may contribute to phenotypic variation passed down for multiple generations. Llamas *et al*. (2012) tested cytosine methylation in ancient DNA as a means to study the role of epigenetics in rapid adaptation to climate and environmental change, without the requirement for DNA sequence alterations. They demonstrated that steppe bison exhibited high morphological diversity, but low mtDNA heterogeneity. If epigenetics is responsible for these morphological changes, the loci where the epigenetic changes occurred will need to be identified.

One of the original intents of salvaging bison in the Nyarling River area was to rescue indigenous wood bison from genetic swamping by plains bison introduced to Wood Buffalo National Park (Reynolds 1979). With a numerical imbalance exceeding 3:1 in favour of plains bison, why do studies show such a considerable representation of wood bison characteristics? There were probably many contributing factors. Graham (1924) believed that about 500 wood bison were scattered in small herds across a northern range of Wood Buffalo National Park that did not mix with the southern population. His summary of the planned release of Wainwright plains bison stipulated that in the first year all animals were to be yearlings, at a ratio of one male to five females. Adult bison were thought to be too difficult to ship to such a remote location and yearlings might be the only age class that could be handled (Harkin 1923). After the experimental first shipment, Graham (1924) allowed later shipments to contain two-year-olds and three-year-olds, but no males of any age. Graham (1924: 189) stated "...the bison transferred from Wainwright will be placed on one or two selected locations in the southern range of Wood Buffalo Park, where they will meet and come under protection and leadership of adult wild bison in those areas." Officially, 47 bison died enroute and the remaining 6,673, comprising 4,826 yearlings, 1,515 two-year-olds and 332 three-year-olds were delivered to their destination (Kitto 1930). However, testimony from persons involved with the unloading indicates that many more bison died between the landing and the nearest meadow (Fuller 2002).

The fact that plains bison males generally do not breed until they are at least five years of age (McHugh 1958; Lott 2002), and so few were shipped, indicates that wood bison bulls could have been the primary sires of the first cohorts from the female plains bison and early hybrid generations (Van Zyll de Jong 1986). Also, because successful competition among male bison for mates is related to age, size, and prior reproductive success (Komers *et al*. 1994b; Wilson *et al*. 2002), the younger, smaller, inexperienced male plains bison from Wainwright would be at a breeding disadvantage. Y chromosomal analysis would be required to evaluate paternally inherited markers. If the northern and southern ranges in Wood Buffalo National Park were partially separate, pure wood bison from the reservoir in the north that entered the hybrid zone and backcrossed with hybrids, would have further diluted the plains genes. Some of the less fit plains regions of the genome may have been selected against, resulting in a decline in their frequency over time from the hybrid zone. Van Camp (1989) and Carbyn *et al.* (1993) discussed several other setbacks the plains bison had in contributing to the gene pool, including local oral history reports of mortality in the thousands among the new arrivals.

APPENDIX A2 – HABITAT TRENDS

Wildfires

Natural fires have produced the greatest results for habitat restoration but are uncontrollable and difficult to predict. A fire that started near Lonely Bay in 1994 was remote enough from values-at-risk to let burn without any suppression action. As it grew to over 50,000 hectares, some places burned very severely, stripping away forest that was replaced with grassy meadows. Before the fire, a few bison had wandered to some of the marl lake beds in that area. The fire enhanced movements from core areas in the south and facilitated further range expansion northward into unoccupied habitat (Chowns pers. comm.2025).

One of the largest fires to affect the Mackenzie bison range started June 1, 1995, on the Horn Plateau. It quickly descended the slopes and swept across the lowlands eastward to the Horn River, and southward to the Lafferty and Rabbitskin Rivers. By the end of the summer, after merging with some other fires, it had grown to 1.2 million hectares. This period of extreme drought also had great impacts on depth of burn in peatlands. Extensive burning to mineral soil occurred in many areas within the perimeter of the burn, especially near the southern base of the plateau (Lafferty Plains). Until then, bison seldom wandered west of Mink Lake, even though there had been frequent fire in the past and unforested tracts were very widespread. After the 1995 fire, bison surged into this new habitat, and it was soon occupied by hundreds of animals. Even while the Lafferty Plains were still recovering its vegetation, large numbers of bison were very attracted to this open habitat (Chowns pers. comm. 2025).

A considerable amount of research has been carried out within the Mackenzie and Nyarling bison ranges on vegetation responses after the 2014 extreme fire events which followed a prolonged, multi-year drought (Day *et al* 2023). In a study of fire frequency within these bison range fires from 2014, Whitman *et al*. (2018) found that black spruce dominance declined at fire intervals approaching 100 years, while jack pine and trembling aspen gained substantially in most post-fire cohorts. In the forest succession study of Dawe *et al*. (2022), many pre-fire 2014 stands within Mackenzie and Nyarling bison ranges were predominantly black spruce, with trembling aspen either absent or poorly represented. However, aspen gained substantially after the fires and will likely persist in the sampled sites unless the next fire-free interval exceeds 100 years. Along with aspen, jack pine rose in prominence at the expense of black spruce and white spruce. Some pre-fire conifer stands remained poorly stocked five years post-fire and may persist as open woodlands (Dawe *et al*. 2022).

In the Mackenzie study area, the strongest resistance to fire spread occurred in stands that originated within the past 10 years, and fuel loads generally remained too low to carry fire for at least 20 years and often for more than 30 years (Whitman *et al*. 2024). Although the probability of fire spread was shown to be approximately 50% lower in recently burned areas, Whitman *et al*. (2024) suggested this was a moderate barrier which could be overcome by only a modest increase of fire weather severity.

Similarly, Thompson *et al*. (2017) reported that despite the variability in biomass among upland forest stands, high fuel loads in Wood Buffalo National Park were observed only after about 20 years following a fire. Surface fires occurred almost exclusively in pine-dominated stands where minimal ground vegetation and deficient ladder fuels to the crown may be reinforced by high fire frequencies.

Drought increases the susceptibility of fuel-limited young forests to reburning, which could reduce black spruce dominance through the combustion of immature or non-serotinous cones. The positive relationship between stand age and seed viability observed after the 2014 fires suggests that shortened fire return intervals negatively impact post-fire regeneration of black spruce in the NWT (Reid *et al*. 2023). Recruitment of all tree species failed almost completely in reburns occurring up to 16 years from the last stand-replacing fires, and poor spruce seedling establishment in the 2014 severe drought-driven fire season means they are unlikely to become stand dominants through succession (Whitman *et al*. 2018). A large pulse of tree recruitment typically occurs immediately after a fire with low or no recruitment in the following decades, suggesting that a reduction in the dominance of conifers and more open woodland in the aftermath of repeated fires will persist into the future (Johnstone *et al*. 2004). Jack pine tree survival was much more apparent after the 2014 fires than for the other species. If drought stress becomes more prominent in NWT forests, both black spruce and drought-sensitive trembling aspen may decline, as drought-tolerant jack pine increases (Whitman *et al*. 2018).

Whitman *et al*. (2019) sampled sites in the Mackenzie bison range that had burned from 1995 to 2015 and discovered that open woodlands with reduced conifer components became more extensive, residual organic layers became much thinner, and cover of herbaceous understory vegetation (particularly forbs) declined. An exception was downy wildrye (*Leymus innovates*), a grass with deep rhizomes, which was a significant indicator species of short interval reburns. Coarse woody debris was substantially removed from sampled sites. According to Johnstone (2006) low decomposition rates in northern forests maintain large amounts of fire-killed coarse woody debris that can persist for many decades. When infrequent fires remove existing deadwood, new fire-killed stems from mature trees are generated, but short interval reburns consume the existing deadwood without replacing it. Also, the absence of coarse woody debris hampers the establishment of seedlings that are sensitive to the microclimate provided by deadwood.

In their review of regeneration failure of conifers in western North American forests that included the upper Mackenzie basin, Stevens-Rumann *et al*. (2022) indicated that seeds remain viable for only a brief period after contact with the ground, and they require sufficient moisture to support germination and survival during the first few growing seasons. Also, seedlings of coniferous species such as black spruce are quite sensitive to desiccation due to their shallow root systems and low carbohydrate reserves. Whitman *et al*. (2019) noted that where dry conditions followed fires in the Mackenzie bison range, seedling density of all tree species was adversely affected, and conifer recruitment constrained by moisture stress was particularly apparent after short-interval reburns. Aspen stems became proportionately more abundant at these sample sites, suggesting that aspen may replace conifers where shortened disturbance intervals are induced by climate change (Whitman *et al*. 2019).

Although climate models predict higher average temperatures and precipitation for the NWT in the coming decades (Price *et al*. 2013), Flannigan *et al*. (2016) calculated that for every 1°C of warming, a 15% increase in precipitation was required to compensate for the effect on fine fuel flammability. Lack of significant increases in precipitation that results in lower water tables and decreases in forest floor and dead fuel moisture content would also contribute to a fire-prone environment.

Higher evapotranspiration rates associated with warmer temperatures exceeding precipitation and longer fire seasons are expected in the NWT going forward (Wotton and Flannigan 1993; Price *et al*. 2013). However, Gaboriau *et al*. (2023) suggested that increasing burn rates of the last decades might be transitory, as changes in vegetation composition and structure moderate future wildfire activity.

APPENDIX A3 – POPULATION TRENDS AND FLUCTUATIONS

Density

Bison densities have been calculated in Table 11 using the total area of occupancy for their populations, which avoids subjective partitioning of primary from secondary ranges. In accordance with the Species at Risk Committee's (2022) definition, each area of occupancy will always have a certain mix of habitats at variable and changeable levels of quality. In Table 11, *maximum population* refers to the maximum number a population has ever attained based on past surveys. Maximum density is calculated based on the index of area of occupancy (IAO) and the maximum population.

Table 11. Wood bison density (bison/km^2). Population data for Nahanni and Mackenzie populations and Hook Lake subpopulation (Greater Wood Buffalo metapopulation) from ECC unpubl. data 2024b. Population data for Nyarling and Little Buffalo subpopulations (Greater Wood Buffalo metapopulation) from Parks Canada unpubl. data 2024.

Herd	IAO (km^2)	Current Population	Current Density	Maximum Population	Maximum Density	Allometric Density[1]	Allometric Estimate[2]
Nahanni	8,756	544	0.06	962	0.11	0.24	2,101
Mackenzie	26,504	1,945	0.07	2,431	0.09	0.24	6,361
Nyarling	4,052	282	0.07	717	0.18	0.24	972
Grand Detour/Little Buffalo	5,608	101	0.02	1018	0.18	0.24	1,346
Hook Lake	5,760	315	0.05	1,701	0.30	0.24	1,382

[1] Allometric density was calculated as $D = 67.9(W)^{-0.882}$ (Peters and Raelson, 1981) where D = density in bison/km^2 and W = body mass in kg. Bison body mass of 590 kg was used here.

[2] Allometric estimates were calculated by multiplying the allometric density prediction by IAO.

Environmental factors that affect an animal's ability to survive and reproduce include weather, food, other animals, pathogens, and habitat, but Peters and Raelson (1984) have shown animal size to be a powerful factor in predicting density of herbivorous mammals. Allometry is the study of how characteristics of living creatures change with size, meaning that an allometric calculation can be used to anticipate the expected or ideal density of a population. If there is a strong allometric relationship between body mass and population density of bison, then an allometric calculation can be used to provide a standard of comparison for deciding whether wood bison are particularly common or rare in certain areas. Peters and Raelson (1984) reported that mean population density (D) of herbivorous mammals' scales to body mass (W) allometrically as $D = 67.9(W)^{-0.882\pm0.04}$. However, population densities of mammals can vary by more than three orders of magnitude from prime to marginal habitats (Silva and Downing 1995).

Recognizing the difficulties of defining carrying capacity and to help decide whether the decline of bison in Wood Buffalo National Park is necessarily a concern, Nudds (1993) used allometrics to estimate an expected population density and appropriate number of bison for the principal bison habitat in Wood Buffalo National Park. Similarly, Plumb *et al.* (2009) used allometrics for bison of Yellowstone National Park that would satisfy concerns regarding forage base, movement ecology, retention of genetic diversity, brucellosis risk management, and other societal constraints. Using a mean body mass estimate of 590 kg derived from Olson (2002) the allometric population density for wood bison is expected to be 0.24 bison/km^2.

The distribution of wood bison populations represents a fraction of the original range, and it is not known how much habitat capable of supporting high densities of wood bison has been lost. Table 10 shows all current densities of wood bison to be under the allometric estimate of 0.24 bison/km^2. After the 1925-1928 addition of plains bison to Wood Buffalo National Park, Kitto (1930) estimated the mixed population at 10,000 bison. In the early 1930s, Soper (1941) thought that bison occupied 8,200 miles^2 (21,240 km^2) within Wood Buffalo National Park. He also provided evidence that some of them were using the Slave River Lowlands between the Park and the Slave River, bringing the total range of the Greater Wood Buffalo metapopulation up to 23,740 km^2. Soper (1941) estimated the bison population of 1934 to be 12,000, giving a density of 0.51 bison/km^2, but Fuller (1950) believed that this estimate was too high. It appears that the Greater Wood Buffalo metapopulation had reached the limits of its current range by 1949 (Fuller 1950). Fuller (1961) estimated the total Wood Buffalo National Park population, plus those that had left the confines of the park (now known as the Greater Wood Buffalo metapopulation) to be 14,000-16,500 bison. Accepting the conservative figure of 14,000, the resulting 0.30 bison/km^2 density value is still higher than the allometric projection of 0.24 bison/km^2. The historical maximum population of 1,700 animals for the Hook Lake subpopulation (Rippin 1971 *in* Nishi 2010), which has always been surveyed separately, is also above the allometric projection.

Eruptive Oscillation

Stage One: *Mortality is low, the population begins to grow, and then the growth becomes exponential. Towards the end of this stage, preferred forage plants in critical parts of the habitat begin to decline.*

In response to the looming threat of extinction of wood bison, the *Unorganized Territories Game Preservation Act* was passed in 1894, but was not enforced or well-advertised in the north until North West Police patrols began in 1897 (Jarvis 1897). Soper (1941) suggested that the limit of population decline was 1896-1900 and may have ebbed as low as 250 animals. After the police became active in the bison range, the bison population began rebounding (Macrae 1901, Seton 1911, Radford 1911, Harper 1932). By the time Wood Buffalo Dominion Park was created in 1922, the population had climbed to 1,500-2,000 animals (Seibert 1925). Between 1925 and 1929, the population was bolstered with the addition of over 6,000 plains bison and may have reached 10,000-12,000 by 1934 (Soper 1941), but early methods of estimating populations were very crude.

After disappearing from the Slave River Lowlands east of the Slave River by 1880 (Radford 1911), bison reinvaded the Hook Lake area in the late 1930s or early 1940s from Wood Buffalo National Park (Fuller 1950). Unfortunately, initial population growth of the newcomers in this pristine habitat was never documented.

From 18 founders in 1963 (Novakowski 1963b), Calef (1976) estimated the Mackenzie population exponential growth rate at 24% until 1975. In these early years, Calef (1984) observed relatively high reproduction and little or no evidence of mortality in any age class of the Mackenzie population. The exponential rate appeared to peak in the early 1970s at 26-27% (Gates and Larter 1990, Larter *et al.* 2000), and this exceptional growth rate had only been observed in captive populations (Van Vuren and Bray 1986). By the mid-1970s, the growth rate started to decelerate (Hawley 1980). Beginning in 1980, there was a major range expansion from the Mackenzie Bison Sanctuary into the Mink Lake area to the northwest and increasing bison density may have been a factor (Gates and Larter 1990). Although almost all Mackenzie Bison Sanctuary foraging activities were in *C. atherodes*-dominated meadows, bison in the Mink Lake area seemed to be utilizing a wider variety of plant species.

Larter and Allaire (2007) outlined the history and status of the Nahanni Population. In 1980, 28 wood bison from the Elk Island National Park Isolation Area were released into the Nahanni Butte area. Supplemental releases carried out in 1989 and 1998 with 12 and 59 individuals respectively, augmented the population. There was an average annual growth rate of approximately 19%, producing an estimate of 403 bison in 2004. Range expansion is still progressing into British Columbia and the Yukon. The Nahanni population appears to have stabilized at about 500 animals (Table 1).

Stage Two: *Vegetation trends continue to decline. Although the population exceeds its carrying capacity, reproduction is still high because of the large proportion of young age groups in the population. Even if the mortality rate of younger animals begins to increase, the total population* *continues to rise. The physical condition of the animals starts to decline, especially in critical periods of the year.*

Fuller (1961, 1966) believed there would be almost no increase in the proportion of aged animals for the first 15 to 20 years after the wood bison population started to grow. Also, as increasingly large calf crops advanced through maturity, net annual increment would grow. By the late 1940s and early 1950s, bison numbers in the Greater Wood Buffalo metapopulation may have reached 12,500-15,000 animals (Fuller 1950). Even with slaughters of up to 1,000 bison per year, carried out for meat and disease control, as well as predation and accidents, recruitment possibly still equalled 8-10% (Fuller 1961).

Until the mid-1960s, bison occupying the area between the Little Buffalo River and the Taltson River (Grand Detour and Hook Lake range) were originally counted as a single unit in the Slave River Lowlands (e.g., Fuller 1950; Novakowski 1961). Ever since Williams (1966) counted over one thousand animals east of the Slave River, the Hook Lake herd has been considered a separate subpopulation. By 1968, the Hook Lake herd was at approximately 1,232 bison and reached a maximum estimate of 1,701 by 1971 (Rippin 1971).

Between 1975 and 1987, the rate of growth of the Mackenzie population declined from 26.7% to 10.3% per annum (Gates and Larter 1990). Although wolves prefer moose, they capitalize on rising bison populations and could have reduced the Mackenzie bison population growth rate (Joly 2001). This population reached its maximum estimated abundance in 1989 at 2,431 animals (Gates *et al.* 1991; Larter *et al.* 2000). Throughout the range they appeared to be increasing their breadth of diet. The first evidence of wolf predation on bison was three calves in 1983 (Chowns and Graf 1987). For the next decade, the frequency of wolf-killed calves seemed to be increasing, and some wolf-killed adults were being discovered.

Stage Three: *Large scale die-offs occur, especially when some element of the habitat becomes critical. The most heavily used parts of the range start to show signs of recovery.*

Fuller (1961, 1966) predicted that when the large cohorts of the early years reached old age, the population would experience a lower reproductive rate and a higher mortality. From approximately 13,000 bison in 1971, the bison of the Greater Wood Buffalo metapopulation declined steeply to less than half of that number by 1976 (Carbyn *et al.*1998; Calef 1976). In the Slave River Lowlands, the combined numbers of the Hook Lake and Grand Detour subpopulations dropped 35% from about 1,904 in March of 1974 to 1,245 after the severe winter of 1974-75 (Van Camp and Calef 1987). Any apparent trends within the Greater Wood Buffalo metapopulation must be treated with caution because of the fluidity of bison movements. When Carbyn *et al.* (1998), analysed the census data from 1971 to 1998, they concluded that the entire decline in Wood Buffalo National Park could be accounted for south of the Peace River. A mass drowning of 3,000 animals in the Peace-Athabasca Delta in 1974 was the largest single die-off ever recorded in the park. According to Bradley and Wilmshurst (2005), all Wood Buffalo National Park subpopulations were probably stable or growing by 1992, except the Delta herd. Recruitment was above five yearlings per 100 cows and increasing. The total Wood Buffalo National Park population number had bottomed out at 2,200 in 1999 (Joly and Messier 2004a). Carbyn *et al.* (1998) believed that a great deterioration of habitat had been occurring since the delta started drying out in recent decades.

After peaking at about 2,431 bison in March 1989, the Mackenzie population suffered a mass drowning of 177 bison two months later. Two major anthrax outbreaks and continuing range expansion, all effectively lowering population density, may currently be forestalling any large-scale die-offs that would be related to critical elements in the habitat. The 2012 anthrax mortality of over 440 animals in combination with predation and collisions reduced the Mackenzie population to approximately 714 animals (Armstrong 2013b).

Stage Four: *The population attains a more stable adjustment with the carrying capacity. Amplitudes of oscillations are determined by a variety of environmental factors, until another large discrepancy emerges between how many animals the environment can support and the numbers actually present.*

Wood Buffalo National Park bison increased from 1999 to 2005, then generally declined through to 2024 (CMA 2025). Two of the Greater Wood Buffalo metapopulation subpopulations occurring within the NWT (Nyarling and Grand Detour/Little Buffalo) showed great fluctuations between the 1980s to 2024 (see Table 3 and Table 4), suggesting intra-metapopulation movements. Wide confidence intervals on estimates may suggest inaccuracies in some estimates may have contributed to the amplitude of the apparent fluctuations. Although any period of stability in the Hook Lake subpopulation is difficult to determine because of information gaps, Table 3 shows numbers have generally been in decline from 2009 to 2024.

After the Mackenzie anthrax outbreak in 2012 and subsequent population crash, Table 3 indicates the Mackenzie bison have been steadily rebounding in numbers to 2023.

APPENDIX A4 – SEARCH EFFORT

Historic Range in the NWT

Slave River Lowlands

Documented references to historic range in the NWT (see Figure 22) start with Samuel Hearne, who ascended the lower Slave River during the winter of 1771-1772 and described the bison his party encountered (Hearne 1795).

While Alexander Mackenzie was descending the Slave River below the rapids at Fort Smith in 1789, he was informed by local people that large herds of bison occupied very extensive plains extending from both sides of the river (Mackenzie 1801).

In 1790, the Hudson's Bay Company sent surveyor Philip Turnor, accompanied by Peter Fidler, into the uncharted Rupert's Land between Lake Athabasca and Great Slave Lake, to determine the positions of the rivers, lakes, and their trading posts, as well as those of their opposition (Tyrrell 1934). Turnor and Fidler reported numerous observations of wood bison throughout the Slave River Lowlands, particularly Fidler who accompanied a band of Chipewyan people for the winter of 1791-1792, sharing their successful hunts and privations.

During his first overland expedition preparing for discovery of the northwest passage, Captain John Franklin (1823) found the people of Fort Resolution in 1820 subsisting mainly on fish, but bison could be obtained after several days walk from the fort.

When travelling up the Little Buffalo River in 1821 on his return trip, Franklin observed numerous bison tracks.

Richard King (1836), surgeon and naturalist attached to George Back's expedition to the Arctic coast in 1833 noted very extensive plains frequented by bison a short distance from either bank of the Slave River.

John Richardson was surgeon and naturalist attached to Captain Franklin's second expedition (1825-1827). During his searching expedition for Captain Franklin's lost expedition led in 1845, Richardson (1851) remarked that the Beaulieu family living at the mouth of Salt River enjoyed ample supplies of bison from the area. King Beaulieu was the family patriarch brought to the NWT from the Red River Settlement in Manitoba by the Hudson's Bay Company, and he settled at Salt River where bison were numerous (Pike 1892).

Explorer Warburton Pike secured an intact bison from Indigenous hunters within 50 miles (80.5 km) southwest of Fort Resolution which became the type specimen for wood bison, described by Rhoads (1897).

Frank Russell (1898) collected natural history specimens for the University of Iowa and had been informed by a Yellowknife Dene chief that he had killed many bison in the Slave River Delta.

Buffalo Lake to Eastern Escarpment

This area extends between Buffalo Lake and the edge of the eastern escarpment (as outlined by Soper 1941).

Some of the last remaining wood bison in the late 19th century found refuge here, perhaps because of its remoteness from the main travel routes. Consequently, early historical records are lacking. Seibert (1923) observed bison between the headwaters of Klewi and Nyarling rivers to about latitude 60° 28' N. Because the northern herd of wood bison ranged from Buffalo Lake to the Little Buffalo River, that justified the northern boundaries for Wood Buffalo National Park (Seibert 1923). Routledge (1908) found bison sign within 120 km westward from the Salt River settlement where travellers rarely visited.

Soper (1941) encountered widely scattered evidence of small bison groups westward from Fort Smith to about longitude 113° 31' W., but from there to the Upper Buffalo River he was told by Indigenous informants that the swampy terrain was inaccessible in summer and mostly shunned by bison. Soper (1941) also stated that an old bison trail extended along the Ninishith Hills at least as far as Copp Lake.

Little Buffalo River to Mackenzie River

This area encompasses the area inland from the south shore of Great Slave Lake to lands adjacent to the upper Mackenzie River as far west as Camsell Bend.

The earliest records are from the vicinity of Mills Lake and the mouth of the Horn River where Mackenzie (1801) found beds and tracks of bison to be very perceptible, and his men killed a female bison.

John Thomson, a North West Company trader, spent the winter of 1800-1801 at Camsell Bend on the Mackenzie River (Thomson 1801). Although he recorded enormous amounts of meat that was brought to the post for consumption and trade, he rarely identified the meat source (other than hare) and never mentioned bison.

When commenting about how many people could be maintained on the resources of the country around Big Island Post, Richardson (1851) stated that a party of good hunters could reliably return with bison meat from the Horn Plateau area.

Roderick Mackenzie was a partner in the North West Company who gave each clerk who opened a new post a list of items he wanted recorded including the water bodies, vegetation, animals, people and hunting. In a letter to Mackenzie, Willard Wentzel, clerk at Fort of the Forks (present day Fort Simpson), described the desperate situation after hare populations crashed, bison were particularly scarce in the area, and the starving North West Company trading post inhabitants resorted to eating dried beaver skins (Wentzel (1811). During his residence there, Wentzel (1821) stated that bison were seldom observed downstream from the beginning of the Mackenzie River. On his map of the area, Wentzel (1822) showed bison distribution west of Great Slave Lake and around Hay River.

During his biological investigation of the Athabasca-Mackenzie region, Edward Preble (1908) read in a Hudson's Bay Company journal at Fort Simpson of two bison killed April 29, 1831, near the mouth of Martin Creek on the Mackenzie 8 miles (13 km) below the fort.

Harvard University zoologist Joel Allen (1877b) received information about two travellers from B.C. to the Yukon, who wintered at Hay River in 1871 and found bison to be common along the southern shores of Great Slave Lake.

The original Fort Providence was moved from Yellowknife Bay, then briefly to Deep Bay near the outlet of Great Slave Lake, before it was re-established in 1862 at its present location on the Mackenzie River (Petitot 1891). Guy Blanchet (1926) was told by a resident of Fort Resolution that his father hunted bison north of old Fort Providence (located at Deep Bay) until about 50 years ago (late 1870s) when the bison moved to the south shore of Great Slave Lake and never returned.

When Frank Russell was exploring the region under the auspices of the University of Iowa, he was informed in 1894 by Pére Ruore, of the Saint Michel Mission at Rae, that he had travelled the Rae-Providence traverse several times and observed many buffalo skulls on the prairies within fifty miles of Fort Providence (Russell 1898).

In 1909, Harry Radford was sent by the American Bison Society to the NWT to carry out a two-year special study of the wood bison. He collected a weathered bison skull on the winter trail between Fort Providence and Fort Rae (Radford (1911).

When Isadore Lafferty was about 9 years old (circa 1900), he found a bison skull on Mission Prairie near Fort Providence and hung it in a tree (Lafferty pers. comm. 1985).

In travels looking for evidence of bison, Routledge (1908) was advised that bison seldom strayed from Buffalo Lake and Buffalo River westward to Hay River.

People from around Jean Marie River formerly travelled to the Slave River to trade for bison hides after bison in their region disappeared (Allaire pers. comm. *in* SARC 2016: 45).

Great Slave Lake to Lac La Martre

This large tract of land stretches from the western shores of Great Slave Lake (Frank Channel to Deep Bay), in a wide swath culminating at Lac La Martre.

When Mackenzie (1801) and his party traversed Lonely Bay on their voyage northward, tracks of bison were observed when men went ashore to pick berries.

The original Fort Providence (near present day Yellowknife) was mainly a Hudson's Bay Company provision post supplying caribou meat to other trading posts, and although bison meat was occasionally procured, bison were not plentiful on that side of Great Slave Lake (Franklin 1823). Rivalry between the Hudson's Bay Company and the Northwest Company often led to the establishment of posts in close proximity to each other. Such was the case when Montagne Island (Old Fort Island) was established in the North Arm, west of (Old) Fort Providence. Similarly, Montagne Island was a Northwest Company provision post, but according to George Simpson (1821) bison in the area were not abundant enough to depend upon for meat supplies.

Old maps show Slave Point to be the bulge of land between Lonely Bay and Great Slave Lake's North Arm (e.g., Petitot 1891), whereas modern maps show Slave Point further south on the north side of Deep Bay. Joseph Sabine, the zoologist attached to Captain Franklin's first expedition, stated that Slave Point (one of the points in the area now known as Gypsum Point) was the most northerly location where bison were observed by Franklin's party (Sabine 1823).

Richardson (1829) described the northerly range of bison as the flat limestone district of Slave Point (now Gypsum Point) on the north side of Great Slave Lake extending to Lac La Martre at latitude 63^{o} or 64^{o}, and that bison did not frequent Precambrian Shield formations.

Simon McGillivray, Hudson's Bay Company chief trader at Fort Resolution, recorded on December 3, 1829, that several hunters returned from the north side of Great Slave Lake with dressed bison hides. Furthermore, on March 13, 1830, he wrote that another party of hunters who spent the winter around Slave Point, Lac La Martre, and Horn Plateau found numerous herds of bison at Slave Point.

In his topographical survey report, Guy Blanchet (1926) stated that in the early days, bison ranged northward to Lac La Martre and thence easterly to Marian Lake, and the plains extending westward from Great Slave Lake show a variety of vegetation including extensive meadows which formerly supported herds of bison.

Liard River

This area is comprised of the lowlands surrounding the Liard and South Nahanni rivers and their tributaries.

MacFarlane (1908) stated that in the early 1800s, many bison roamed to the Liard River. Of all tributaries of the Mackenzie River, Wentzel (1821) claimed the Liard River area was the richest in furbearers and large animals including bison. Similarly, Simpson (1821) said that the Liard country abounded with bison. Ogilvie (1893) reported bison crossing the Liard River in 1891, and bison were seen in the mountains northwest of Fort Liard. Russell (1898) stated that a few bison were killed near Fort Liard, but they had become rare in that area.

In the past, Acho Dene Koe people around the Liard River used old bison trails as travel routes (Allaire pers. comm. *in* SARC 2016: 45).

Search Effort

1897 to 1907

After wood bison had reached the brink of extinction and the *Unorganized Territories Game Preservation Act* was passed in 1894 to protect them, officers of the North West Mounted Police were appointed as ex-officio game guardians. Until 1897, the police had been restricted in the north to outposts on the Athabasca River. With the gold rush into the Klondike, the police commissioner decided to establish winter patrols along the major waterways as far north as Fort Resolution on Great Slave Lake (Herschmer 1898). As the first officer to be sent to Fort Smith and Fort Resolution to enforce Canadian laws, Inspector Arthur Jarvis was instructed to locate the remaining wood bison, determine exact numbers and find out whether the 1894 game act was effective. All wood bison were found to be west of the Slave River from the Peace River to within 20 miles (32 km) of Fort Resolution. No more than 300 existed, and most of the residents in this area were unaware of the protective legislation. He also heard there may still be a few bison in the upper Liard River (Jarvis 1897). However, there were no reports of these Liard animals after 1897 (Soper 1941).

During his travels in 1901 to Fort Chipewyan, Fort Smith and Fort Resolution as Treaty 8 Commissioner, Macrae (1901) interviewed a large number of Indigenous people who had returned from the bison range. He concluded that wood bison existed in three separate herds: Salt River south to Peace River, east and west of Salt River, and Salt River north to Great Slave Lake.

In 1904, the prefix 'Royal' was added to the national police force. Royal North West Mounted Police Inspector Jarvis continued exploration of the areas around the Grand Detour, Nyarling and Salt rivers with naturalists Preble and Seton, who published their discoveries pertaining to wood bison (Preble 1908; Seton 1911). Drawing upon those experiences, Jarvis (1907) stated that sporadic law enforcement was insufficient to prevent poaching of bison and recommended that a Dominion game sanctuary with resident game guardians was a better solution.

1908-1910

Royal North West Mounted Police Commissioner Aylesworth Perry established permanent detachments at Fort Vermilion, Fort Chipewyan and Fort Smith in 1908, and forwarded the Dominion game sanctuary recommendation to Ottawa (Perry 1909). To enforce the prohibition of bison hunting, it was imperative that all police officers who followed Jarvis become familiar with the distribution of the remnant herds. In 1908, Superintendent William Routledge along with François Biscaye, Michel Mandeville, Pierre Lahache, and Gregoire Daniels in his party searched for bison 120 km westward from the Salt River settlement (Routledge 1908). Many years before, bison had been numerous on the first prairie they crossed, but none had been there since. Reaching a strip of prairie openings extending from Great Slave Lake around the mouth of Buffalo River southward to the Peace Point area, they encountered considerable bison activity. Routledge (1908) was also advised that bison seldom strayed westward from Buffalo Lake and Buffalo River to Hay River because of very bad muskeg.

During 1909, many police patrols searched for wood bison and officers tried to obtain all the information they could about the bison range. When Sergeant Robert McLeod travelled from Fort Vermilion on the Peace River to the mouth of Hay River on the south shore of Great Slave Lake, he observed no sign of bison, nor feed for them (McLeod 1909). He heard from Indigenous informants that bison never had been known to range west of Buffalo Lake, and bison no longer occurred within two days travel east of Buffalo Lake. When Corporal A. H. L. Mellor, Joseph Beaulieu and Narcisse Mercredi explored the area southwest of Fort Smith, they found much evidence of bison including a herd of at least 75 (Mellor 1909). Constable W. A. Johnson and Pierre Squirrel found tracks in a few locations between the Salt River settlement and Little Buffalo River (Johnson 1909). During their patrol of the area between Fort Chipewyan and Fort Smith, Constable Gairdner, Special Constable Daniels and Michael Voyageur saw one bison and many tracks (Gairdner 1909). From tracks and other signs observed by Constable Bates during fall and winter patrols to Peace River, he estimated that there were about 300 bison in the southern part of the range (Perry (1910).

Patrols continued in 1910. Under the auspices of the Royal North West Mounted Police, Buffalo Guardian Pierre Gladu searched for bison to the northwest of Fort Chipewyan and determined that their range did not extend as far west as Jackfish River (Gladu 1910). Sergeant McLeod and Alfred Atilaw traveled across the Caribou Mountains from Fort Vermilion to the mouth of Hay River and found no bison nor good grazing habitat for them (McLeod 1911). The Indigenous people they met were familiar with the bison protection regulations and stated that the western edge of bison distribution was 35-40 miles (56-64 km) east of Buffalo Lake. Corporal Mellor and Constable Johnson patrolled from west of Little Buffalo River to Sulphur Point on Great Slave Lake to the shores of Buffalo Lake and found no bison. From a summary of that patrol and other police searches, Mellor (1910) outlined the approximate limits of bison distribution as bounded westerly by the Caribou Mountains, southerly by the Peace River, easterly by the Slave River, and northerly by a line from the Caribou Mountains 50 miles (80km) south of Buffalo Lake to Point Ennuyeuse on the Slave River.

Harry Radford was sent by the American Bison Society for a two-year study of the present and former range of wood bison in 1909. He confirmed that the subspecies had disappeared from all parts of their original range, particularly in the past 15 years, except for the area west of the Slave River (Radford 1911). Also, he believed that police protection had stemmed the decline, and 325-335 wood bison were widely scattered in small roving bands.

1911 to 1922

When the Royal North West Mounted Police were relieved of their special supervision of wood bison in 1911, the responsibility was transferred to Game Guardians, under the supervision of George Mulloy of the Forestry Branch. All searches for wood bison were carried out on the ground with dog teams in winter, and by canoe and horseback during the rest of the year. Mulloy and newly appointed Peter McCallum were the first to monitor the bison range under the Game Guardian mandate. Initial investigations mainly covered the area north of the upper Little Buffalo River, and they concluded that two separate herds remained (Mulloy 1912). West of the Ninishith Hills, Mulloy (1912) observed bison sign everywhere. He was also told by his guide that these hills were the southwestern border of the northern bison range and the country to Buffalo Lake was all prairie. From the description provided by Mulloy (1912), the southeastern boundary of this herd was around Sass River (which he called Bear Creek). Bison that were reported by Mellor (1912) to be still ranging between the Little Buffalo and Slave rivers, as far north as the Fort Resolution area, had evidently disappeared by 1916 Camsell (1917). As the number of Game Guardians grew to 8, they lived in cabins constructed by themselves in different parts of the range and were visited periodically by an inspector for updates (Garretson 1923). During a comprehensive faunal reconnaissance of the Great Slave Lake region in 1914, Harper (1932) accompanied McCallum on patrol and documented the state of the knowledge of wood bison. McCallum believed that the population had grown to about 500 animals, and the larger northern herd was separated from the southern herd by jack pine forest 20-30 miles (32-48 km) in width.

As a prelude to establishing a Dominion game sanctuary for wood bison, Seibert (1923) and Kitto (1924) carried out comprehensive surveys of bison distribution from 1920 to 1922. Their work helped determine the boundaries for the creation of Wood Buffalo Dominion Park in 1922 (or Wood Buffalo National Park as it was renamed in 1930). Seibert's investigations were mainly focused within the NWT portion of the range as he mapped distribution and assessed habitat conditions. The area occupied by bison to the northeast, east and south was well known and here the park was bounded by the Nyarling, Little Buffalo, Slave and Peace rivers, excluding the settlement environs of Salt River, Fort Smith and Fort Fitzgerald. In the western and northwestern areas where Kitto and Seibert were less informed, park boundaries were fixed by straight lines conservatively beyond the known range.

1923 to 1930

After the *National Parks Act* was passed in 1930, a warden service replaced the Game Guardians with cabins, roads, trails and telephone lines constructed throughout the park for improved bison monitoring efforts (Kitto 1930). When about 400 Wainwright bison were observed crossing the Peace River southward to the Peace-Athabasca Delta in 1925-26, the park boundaries were enlarged to accommodate this range expansion (Seton 1927).

From 1928 to 1930, Hugh Raup travelled extensively in his evaluation of bison range conditions in Wood Buffalo National Park from topographical, soil and vegetation perspectives Raup (1933). He also collated early history, local knowledge of long-term residents, and observations of park wardens regarding bison habits and their geographical distribution. The remains of old connecting bison trails gave Raup reason to believe that the separation between the northern and southern herds occurred only after their maximum population decline, otherwise no real barriers to movement existed. Because bison numbers were steadily increasing, he believed that interchange between the two herds would recommence soon, if not already. Raup observed that bison were returning to the Salt Plains where they were formerly abundant. With information collected about the early history and their habitat requirements, he predicted range expansion to the south and west of the lower Peace River, the base of the Caribou Mountain plateau, and the upper Hay River, but limited by agricultural development in areas beyond the park. He also anticipated range expansion across the Little Buffalo and Slave rivers as far east as the Precambrian shield.

1931 to 1946

In an attempt to overcome difficulties of estimating the bison population from the ground, the first aerial bison survey in Wood Buffalo National Park took place in 1931 with the cooperation of the Royal Canadian Air Force. All bison were to be photographed from orderly flight lines over the winter range, and a Park Warden was present for a direct visual count. Reports from the wardens described the outcome as unsatisfactory, mainly because of the problem with forest cover (Soper 1941).

Unconvinced about the feasibility of aerial surveys after his own attempt in 1932, J. Dewey Soper investigated the numbers and distribution of bison in Wood Buffalo National Park from the ground during the period of 1932-34 (Soper 1941). His efforts involved a systematic evaluation of pasturage within 72 square mile (186.5 km^2) quadrats of land, and the degree of use by bison. Even at low density, he found that bison made their presence very obvious in the form of trails, trees that are rubbed or horned, and willows browsed and thrashed into odd shapes. Soper (1941) calculated a population of 12,000 bison but conceded that neither aerial nor ground surveys alone were capable of providing a very creditable approximation. He believed that the population occupied about 8,200 miles^2 (21,240 km^2) in eastern and central portions of the park, whereas 9,100 miles^2 (23,570 km^2) in western and northern areas were substantially uninhabited by bison. Although there was plenty of habitat available for expansion, he considered the section of the park north of the Caribou Mountain plateau to be unsuitable for bison. Soper also noted a few restless herds that occasionally left the park, including a group of about 40 animals that temporarily crossed to the east side of the Slave River during the winter of 1933-34. This was an indication that bison were starting to reuse the Slave River Lowlands (at least as far east as the Slave River), but this was not part of Soper's study area.

1947 to 1961

Aerial surveys were restarted by Oldham (1947) and have been used exclusively for population estimates ever since. Due to their large size, dark colouration, and preference for open habitat, bison are easily spotted from the air against a white snowy background. Feeding craters in snow often signal to the observer that further searching will reveal their presence. In 1949, William Fuller improved upon Oldham's strip transect techniques by surveying later in the winter, employing two observers, covering a narrower strip, and maintaining unidirectional flight lines (Fuller 1950). In his review of the problems encountered by earlier census attempts, Fuller believed that Soper's 1934 (1941) ground estimate of 12,000 was too high, and Oldham's 1947 aerial estimate of 7,482 was too low. By 1949, Fuller thought that the ranges in and around Wood Buffalo Park contained at least 12,000 bison. Since the time of Soper's work, Fuller determined that the bison population had expanded east of the Slave River (which he did not survey), to the eastern base of the Caribou Mountain plateau, and further into areas around the lower Peace River to encompass a region that resembles the current area of occupation of the Greater Wood Buffalo metapopulation. Fuller also stated that the population trend was as important as absolute numbers, and if survey methods were standardized, trends may be tracked. Fuller (1951) resurveyed the bison range two years later to reconfirm his 1949 results.

Nicholas Novakowski duplicated Fuller's methodology in 1957 and estimated a bison population of 12,000-14,000 (Novakowski 1957a). He also discovered about 200 bison at the headwaters of the Nyarling River, and subsequent flights showed these animals to be quite isolated from all other herds. The Nyarling subpopulation was studied in detail with the intention of using it for establishing disease-free herds of pure wood bison (Novakowski 1959). As bison in the Slave River Lowlands were becoming more important, Novakowski (1961) estimated that 1,300 occurred between the Little Buffalo and Taltson rivers.

1962 to 1971

Starting in 1962, six anthrax outbreaks had killed over 1,000 bison in the Greater Wood Buffalo metapopulation by 1971 (Choquette *et al*. 1972). Most search efforts were directed towards locating infected carcasses for disposal and rounding-up herds for vaccination. As a result, comprehensive bison censuses in Wood Buffalo National Park were deferred.

Following the salvage of wood bison from the Nyarling River area, the Mackenzie bison population was established on August 14, 1963 (Novakowski 1963b). James Bourque was appointed to monitor the herd for the first few years while they remained in the vicinity of Falaise Lake. The aerial surveys in 1968 and 1969 that located 42 and 56 bison respectively indicated that animals had started to occupy Dieppe and Calais lakes (Gates and Larter 1990).

Williams (1966) was the first to survey the Slave River Lowlands herds east and west of the river as separate entities. Results from strip transects of partial coverage estimated 302 bison for the Grand Detour subpopulation and 1,430 for the Hook Lake subpopulation. The mandate for wildlife management outside of Wood Buffalo National Park was transferred to the new Government of the Northwest Territories when it was created in 1967. Consequently, surveys of the Grand Detour subpopulation whose animals moved in and out of the park were not being coordinated between the federal and territorial agencies. When Hall (1968) flew transects of partial coverage, he estimated 249 in the Grand Detour area and 1,232 for the Hook Lake subpopulation. Rippin (1971 *in* Van Camp and Calef 1987) carried out the first strip transect total coverage survey in the Slave River Lowlands. He estimated 336 bison for the Grand Detour subpopulation, and his 1,700 estimate (Rippin 1971 *in* Nishi 2010) east of the Slave River is the highest ever recorded for the Hook Lake subpopulation.

1972 to 1986

The beginning of this time period marked the onset of a long-term decline of the Greater Wood Buffalo metapopulation. From the initial anthrax outbreak until 1974, surveys in Wood Buffalo National Park were limited to the high bison concentrations of the Hay Camp and Delta subpopulations, mainly to assist with the placement of vaccination corrals (Tempany and Cooper 1975). In 1975, coverage was extended to the Nyarling and Grand Detour ranges, but survey effort in those areas varied between years (Bradley and Wilmshurst 2005). Surveys in the Slave River Lowlands followed the same flight lines as established by Rippin in 1971 for the next several years (Van Camp and Calef 1987), which would have limited search effort in peripheral areas. Calef (1976) indicated that bison were distributed across most of the Slave River Lowlands from the delta to the Alberta border, but that they concentrated on the large prairies from mid-May to mid-July. He also stated that movements could be erratic and during the particularly severe weather of 1974-75, most of the animals wintered further south than usual.

Growth of the Mackenzie population was documented by total count surveys carried out every year. The procedure was to search 100% of the marl lake beds occupied by bison and the major trails connecting them. Less than three hours of flight time was sufficient to account for virtually the entire population. Bison were beginning to occupy Calais Lake (Jacobson 1974) and Boulogne Lake (Gates and Larter 1990). After bison started invading the Mink Lake area in 1980, the extended search effort doubled the survey flight time. The number of bison observed became the minimum estimate for the population, with no accompanying estimate of precision.

The Nahanni population was established in 1980 when 28 wood bison from Elk Island National Park were released (Reynolds 1982). The population was monitored by surveys that tracked the total count and expanding distribution (Larter and Allaire 2007).

1987 to 2001

In 1987, a bison-free management zone (Bison Control Area) was established south of the Mackenzie River and north of the Mackenzie Highway, between Mills Lake and Hay River, to prevent the Greater Wood Buffalo metapopulation bison from infecting the Mackenzie and Nahanni populations with tuberculosis and brucellosis. In 1990, the control area was greatly expanded to the Alberta border, between Trout River and Wood Buffalo National Park (Gates and Gray 1992). Since then, an area of 39,623 km^2 has been searched several times per year, by ground and by air, for the purpose of removing bison (Greig and Cox 2012). Geographic information system (GIS) software and global positioning system (GPS) technology became available for aerial survey navigation.

The Mackenzie population was expanding its range to Mills and Beaver lakes on the Mackenzie River, Lonely Bay and Frank Channel on Great Slave Lake, and the base of the Horn Plateau. In addition to systematic surveys in 1989, 1992, 1996, 1998, and 2000, targeted searches to monitor these movements were documented by field officers in the Wildlife Sightings appendices of their Monthly Reports (Chowns pers. comm. *in* SARC 2016: 226). As the Mackenzie population became too large and dispersed to rely solely on total counts, the study area was stratified into high, medium and low density units (Gates *et al.* 1991). The high density stratum consisted of the main meadows where bison concentrated and these areas were still covered by total counts. Systematic parallel transects covered medium and low density strata between areas of high density. Since the first Mackenzie bison anthrax outbreak in 1993 (Gates *et al.* 1995), regular, widespread searches have been carried out in the summer season for carcass detection and disposal (CMA 2025).

Prior to the establishment of permanent transects in the high-density areas of Wood Buffalo National Park in 1991, search effort changed almost every year (Bradley and Wilmshurst 2005). Lower density areas that were covered by reconnaissance flights depended on available funding. Fifty survey hours were flown annually.

The Hook Lake subpopulation had declined to such low numbers that the 1987, 1994, 1996 and 2000 minimum population estimates were based solely on total counts (Ellsworth pers. comm. *in* SARC 2016: 226).

Aerial surveys of the primary bison range in the Nahanni Butte and Netla and Kotaneelee River areas, the Liard River Valley and its islands from Flett River to Fort Liard and the cutblocks in the La Biche River area of northeastern British Columbia were carried out in 1995, 1996, and 1997 to generate a minimum population estimate (Larter and Allaire 2007). However, these were not systematic aerial surveys of the population that could be replicated.

2002 to 2011

A biological program for the Dehcho Region was established in 2002, which included more regular monitoring of the growing Nahanni bison population (Larter and Allaire 2007). In 2003, they added all information from local residents and the Governments of British Columbia and Yukon Territory on bison distribution to the knowledge base for compilation of a map of the winter range of the Nahanni bison population. For the 2004 aerial survey, 1,288 km of parallel strip-transect lines were flown at 4 km intervals over the Nahanni bison winter range in the NWT, British Columbia and the Yukon (Larter *et al*. 2007). A similar survey of nearly 20 hours was carried out in 2011, except that the transect lines were increased to 2,155 km at 3.5 km apart (Larter and Allaire 2013). The population was estimated at 431 (± 213, 95% CI). This had a lower coefficient of variation than the 2004 estimate, partially because transect lines were lengthened according to expanding the bison range, animals were more evenly distributed, and fewer transects were used where no bison were observed in 2004. Following the survey, collared animals were located beyond the 2011 survey area boundaries, which indicated continuing range expansion.

In 2002, permanent transects were established in the lower density areas of Wood Buffalo National Park, resulting in an annual effort exceeding 100 hours. Prior to the establishment of permanent transects in the high-density areas of Wood Buffalo National Park in 1991, search effort changed almost every year (Bradley and Wilmshurst 2005). Lower density areas that were covered by reconnaissance flights depended on available funding. Fifty survey hours were flown annually. To enable comparisons with 1990s level of effort, the increase in survey effort was compensated by buffering the flight lines (Bradley and Wilmshurst 2005). The 2009 bison survey was classified into four strata consisting of total count, strip transect, combined total count/strip transect, and reconnaissance of areas that are expected to contain few or no bison (Vassal and Kindopp 2010).

The 2009 Slave River Lowlands survey of the Hook Lake and Grand Detour subpopulations used over 23 hours of flying time and was coordinated with Wood Buffalo National Park's bison survey. A total of 1,162 bison were observed on and off transects, giving a population estimate of 1,790 ± 323, which is nearly triple the previous estimate of 600 in 2000 (Armstrong 2011).

The Mackenzie population surveys were increasing above 75 hours of flying time. From a total of 1,252 bison observed on and off transects in 2008, the population estimate was 1,555 ± 146, about 22% less than the 2000 estimate of 1,998 ± 163 bison (Armstrong 2010).

2012 to 2024

When the Mackenzie population estimate in 2012 was reanalysed with 2013 data, the estimate was 1,531 ± 257. The Mackenzie population was resurveyed in 2013 because of an anthrax outbreak in summer 2012, producing an estimate of 714 ± 156 (Armstrong 2013b).

According to Steinwand *et al*. (2025), bison monitoring of the new Tłı̨chǫ Highway (2021-2025) revealed the highest number tallied on the highway in 2022, more bison observed daily in 2023, and greater numbers of bison during the warmer months of the year. The yearly distribution data show bison have been moving further north along the highway corridor.

The Wood Buffalo National Park bison survey design has not changed since 2003, and combines total count, strip transect, combined total count/strip transect, and reconnaissance of areas that are expected to contain few or no bison to achieve population estimates (Rabley pers. comm. 2025).

APPENDIX A5 – PREDATION

Case History: Impacts during an increasing Mackenzie Bison Population (1963-1992)

From 1963 when 18 bison founded the Mackenzie herd, the mean exponential growth rate was 24% until 1975 when the herd reached 300 bison (Calef 1975). An active wolf poisoning program was in place until the end of the 1960s (Look pers. comm. *in* SARC 2016), but bounties continued to be paid for wolves until 1974. Boreal caribou and moose were abundant on the bison range (Kimble pers. comm. *in* SARC 2016, Jacobson 1976), probably at a very low wolf to prey ratio. No sign of predation on bison was evident (Calef 1975). The predator-prey relationship was likely a wolf-caribou/moose system.

The Mackenzie Bison Sanctuary bison population growth was slowing as it surpassed 600 animals (Hawley 1980). Although the wolf population was rebounding, many Indigenous trappers harboured an aversion to killing wolves (Look pers. comm. *in* SARC 2016). An old male bison observed on Falaise Lake in March 1980 appeared to have been wounded by wolves, but on the same day, a wolf-killed moose was also found on Falaise Lake, despite the presence of over 300 bison surrounding the kill site (unpublished ENR Officer reports). The predator-prey relationship appeared to have switched from wolf-caribou/moose to a wolf-moose system, supplemented opportunistically with bison.

The rate of growth was still slowing as the Mackenzie population surpassed 1,000 animals after 1983. Wolves were becoming more of a menace to trappers by destroying valuable furbearers caught in traps (Look pers. comm 1985). Harvest levels of moose by residents of Fort Providence were decreasing and fewer were being observed on bison surveys. Increasing frequency of wolf-killed bison calves indicated that the prey base was broadening to bison. If the wolf to prey ratio was rising, moose probably comprised a dwindling fraction of the prey base. The predator-prey relationship seemed to be transitioning from wolf-moose to a wolf-bison system.

The population rate of growth had slowed to 10.3% by 1987 (Gates and Larter 1990), and the population had essentially stopped growing by 1989 when numbers reached 2,431 (Gates *et al.* 1991; refer to Table 4). Wolf predation may have been a factor as they were being observed in larger packs (up to 20 individuals) than trappers considered normal in the past (Chowns pers. comm. 2025). Moose had become so rare that bison comprised the overwhelming bulk of the prey biomass (1,106 tonnes bison: 46 tonnes moose), but the number of wolf scats containing moose was significantly greater than expected given the (lack of) availability (Larter *et al.* 1994). The only other mammal prey identified were snowshoe hare and mice. The wolf to prey ratio was probably still increasing and predation on adult bison was confirmed (Larter *et al.* 1994).

Case History: Impacts during a decreasing Greater Wood Buffalo metapopulation (1971-1999)

By 1934, the Wood Buffalo National Park bison population likely numbered between 10,000 and 12,000, reaching 12,500-15,000 animals by the late 1940s to early 1950s (Fuller 1950, 1966). After 1971, the wolf control program was essentially over and the Greater Wood Buffalo metapopulation began to decline rapidly in the presence of more wolves; bison were the primary prey (Van Camp and Calef 1987; Carbyn *et al.* 1993). From 11,000 bison in 1971, the Wood Buffalo National Park numbers plummeted to approximately 2,300 by 1998, and during nearly the same period, the Slave River Lowlands bison numbers dropped from 2,037 to 518 (Van Camp and Calef 1987; Carbyn *et al.* 1998). The decline was attributed to excessive predation on calves resulting in low recruitment. One aggregation of wolves in Wood Buffalo National Park in February 1974 numbered 42 individuals (Fau and Tempany 1976). The bison population was depressed further by the 1974 drowning of 3,000 animals, which could conceivably have provided a short-term glut of carrion to boost the wolf to prey ratio.

Following the drowning event, Wood Buffalo National Park bison failed to rebound and partially stabilized between 5,000-6,000 animals for the next eight years (Bradley and Wilmshurst 2005). Wolf numbers appeared to compensate downward for the smaller food base (Joly and Messier 2000), but the lag time for this was unknown and wolves continued to exert predation pressure during the decline.

After the severe winter of 1974-75 in the Slave River Lowlands, the combined numbers of the Hook Lake and Grand Detour subpopulations dropped from about 1,904 to 1,245, for a total loss of about 35% (Van Camp and Calef 1987). Similar to Wood Buffalo National Park, bison of the Slave River Lowlands failed to rebound after the precipitous drop in numbers. Van Camp (1987) estimated that 64 to 76 wolves were preying upon approximately 754 bison of the Slave River Lowlands during the winter of 1976-77, and capitalizing on wounded animals, offal, and diseased carcasses left in the field by hunters. Despite an experimental wolf reduction carried out in the Slave River Lowlands between 1977 and 1979 that eliminated most of the wolves, juvenile recruitment did not improve and the bison continued declining to 551 in March 1979 (Jalkotzy 1979).

The Wood Buffalo National Park bison continued to decline from 5,600 at the beginning of the 1980s until 1991 when it dipped to 3,310 animals. Recruitment dropped as low as three yearlings: 100 cows (Carbyn *et al*. 1993). Despite a total decline of 41% in bison numbers, there was increase in the wolf population of 39% from 110-130 to 150-180. Predator-prey studies in the Slave River Lowlands were finished and the Hook Lake herd dropped to a new low of 183 bison in 1987 (Gates 1988). After the Hay Camp subpopulation declined to 300 in the mid-1980s, predation moderated (Carbyn *et al*. 1993), suggesting a threshold bison density affecting the wolf population. As previously stated, the Hook Lake and the Delta subpopulations seemed to account for most of the decline and had the highest predation rates in the Greater Wood Buffalo metapopulation (Van Camp 1987; Carbyn *et al.* 1993).

APPENDIX B – THREATS ASSESSMENT[4]

Threats have been classified for wood bison in the NWT only (i.e., not including threats that may be present in neighbouring jurisdictions). The threats assessment is based on whether threats are of concern for the sustainability of the species in the NWT over approximately the next 10 years.

This threats assessment was completed collaboratively by members of the NWT Species at Risk Committee, at a meeting on June 20, 2025. The threats assessment will be reviewed and revised as required when the status report is reviewed in 10 years or at the request of a Management Authority or the Conference of Management Authorities. Parameters used to assess threats are listed in Table B1.

Table B1. Parameters used in threats assessment.

Parameter	Description	Categories
LIKELIHOOD		
Timing (i.e., immediacy)	Indicates if the threat is presently happening, expected in the short term (<10 years), expected in the long term (>10 years), or not expected to happen.	Happening now Short-term future Long-term future Not expected
Probability of event within 10 years	Indicates the likelihood of the threat to occur over the next 10 years.	High Medium Low
CAUSAL CERTAINTY		
Certainty	Indicates the confidence that the threat will have an impact on the population.	High Medium Low
MAGNITUDE		

[4] This approach to threats assessment represents a modification of the International Union for the Conservation of Nature's (IUCN) traditional threats calculator. It was originally modified for use in the Inuvialuit Settlement Region Polar Bear Joint Management Plan (Joint Secretariat 2017). This modified threats assessment approach was adopted as the standard threats assessment method by the Species at Risk Committee and Conference of Management Authorities in 2019.

Extent (scope)	Indicates the spatial extent of the threat (based on percentage of population or area affected).	Widespread (>50%) Localized (<50%)
Severity of population-level effect	Indicates how severe the impact of the threat would be at a population level if it occurred.	High Medium Low Unknown
Temporality	Indicates the frequency with which the threat occurs.	Seasonal Continuous
Overall level of concern	**Indicates the overall threat to the population (considering the above).**	**High** **Medium** **Low**

Overall Level of Concern

The overall level of concern for threats to wood bison are noted below. Please note that combinations of individual threats could result in cumulative impacts to wood bison in the NWT. Details can be found in the *Detailed Threats Assessment*.

Overall level of concern:

- **Threat 1 – Anthrax** **High**
- **Threat 2 – Overharvesting** **Medium-High**
- **Threat 3 – Bovine tuberculosis and brucellosis** **Medium**
- **Threat 4 – Vehicle collisions** **Medium**
- **Threat 5 – Severe weather events** **Medium**
- **Threat 6 – Drowning** **Medium**
- **Threat 7 – Predation** **Medium**
- **Threat 8 – Low genetic diversity** **Low-Medium**

Detailed Threats Assessment

Threat #1. Anthrax	
Specific threat	Anthrax is an extremely lethal pathogen, with serious implications for wood bison in the NWT.
Stress	Anthrax is caused by the bacterium *Bacillus anthracis*, which is found naturally in the soil. Transmission pathways include inhalation, hematophagous (blood-eating) insects, and ingestion. After the spores germinate into the vegetative form of the bacterium inside its host, replication in the bloodstream occurs intensively within a few days, and massive release of toxins causes septicaemia and often rapid death. Little opportunity exists for bison to evolve innate genetic immunity due to the high lethality of anthrax. Outbreaks of varying proportions have arisen periodically in the Greater Wood Buffalo metapopulation and Mackenzie bison population, and many years may elapse between epidemics of high mortality. Between 1962 and 2024, there were 15 recorded outbreaks in Wood Buffalo National Park, nine in the Slave River Lowlands (outside of the park), and three in the Mackenzie bison range, resulting in a total of 2,357 known mortalities. No cases of anthrax have been found in the Nahanni population.
Extent	Localized (<50%)
Severity	High
Temporality	Seasonal
Timing	Short-term
Probability	High
Causal certainty	High
Overall level of concern	**High**

Threat #2. Overharvesting	
Specific threat	Historically, hunting was considered to be the largest threat to wood bison. Conservation measures, including the establishment of Wood Buffalo National Park in 1922 and harvest quotas for the Nahanni and Mackenzie populations, have diminished this threat. However, bison in the Greater Wood Buffalo

	metapopulation outside of Wood Buffalo National Park (Slave River Lowlands) continue to be hunted with few restrictions.
Stress	Wood bison are hunted to some degree throughout their range in the NWT. Harvest of Mackenzie and Nahanni bison are managed through quotas (40 bulls and 7 bulls, respectively). These harvest quotas are based on total population size with consideration of recent trends. There are no regulations governing the number of bison that may be harvested from the Slave River Lowlands by Indigenous people. Resident hunters may purchase one bison tag per year. From 1969 to 1976, harvest exceeded an average of 140 bison per year in the Slave River Lowlands subpopulations (Hook Lake and Grand Detour). In 1977, resident and recreational hunting were terminated. General Hunting Licence (GHL) holders continued to harvest 4-8% of the Slave River Lowlands population (higher than the 3.9% recruitment rate) until 1979. These estimates are considered minimums, as harvest reporting is not a legal requirement for GHL hunters, and these figures may not include wounding losses or unreported kills. Total harvest for the Slave River Lowlands subpopulation since 1979 is unknown. There are concerns that demand for bison hunting may increase when other species such as moose or caribou are not available. Hunting pressure tends to increase in conjunction with increased access to wood bison habitat. Seismic lines and other linear disturbance, while creating forage for wood bison, also increase hunting pressure through increased access. When hunting pressure increases, wood bison are known to move into the bush (poorer habitat) and away from access routes.
Extent	Localized (<50%)
Severity	High
Temporality	Continuous
Timing	Happening now
Probability	High
Causal certainty	Medium
Overall level of concern	**Medium-High**

Threat #3. Bovine tuberculosis and brucellosis	
Specific threat	Bovine tuberculosis and bovine brucellosis are present throughout the range of the Greater Wood Buffalo metapopulation. These diseases can cause chronic

	health issues or death, weakening bison populations' resilience to environmental disturbances and impacting overall population numbers.
Stress	In the NWT, bovine tuberculosis and bovine brucellosis are present only in the Greater Wood Buffalo metapopulation (they have not been found in either the Mackenzie or Nahanni populations). All bison in the Greater Wood Buffalo metapopulation have potentially been exposed and are susceptible to infection from tuberculosis. Almost all modes of infection are through the respiratory and digestive systems, and it occasionally passes from mother to offspring via the placenta or milk. Among subpopulations in Wood Buffalo National Park, the overall incidence of tuberculosis was estimated at 49% (2004). The probability of pregnancy may be 30% less likely for females with both brucellosis and tuberculosis, compared to females with one or neither disease. Annual mortality of bison from tuberculosis has been estimated at 5%. Bovine brucellosis mainly impacts female bison reproduction by causing abortion of the foetus. Most animals abort during the first pregnancy following infection but will carry subsequent pregnancies to term. Seropositive rates for brucellosis in and around Wood Buffalo National Park have generally remained constant, around 31%, although these bison do not necessarily all have the disease. The combined effects of tuberculosis and brucellosis on adult mortality at the population level have been estimated at about 1% per annum. Levels of brucellosis and tuberculosis have not decreased over time within the Greater Wood Buffalo metapopulation despite a major decline in population size. The only feasible method for eradicating tuberculosis from a herd seems to be the removal of all infected animals, as well as all exposed susceptible animals.
Extent	Localized (<50%)
Severity	Low-Medium – Severity may be higher in populations that are currently disease-free (Mackenzie and Nahanni)
Temporality	Continuous
Timing	Happening now
Probability	High
Causal certainty	Medium
Overall level of concern	**Medium**

Threat #4. Vehicle collisions	
Specific threat	Vehicle collisions are a common cause of mortality for wood bison in the NWT. Bison tend to congregate along roads (used for grazing and movement) and present a traffic hazard throughout their range. Members of the Dehcho First Nation and Tłı̨chǫ citizens have noted concerns about the number of wood bison being killed on highways and have suggested vehicle collisions may be the most important threat facing wood bison.
Stress	An average of 12 vehicle-bison collisions are reported to the GNWT Department of ECC every year, with 2020 representing the most collisions on record in a single year (31 collisions reported). Although many accidents involve a single animal, sometimes multiple animals are involved. Those most frequently killed are adult females, followed by calves, then adult males. Collisions are most frequent from August to December, and between dusk and dawn. During winters with heavy snowfall, bison are especially likely to use roads for easier movement, increasing the potential for collisions. About 89% of vehicle-bison collisions in the NWT occur in the Mackenzie bison range. The construction of the Deh Cho Bridge (opened in 2012) may have contributed to additional vehicle collisions in the Mackenzie bison range due to an increase in nighttime traffic. Bison are also expected to continue to move northward along the Tłı̨chǫ Highway toward Whatì, increasing the number of vehicle-bison collisions.
Extent	Localized (<50%)
Severity	Medium
Temporality	Seasonal
Timing	Happening now
Probability	High
Causal certainty	High
Overall level of concern	**Medium**

Threat #5. Severe weather events	
Specific threat	Adverse snow conditions can cause substantial bison losses through the winter. Freeze-thaw events can create a thick frozen crust over the snow that impairs foraging and mobility of bison and increases vulnerability to wolves and hunters.

Stress	Harsh winters with deep snow and/or freeze-thaw events can be an important source of bison mortality. Snow refrozen after rain or thawing may be particularly devastating to bison. Such conditions can lead to starvation and heightened vulnerability to predation. For example, in 2013, the Hay-Zama (Alberta) wood bison suffered from harsh winter conditions with estimates of calf survival at only 5%. In the NWT, a November snowstorm followed by freezing rain led to the loss of approximately 33% of the Hook Lake subpopulation during the winter of 1974-75, and an extreme late winter freeze-thaw event in the Nahanni range in 2016 coincided with the lowest overwinter calf survival recorded, with only two yearlings observed during the classification survey that year. Bison are not well-adapted to deep snow when compared to North American cervids and extreme snow depths also increase their vulnerability to predation. Snowpack is projected to deepen across NWT bison ranges in later decades, but it is expected to be offset by rising temperatures that shorten the period of snow accumulation during spring and fall. The worst-case scenario for bison would be more frequent extreme snowfall events coupled with thawing or rain. Winter precipitation in the NWT has been modelled to be 50-60% higher by the 2080s, and a warming climate increases the probability of precipitation falling as rain rather than snow.
Extent	Widespread (>50%)
Severity	Medium (highly variable)
Temporality	Seasonal
Timing	Short-term future
Probability	High
Causal certainty	High
Overall level of concern	**Medium**

Threat #6. Drowning	
Specific threat	Drownings from attempts to swim across rivers and falling through ice are unpredictable events that can cause sudden mass mortalities and can potentially be devastating to small wood bison populations.
Stress	A number of instances of bison falling through thin ice and drowning have been documented. In cases where bison break through lake or river ice, they are generally unable to climb out. For example, in 1989, 177 bison perished through

	spring ice on Falaise Lake in the Mackenzie Bison Sanctuary. In the Peace-Athabasca Delta (Alberta), about 3,000 bison drowned over the spring, summer and fall of 1974. Boat and barge traffic also represents a potential threat to wood bison in the NWT. Wood bison, especially calves and mature males, which sit lower in the water than other age classes, are vulnerable to waves and wakes.
Extent	Localized (<50%)
Severity	Medium
Temporality	Seasonal
Timing	Short-term future
Probability	Medium
Causal certainty	Medium
Overall level of concern	**Medium**

Threat #7. Predation	
Specific threat	Wolves are the main source of predation for bison. Black bears may also be minor predators. Predation was identified as a prominent factor when the Greater Wood Buffalo metapopulation was in decline in the mid-1970s. In recent years, communities around Wood Buffalo National Park have expressed concerns that low calf survival in bison herds in that area may be due to wolf predation.
Stress	Wolf predation affects bison populations mainly in winter when bison are in relatively poor condition. Generally, the very young or the very old are targeted, and vulnerability may be worsened by habitat structure, disease, and alternate prey that support high wolf numbers. Wolves have been seen killing more bison than they can eat. Members of the Salt River First Nation have reported wolf packs of 100 individuals attacking smaller groups of 30 wood bison around Lake Claire in Wood Buffalo National Park. In the Mackenzie population, predation was not observed on calves until 1983 and was much later for adult bison. Larter *et al.* (2000) stated that this bison population appeared to be regulated by food supply, despite considerable wolf predation on calves.
Extent	Widespread (>50%)
Severity	Medium

Temporality	Continuous
Timing	Happening now
Probability	High
Causal certainty	High
Overall level of concern	**Medium**

Threat #8. Low genetic diversity	
Specific threat	Two of the NWT's three wood bison populations (Mackenzie and Nahanni) were derived from remnants of much larger populations, such that the original gene pools may be poorly represented. Genetic diversity may be further reduced if new parent populations are already genetically impoverished.
Stress	Low genetic diversity and inbreeding among closely related individuals causes a higher probability of recessive deleterious alleles being expressed in the progeny. The resulting decreased fitness, known as inbreeding depression, is often manifested by under-weight births, low survival, and poor reproduction, as well as reduced resistance to disease, predation and environmental stress. As a population becomes more homogenous, it has fewer individuals with unique resistance traits to certain pathogens. Genetic drift (the loss of alleles by chance) is intensified when populations remain small and isolated for many generations. Interbreeding of wood bison with cattle and plains bison (either of pure lineage or carrying some cattle heritage from past breeding experiments) could also potentially threaten the genetic integrity, fitness and evolutionary pathway of wood bison.
Extent	Widespread (>50%)
Severity	Unknown
Temporality	Continuous
Timing	Happening now
Probability	Unknown
Causal certainty	Low
Overall level of concern	**Low-Medium**