



Species Status Report

Wood Bison

Bison bison athabascaae

Bison | Buffalo | Bison des bois (French)

Sakāwmostos (Cree)

Ejuda (Dene Kədá)

Dechj̄tah goegíé (Dene Zhatié)

Dechen yághe ejere, Thachin ya n'jere, ʔejjere (Denésų́łíné/Chipewyan)

Aak'ii, Dachan tat gwa'aak'j̄j̄ (Gwichya Gwich'in)

Dachan tat gwi'aak'ii (Teetł'it Gwich'in)

Dechj̄ta gojie, Enareh gojie, Ejie, Ejiezaa (Tł̄chq̄)

IN THE NORTHWEST TERRITORIES

NORTHWEST TERRITORIES
**SPECIES
AT RISK**
COMMITTEE

REASSESSMENT – THREATENED

MAY 2026



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).

Suggested citation:

Species at Risk Committee. 2026. Species Status Report for Wood Bison (*Bison bison athabasca*) in the Northwest Territories. Species at Risk Committee, Yellowknife, NT.

© Government of the Northwest Territories on behalf of the Species at Risk Committee
ISBN: 978-0-7708-0317-9

Production Note

The drafts of this report were prepared by Blyth and Bathe Inc. (Indigenous and community knowledge component) and Tom Chowns (scientific knowledge component) under contract with the Government of the Northwest Territories, and edited by Joslyn Oosenbrug and Michele Grabke, Species at Risk Secretariat.

This report is an update of the Species Status Report for Wood Bison (*Bison bison athabasca*) 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: 1-855-783-4301 (toll free)
Fax: 867-873-0221
E-mail: SARA@gov.nt.ca
www.nwt-speciesatrisk.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.nwt-speciesatrisk.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

ASSESSMENT OF WOOD BISON

The Northwest Territories Species at Risk Committee met on April 14-16 and on April 24, 2026, and reassessed the biological status of wood bison in the Northwest Territories. The assessment was based on this approved status report. The assessment process and objective biological criteria used by the Species at Risk Committee are based on Indigenous and community knowledge (ICK) and scientific knowledge (SK) and are available at: www.nwt-speciesatrisk.ca.

Assessment: Threatened in the Northwest Territories

Threatened – The species is likely to become Endangered in the NWT if nothing is done to reverse the factors leading to its extirpation or extinction.

Reasons for the assessment: Wood bison fit criteria ICK (a) for Special Concern and SK (C1 and D2) for Threatened.

Status Category	Criterion	
Special Concern	ICK(a)	Knowledge holders are observing changes in abundance, habitat quality/quantity, movements, or range, but these changes are not yet large enough to qualify the species for Threatened and knowledge holders express concern that the species is being adversely impacted by one or more natural or human-caused threats.
Threatened	SK(C1)	The species qualifies for Endangered status under SK (C1). Available information indicates that the number of mature individuals in the NWT is less than 2,500 and there is an estimated continuing decline in total number of mature individuals of at least 20% over the last two bison generations. However, there is indication of potential rescue effect for the Slave River Lowlands population from wood bison within Wood Buffalo National Park, therefore the status is reduced to Threatened.
	SK(D2)	The number of locations is restricted (≤ 5 locations) such that the species is prone to the effects of human activities or stochastic events within a very short time period (1-2 generations) in an uncertain future, and is thus capable of becoming Extinct, Extirpated or Endangered.

The Species at Risk Committee determined that wood bison fit Indigenous and community knowledge criteria for Special Concern and scientific knowledge criteria for Threatened. Based on all available information, the overall assessment for wood bison in the NWT is Threatened.

Main factors (ICK):

- In assessing wood bison, the available information about community concerns covered a period of 50-70 years ago to the present day (1956 to 2026). As a result, the assessment of wood bison did not address relationships with wood bison prior to their historic extirpation from the northern part of the NWT.
- Communities around Wood Buffalo National Park have expressed concern about the health and declines of wood bison populations in the Slave River Lowlands and in the park.
- Bovine brucellosis, tuberculosis, and anthrax are important threats for wood bison and long-term concerns have been expressed about the impact of these diseases on wood bison.
- Community members within the ranges of NWT bison populations have expressed concern about the number of wood bison-vehicle collisions on highways. Vehicle collisions with bison are an important threat to wood bison as well as to public safety.
- Across the NWT wood bison range, communities have vastly different experiences and concerns depending on when wood bison disappeared from their traditional territories and when or whether they were reintroduced. Communities around Wood Buffalo National Park have maintained their biocultural linkages to wood bison, while some communities in the Dehcho and Tłı̨chǫ regions are redeveloping them as wood bison return to parts of their historic ranges.

Main factors (SK):

- Information on wood bison in the NWT were available for Nahanni, Mackenzie and Slave River Lowlands populations. Data on population trends over the last 2-3 bison generations were not available for wood bison in Wood Buffalo National Park.
- Based on available information, the wood bison population in the NWT is estimated at about 2,764 animals in three disjunct populations (Mackenzie, Nahanni, and Slave River Lowlands). There are approximately 2,128 mature individuals (adult wood bison) in the NWT.
- The total number of mature individuals (adult wood bison) has declined over the last two wood bison generations. The estimated decline is between 20% (calculated using an 8-year generation time) and 22% (calculated using a 7-year generation time).

- The potential for rescue from wood bison in the Greater Wood Buffalo Metapopulation is high for one population (Slave River Lowlands), therefore the risk of extirpation was reduced from Endangered to Threatened.
- Wood bison occur in only three locations and are prone to the effects of human activities and stochastic events (for example anthrax outbreaks) within a very short time period (1-2 generations), such that the species could become Endangered in a short period of time.

Additional factors:

- The population bottleneck that occurred in the late 19th and early 20th century and reestablishment of NWT wood bison populations from just a few dozen animals has limited genetic variation in these populations. Low genetic diversity can result in decreased fitness, manifesting as under-weight births, low survival and disease resistance, and poor reproduction.

Positive influences on the species and their habitat:

- Cross-cultural approaches to wildlife management, land use and conservation planning, and habitat management provide a vital foundation for the stewardship of wood bison in the NWT.
- Genetic research is exploring ways to improve genetic diversity and investigate disease control/mitigation measure in wood bison.
- Disease transmission between wood bison populations is prevented through a Bison Control Area established between Wood Buffalo National Park and the Mackenzie River. Ongoing anthrax surveillance and response measures help mitigate the impacts of this disease on affected populations.
- Most wood bison populations in the NWT are protected from overharvesting by quotas.

Recommendations:

- Encourage respectful and responsible harvest activities related to wood bison to revive and/or support cultural connections to the species, including community hunts.
- Document Indigenous and community knowledge on wood bison populations, including habitat and threats.
- Continue long-term monitoring of wood bison populations to gather information on trends related to wood bison populations and distribution. Ensure results are robust, communicated in a timely manner, and made available to the public.

- Ensure territorial and federal government agencies and management partners collect, validate, and share reliable information on wood bison and their habitat with community members and each other in an open, transparent, and coordinated manner.
- Investigate and adopt innovative and effective road safety measures to reduce bison-vehicle collisions. Integrate bison-vehicle collision databases to inform these measures.
- Investigate measures to improve wood bison habitat, including prescribed burns.
- Expand health monitoring to get a better understanding of the sublethal impacts of diseases (e.g., bovine brucellosis and tuberculosis) on wood bison populations.
- Encourage sharing wood bison observations on iNaturalist.ca and/or reporting observations to WildlifeObs@gov.nt.ca.

Executive Summary

Indigenous and Community Knowledge	Scientific Knowledge
About the Species	
<p>Description</p> <p>Wood bison hold profound spiritual and cultural significance for many Indigenous communities — symbolizing strength, resilience, and a deep connection to the land. They are often described in Indigenous languages as “hefty,” and may be referred to using the same term as muskox.</p> <p>Historically abundant, the decline of wood bison populations in the late 1800s impacted food security and disrupted cultural practices, making it challenging for younger generations to connect with their heritage. While some have welcomed efforts over recent decades to restore wood bison to their historic ranges, these reintroductions have also created conflicts with local communities. Bison are known to damage property and present a safety hazard on roadways. They may also compete for resources with species such as caribou and moose and are often seen as a threat to these species.</p> <p>Biology and Behaviour</p> <p>Wood bison prefer grass and sedge meadows, which provide high-quality forage; although foraging behaviour often varies by herd. Bison avoid muskeg, steep terrain, and dense forest, and favour areas with less snow or recent burns with newer vegetation. They calve in late spring or early</p>	<p>Description</p> <p>Wood bison are characterized by their enormous size, pronounced shoulder hump, long woolly pelage especially on the head and forequarters, wide muzzle, and short, rounded horns that curve upwards from the sides of the head. In mature animals, the coat is generally dark brown and black. As the largest native terrestrial mammal in North America, mature wood bison bulls measure over 1.8 metres at the shoulder and reach a maximum, on average, of 910 kilograms, while mature cows average 567 kilograms.</p> <p>Life Cycle and Reproduction</p> <p>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.</p> <p>The average generation time for wood bison has been calculated at 7-8 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.</p>

<p>summer after an early fall rut, although young calves can occasionally be seen year-round. Wood bison are often seen in small groups; group size is variable and can change throughout the year.</p> <p>Interactions</p> <p>Wolves are the main predator of wood bison. In the North Slave region, greater numbers of wolves observed in the mid-2000s were attributed to an increasing wood bison population. Wolves have been blamed for declining bison populations in Wood Buffalo National Park.</p>	<p>Wood bison are large herbivores that specialize in grazing sedges and grasses, especially in winter. They also supplement their diet by browsing shrubs and saplings. Wood bison habitat ideally consists of a mosaic of lowland meadow and upland meadow to ensure adequate forage resources and is typically interspersed with forest that is used for shelter, resting, ruminating and avoiding biting flies.</p> <p>Bison are gregarious animals. Cows, calves and young bulls may form large mixed groups. Except for the breeding season, mature bulls roam alone or in small temporary groups.</p> <p>Interactions</p> <p>The only documented source of predation for bison is wolves which focus primarily on groups containing calves. When fleeing from wolves in open areas, cows with young calves take the lead, while bulls are seen at the rear of the herds. 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, increasing their vulnerability to predation and hunting.</p> <p>Bison easily become habituated to human presence and infrastructure; they often congregate along roads and may become a traffic hazard. Bison also utilize cutblocks and linear features cut in forested areas for travel and forage.</p>
---	--

Place	
<p>Distribution</p> <p>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 the Slave River Lowlands.</p> <p>Wood bison bulls and cows exhibit distinct movement behaviours. Bulls are more likely to travel alone and disperse great distances 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.</p> <p>Movement and Dispersal</p> <p>Wood bison have expanded their range since they were reintroduced in 1963 (Mackenzie population) and 1980 (Nahanni population), primarily along highway rights-of-way and into newly burned areas, which provide high-quality forage such as grasses and sedges. Flooding of former wood bison habitat in the Mackenzie and Slave River Lowlands has reduced available feeding areas.</p>	<p>Distribution</p> <p>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.</p> <p>Within the Greater Wood Buffalo metapopulation, which spans Alberta and the NWT, three subpopulations occur within the NWT (Nyarling River, Grand Detour/Little Buffalo, and Hook Lake). The Nyarling River subpopulation is entirely within Wood Buffalo National Park, while the Grand Detour/Little Buffalo subpopulation moves in and out of the park. Inside the park it is known as Little Buffalo; outside of the park it is known as Grand Detour. The Grand Detour and Hook Lake subpopulations are collectively referred to as the Slave River Lowlands population.</p> <p>Habitat Requirements, Availability, Trends and Fragmentation</p> <p>As the largest land mammal in North America, wood bison require plenty of space. The Mackenzie and Nahanni populations continue to expand into former historic range, often along highway rights-of-way. The Tłı̄chq Highway (Highway 9) opened in 2021 and has facilitated the northward movement of the</p>

	<p>Mackenzie population. Habitat components of wood bison range include floodplains, marl lake basins, fens, bogs, salt plains, karst terrain, and uplands. Inherently unstable, bison habitat is constantly changing through vegetation succession and retrogression. These early stages of vegetation must be revitalized and maintained by frequent disturbances such as flood/drawdowns and fires. The emergence of discontinuities in the preferred environment of bison results in habitat and population fragmentation. Habitat and population fragmentation occur through natural discontinuities such as steep mountains, dense forest, or extensive muskegs, and through human land conversion or disease control measures (e.g., NWT Bison Control Area).</p>
<p>Population</p>	
<p>Abundance, Population Dynamics, and Changes in Population Size</p> <p>Increased observations of Mackenzie wood bison combined with population survey results indicate a steadily increasing population, while declining trends in the Slave River Lowlands and Wood Buffalo National Park have prompted community members to consider how best to mitigate harvest pressure and other human impacts. Communities in and around Wood Buffalo National Park have escalated their concerns about impacts from upstream flow regulation and oil sands activities to the United Nations. Changes in populations size</p>	<p>Abundance</p> <p>The total NWT population of wood bison (outside of Wood Buffalo National Park) is approximately 2,764, which is about 32% of the global population of free-roaming wood bison. The population of Nahanni bison is currently estimated at 563 (2025) and the Mackenzie bison population is 1,945 (2023). The population of bison in the Slave River Lowlands (Hook Lake and Grand Detour subpopulations) is 256 (2024). Population densities based on area of occupation range from 0.03 bison/km² (Slave River Lowlands) to 0.09 bison/km² (Mackenzie).</p> <p>Population Dynamics</p>

<p>of Nahanni wood bison were not covered in the available literature.</p> <p>Health</p> <p>Anthrax is a concern for bison populations in Wood Buffalo National Park; although tuberculosis and brucellosis are commonly encountered in bison in this area, these diseases are generally considered to be a natural part of life for wildlife. Rescue is considered possible based on long-distance movements observed in bison populations, particularly in bulls.</p> <p>Rescue Effects</p> <p>The possibility of rescue was not covered in available sources. Wood bison, in particular bulls, are known to travel long distances. However, barriers to wood bison movements may include large areas of poor habitat such as muskeg, some wide rivers, ice jams, steep terrain, and areas with increased hunting pressure.</p>	<p>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%.</p> <p>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 subpopulations in Wood Buffalo National Park is high for the Grand Detour 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.</p> <p>Trends and Fluctuations</p> <p>Overall, the NWT population of wood bison has declined over the last two bison generations. The percent decline is estimated to be between 20% (for a 7-year generation time; 2012-2026) and 22% (for an 8-year generation time; 2010-2026) as per the International Union for the Conservation of Nature [IUCN] Criterion A exponential assumption, two data point calculator. Calculated using a linear assumption, the two-generation decline based on census data and derived values is approximately 11% (7-year generation time). Within the last bison</p>
---	---

	<p>generation (2019-2026), the NWT population is estimated to have increased by 9%.</p> <p>Possibility of Rescue</p> <p>Rescue is possible for Slave River Lowlands subpopulations, which are part of the Greater Wood Buffalo metapopulation. The Mackenzie population is too remote and isolated by the Bison Control Area and the Mackenzie River for immigration to be a factor.</p> <p>The likelihood of the Nahanni population being rescued by dispersal from elsewhere is also remote. The Aishihik population in southwestern Yukon is more than 700 km from the Nahanni population with intervening mountain barriers, providing virtually no potential for rescue. Although the Nahanni population is not far from the Nordquist bison in northern British Columbia, this population is very small and there has been no known movement between the two.</p>
Threats and Limiting Factors	
<p>Historically, overharvesting was the greatest threat to wood bison and was responsible for extirpation in many areas. More recently, the most important threats to wood bison include disease outbreaks, vehicle collisions, human-bison conflicts, and habitat changes.</p> <p>The way disease outbreaks are managed may also be considered a threat to wood bison, and there has historically been mistrust between Indigenous communities and government officials over management decisions. Some consider bison diseases</p>	<p>Anthrax and bovine tuberculosis are considered to have the most serious disease implications for wood bison recovery. Bovine brucellosis is also considered a major impediment to recovery and Johne's disease and malignant catarrhal fever are considered medium impediments. Diseases may interact where one enhances the pathological effects of the other, overwhelming the immune response for the host.</p> <p>Human-caused mortality, including overhunting and culls for disease control and</p>

<p>such as brucellosis and tuberculosis to be a normal aspect of the natural life cycle of wood bison, and that tactics to completely remove the disease could cause large changes to relationships among species.</p> <p>Wood bison die offs have also occurred in extreme events, such as starvation from exceedingly harsh winter weather and drowning due to flooding or falling through the ice.</p>	<p>vaccination roundups, represents an important historical threat to wood bison. Bison in the Slave River Lowlands bison or those 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. A relatively small number of bison are removed because of bison-human conflicts and to prevent the spread of diseases.</p> <p>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.</p> <p>There has been concern about diminishing flood/drawdown cycles and detrimental effects on bison habitat downstream in Wood Buffalo National Park as a result of flow regulation at the W.A.C. Bennett Dam and the Williston Reservoir. Declining snowpacks in the catchments of other main tributaries since the mid-1970s and a shorter ice season compound the problem.</p> <p>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. All current wood bison populations have been derived from remnants of much larger populations whose original gene pools may be poorly represented.</p>
---	--

	<p>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- and late- winter freeze-thaw events that create an icy barrier to grazing, can cause substantial bison losses due to starvation.</p> <p>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.</p>
<p>Positive Influences</p>	
<p>Cross-cultural approaches to wood bison stewardship are supporting wood bison recovery 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 their current biological status and support the collection of harvest information.</p> <p>Land use and conservation planning initiatives, such as the establishment of Edézhíe (Dehcho Protected Area and National Wildlife Area), protect important wood bison habitat and enhance the role of</p>	<p>Monitoring and removal of bison in the Bison Control Area (BCA) between Wood Buffalo National Park and the Mackenzie River has been ongoing since 1987 to reduce the risk of disease transmission. Some bison in the greater Wood Buffalo metapopulation are known to be infected with bovine tuberculosis and/or brucellosis, and the BCA prevents contact between these bison and the disease-free Mackenzie and Nahanni populations. However, ongoing management actions needed to reduce the spread of disease also constrain population growth and expansion of these populations. The Bison Integrated Genomics (BIG) Project is developing new strategies to rapidly diagnose these diseases and develop a vaccine that could be delivered orally to wild bison populations.</p>

<p>Indigenous guardians in managing for wood bison on the landscape.</p> <p>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.</p>	<p>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.</p> <p>Most wood bison populations in the NWT are protected from overharvesting by quotas. Annual awareness campaigns aim to reduce bison mortalities from vehicle collisions.</p> <p>Advances in habitat conservation and enhancement include the establishment of Edézhíé (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. Enhanced federal funding is being provided to maintain ecosystem values in Wood Buffalo National Park and support the recovery of wood bison populations along the Alberta-NWT border.</p> <p>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. Letting wildfires burn on the landscape can improve bison habitat by promoting new growth and shifting conifer forests towards grass/shrublands favoured by</p>
---	--

	<p>wood bison. Wood bison may also derive foraging opportunities from disturbances that revert mature forest to early successional vegetation, and these animals readily use road rights-of-way and seismic lines as travel routes.</p> <p>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 bison. Efforts 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 are ongoing.</p> <p>Collaborative management of wood bison populations in the NWT and across Canada are ongoing through various fora, including three bison working groups for the Mackenzie, Nahanni and Slave River Lowlands populations, which play a crucial role in implementing management actions, as well as bringing their organizations' perspectives into decision-making about wood bison in the NWT. The Conference of Management Authorities brings together NWT wildlife Management Authorities to make collaborative decisions about species at risk in the NWT, including wood bison.</p>
--	--

Technical Summary – Indigenous and Community Knowledge Component

Question	Indigenous and Community Knowledge
Population	
How often is the species observed compared to the past ¹ (less, more, same)? Include an estimate of how much of the species range these observations represent (percentage).	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. Bison were reintroduced to parts of their historic ranges starting in 1963 (Mackenzie) and 1980 (Nahanni) and are frequently observed in these areas.
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)?	Communities around Wood Buffalo National Park have expressed uncertainty about how bison populations in the park are doing. There is also a moderate level of concern about declining bison populations in the Slave River Lowlands.
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)	Long-term concerns are expressed about the level of disease in wood bison, although some believe the impacts of disease to be overestimated. Concerns are more likely to be expressed about impacts of too many wood bison than too few.
Distribution	
Is the species still observed in all the places it was in the past ¹ ? Or is the species now unavailable, or less	Due to reintroductions, wood bison are now observed in more places than in the past (50-70 years ago), and their distribution is increasing. Wood bison have been

¹ In this context, 'past' refers to within the last generation, or approximately 50-70 years ago.

available, in areas where it was historically abundant?	present in Wood Buffalo National Park and adjacent areas throughout the decline and recovery.
Have declines or changes to movements of the species been observed? If so, are these changes to movements or distribution considered normal or unusual for the species?	Wood bison have been observed along the Tłı̄chǫ Highway (Highway 9; opened in 2021) as far as the community of Whatı̄. This represents an expansion of their range into areas where the species has been absent from the local landscape for many generations. Similar movements have been observed in other regions (e.g., Nahanni bison in the Liard River valley). 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. Concerns are more likely to be expressed about the encroachment of bison on the ranges of other species (e.g., caribou and moose).
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?	Much of the NWT may have suitable wood bison habitat that is currently not used by wood bison. Wood bison habitat and habitat quality is declining with 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 prefer grass and sedge meadows. These habitats are maintained by periodic flooding and wildfires. Bison also use salt licks; however, there is no indication their movements are defined by the presence or absence of this feature.
Biocultural linkages	
Have declines resulted in significant adverse impacts to Indigenous	The disappearance of wood bison from large portions of their historic range in the 1800-1900s resulted in significant and ongoing impacts to Indigenous

cultures and traditional ways of life tied to the species or its habitat?	cultures and traditional ways of life. Reintroduced bison may be considered a 'novel' or nuisance wildlife species in areas where the species has been absent from the landscape for several generations.
Are continued cultural connections and practices related to the species now impossible or extremely impaired?	No. Reintroduction of bison and expansion across their former range has provided opportunities to restore cultural connections and harvest practices.
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 concerns depending on when wood bison disappeared from their traditional territories and when or whether they were reintroduced. Communities around Wood Buffalo National Park have maintained their biocultural linkages to wood bison, while some communities in the Dehcho and Tłı̄chǫ regions 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?	<p>Disease and overhunting are reported as the main 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. Vehicle collisions with bison are considered a threat to bison as well as public safety.</p> <p>Disease eradication efforts such as herding animals to vaccinate, vaccinations or treatments, and allowing unmitigated hunting of diseased populations in the last half-century have threatened wood bison in the past. Modern disease management efforts may be perceived as conflicting with "letting nature take its course."</p>

	Changes to habitat from timber harvest, high water levels, and/or intense wildfires are seen as lesser threats to wood bison in the NWT. Bison may also die from periodic extreme winter weather or drowning.
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?	There are mixed feelings towards the approach to disease management taken by governments. Working groups for the Mackenzie, Nahanni and Slave River Lowlands bison populations provide recommendations to manage harvest.
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.	<p>Increased involvement of local communities in the co-management of wood bison and traditional Indigenous stewardship protocols ('only taking what you need') appear to have a positive influence though the magnitude of influence is not available in the sources reviewed.</p> <p>Land use planning initiatives, such as protection of wood bison habitat near Wood Buffalo National Park and the establishment of Edézhíe (Dehcho Protected Area and National Wildlife Area) and the development of a Dehcho Land Use Plan are expected to be positive influences.</p>

	<p>Forest fires of moderate intensity are a positive influence, as they create bison habitat and encourage forage. The bison-free buffer zone between Wood Buffalo National Park and the Mackenzie Wood Bison Sanctuary is seen as a positive influence on wood bison in preventing disease transmission.</p> <p>Imminence and degree are not discussed in Indigenous and community knowledge sources</p>
--	---

Technical Summary – Scientific Knowledge Component

Question	Scientific Knowledge
Population Trends	
Generation time (average age of parents in the population)	7-8 years
Number of mature individuals in the NWT	2,128 (excluding bison in Wood Buffalo National Park)
Percent change in total number of mature individuals over the last 3 generations²	49% decline for a 7-year generation time (2005-2026) 8% decline for an 8-year generation time (2002-2026)
Percent change in total number of mature individuals over the next 3 generations	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
Percent change in total number of mature individuals over the last 2 generations²	20% decline for a 7-year generation time (2012-2026) 22% decline for an 8-year generation time (2010-2026)

² For more on how population change is calculated, refer to *Trends and Fluctuations*.

Percent change in total number of mature individuals over the next 2 generations	Unknown
Percent change in total number of mature individuals over any 10 year or 2 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 causes of the decline are not clearly understood. The cause of the decline must be determined before concluding whether it is likely to continue and if remedial actions would 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	209,010 km ² – including range outside the NWT 160,389 km ² – NWT range only
Index of area of occupancy (IAO) in the NWT (in km ² ; based on 2 x 2 grid)	56,676 km ² – including range outside the NWT 48,640 km ² – NWT range only
Number of extant locations ³ in the NWT	3
Is there a continuing decline in area, extent, and/or quality of habitat?	No – Habitat decline fluctuates primarily based on climatic conditions
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	Yes The Mackenzie population includes 70% of the total NWT population of wood bison. They are isolated from the

³ 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.

small and isolated populations)?	remaining NWT bison, which occur in the Nahanni population and the Greater Wood Buffalo metapopulation.
Immigration from Populations Elsewhere	
Does the species exist elsewhere?	Yes
Status of the outside population(s)?	Threatened (National) – Canada Threatened – 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 on immigration for long-term survival?	Self-sustaining
Threats and Limiting Factors	
Briefly summarize negative influences and indicate the magnitude and imminence for each.	<p>Four infectious bacterial diseases are currently of concern to the conservation of wood bison. Anthrax (<i>Bacillus anthracis</i>) and bovine tuberculosis (<i>Mycobacterium bovis</i>) are considered to have the most serious disease implications for bison recovery. Bovine brucellosis (<i>Brucella abortus</i>) is also considered a significant impediment to recovery. Johne's disease (<i>Mycobacterium avium</i> subspecies <i>paratuberculosis</i>) and malignant catarrhal fever (ovine herpesvirus-2) are also considered a medium impediment.</p> <p>Human-caused mortality, including hunting, vehicle collisions and management activities such as culls for disease</p>

	<p>control, represent less of a threat today than it has historically. Harvest is regulated for Mackenzie and Nahanni bison; however, there is no limit on Indigenous harvesters in the Slave River Lowlands (outside of Wood Buffalo National Park), and harvest data for this population is not collected.</p> <p>Vehicle collisions are an important cause of mortality for wood bison in the NWT, especially in the Mackenzie and Nahanni populations. While bison may also be killed because of bison-human conflicts and to prevent the spread of diseases, this number is relatively small.</p> <p>Loss and deterioration of habitat in bison ranges can be threatened by forest expansion due to diminishing flood/drawdown cycles and destabilization of vegetation communities due to fire suppression.</p> <p>Low genetic diversity and inbreeding among closely related individuals can result in decreased fitness, often manifested by underweight births, low survival, and poor reproduction, as well as reduced resistance to disease, predation and environmental stress. While there is no evidence of inbreeding depression in any wood bison populations, it is difficult to demonstrate without comparison to a control group. Hybridization of wood bison with cattle and plains bison can also threaten genetic integrity, fitness and the evolutionary pathway of wood bison.</p> <p>Adverse snow conditions or drowning may lead occasionally to mass mortality of wood bison. When bison break through thin ice on lakes or rivers, they are generally unable to climb out. For example, in 1989, 177 bison perished after breaking through spring ice on Falaise Lake in the Mackenzie Bison Sanctuary.</p> <p>Heavy snowfall followed by rain and refreezing can form a thick frozen crust that impairs foraging and mobility of bison and increases vulnerability to wolves and hunters. A warming climate increases the probability of precipitation falling as</p>
--	--

	<p>rain rather than snow and may increase the frequency of icing events.</p> <p>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. Advanced diseases may also predispose bison to predation. 'Risk effects' of predation on bison, including energetics, lower mating success, and emigration, have never been examined.</p>
--	--

Positive Influences

<p>Briefly summarize positive influences and indicate the magnitude and imminence for each.</p>	<p>Actions to control the spread of disease between bison populations are underway. These include the Bison Control Area between Wood Buffalo National Park and the Mackenzie River, which restricts movements between infected and healthy bison populations to reduce the risk of tuberculosis and brucellosis transmission. Anthrax surveillance flights are carried out each summer, and an Anthrax Emergency Response Plan is implemented for anthrax outbreaks. 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 as well as exploring the development of vaccines targeting bovine tuberculosis and brucellosis in wood bison.</p> <p>Human-caused bison mortality is mitigated primarily through hunting restrictions. Harvest is prohibited inside Wood Buffalo National Park, and the reintroduced Mackenzie and Nahanni populations are managed through adaptable harvest quotas. The current co-management approach through community-based bison working groups shares the commitment for appropriate conservation measures.</p> <p>Wood Buffalo National Park protects nearly 45,000 km², including important wood bison habitat. The establishment</p>
---	---

	<p>of Edézhíe (Dehcho Protected Area and National Wildlife Area) and land withdrawals in place in the North Slave and Dehcho regions further ensure harvest and human land-use impacts are carefully managed.</p> <p>Managing genetic diversity is important for the viability of wood bison populations. Minimum standards pertaining to effective population size have been established for starting new wood bison populations. Advances in reproductive technology are continuing to find ways to salvage valuable genetic material from diseased populations.</p> <p>Co-management partnerships are in place to cooperatively manage wood bison populations across multiple jurisdictions. Working groups implement management plans for the Mackenzie, Nahanni, and Slave River Lowlands bison populations.</p> <p>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.</p> <p>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.</p>
--	---

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	Edézhíe 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	Tłı̨chǫ Government
WBNP	Wood Buffalo National Park
WRRB	Wek'èezhìi Renewable Resources Board

Table of Contents

ASSESSMENT OF WOOD BISON	3
Executive Summary	7
Technical Summary – Indigenous and Community Knowledge Component	17
Technical Summary – Scientific Knowledge Component	22
Acronyms	29
Table of Contents	30
List of Tables	37
List of Figures	38
PLACE NAMES	40
INDIGENOUS AND COMMUNITY KNOWLEDGE COMPONENT	43
Preface	43
Preamble	44
ABOUT THE SPECIES	45
<i>Names and Classification</i>	45
<i>Description</i>	46
<i>Relationship with People</i>	47
Harvest	48
Reintroduction	49
Conflict with People	50
<i>Biology and Behaviour</i>	52
Diet and Feeding Behaviour	52
Adaptations to Northern Regions	53
Relationship Within and Among Species	54
PLACE	57
<i>Historic Distribution</i>	57

<i>NWT Distribution</i>	58
Wood Buffalo National Park Population	60
Slave River Lowlands Population	61
Mackenzie Population.....	62
Nahanni Population	62
Other Observations	63
<i>Movement and Dispersal</i>	63
Movement Corridors and Water Crossings	64
<i>Changes in Distribution</i>	70
<i>Search Effort and Harvest Patterns</i>	72
<i>Key Habitats</i>	72
Seasonal Habitat Requirements.....	73
<i>Habitat Trends</i>	74
<i>Habitat Fragmentation</i>	76
POPULATION	77
<i>Abundance</i>	77
<i>Changes in Population Size</i>	77
<i>Health</i>	78
<i>Rescue Effects</i>	79
THREATS AND LIMITING FACTORS	80
<i>Disease and Disease Management Efforts</i>	80
<i>Overhunting</i>	82
<i>Vehicle Collisions</i>	84
<i>Habitat Changes</i>	85
<i>Human-bison Conflicts</i>	86
<i>Other Threats</i>	86
POSITIVE INFLUENCES	87
<i>Co-management</i>	87
<i>Harvest Management</i>	87
<i>Conservation Planning</i>	88

<i>Fire</i>	89
<i>Other Positive Influences</i>	90
ACKNOWLEDGEMENTS	91
AUTHORITIES CONTACTED	92
BIOGRAPHY OF PREPARERS	95
SCIENTIFIC KNOWLEDGE COMPONENT	96
ABOUT THE SPECIES	96
<i>Names and Classification</i>	96
Systematic/Taxonomic Clarifications	97
<i>Description</i>	98
<i>Life Cycle and Reproduction</i>	99
Age Groups	99
Breeding Behaviour	100
Cow-Calf Behaviour	102
Generation Time	103
<i>Physiology and Adaptability</i>	103
Physiological Requirements	103
Foraging Habits	104
Adaptations for Sustenance	106
Susceptibility to Environmental Changes	106
Vulnerability to Extreme Conditions	107
Adaptations to Adversity	108
<i>Interactions</i>	109
Conspecifics	109
Competitors	110
Predators	111
Insects and Parasites	113
Humans	114
PLACE	115
<i>Distribution</i>	115

Historical Distribution	115
Continental Distribution	117
NWT Distribution.....	121
<i>Distribution Trends</i>	125
<i>Movements</i>	128
<i>Habitat Requirements</i>	130
<i>Habitat Availability</i>	132
Present Habitat.....	132
Potential Habitat	134
<i>Habitat Trends</i>	137
Flooding Frequency	137
Role of Fire	139
Human-caused Habitat Changes.....	142
<i>Habitat Fragmentation</i>	143
POPULATION	144
<i>Abundance</i>	144
Density	146
Carrying Capacity	147
<i>Population Dynamics</i>	148
Age at Maturity and Longevity.....	148
Fecundity.....	149
Birth Rate	150
Recruitment.....	152
Adult Survival	153
Sex Ratio	153
Immigration and Emigration.....	154
Possibility of Rescue	154
<i>Trends and Fluctuations</i>	155
Historical Decline.....	155
Population Changes.....	155
Rate of Growth or Decline.....	161

Population Viability Analysis.....	163
Eruptive Oscillation.....	164
THREATS AND LIMITING FACTORS.....	165
<i>Disease and Disease Management.....</i>	<i>165</i>
Anthrax.....	166
Bovine Tuberculosis.....	169
Bovine Brucellosis.....	171
Johne’s Disease.....	172
Malignant Catarrhal Fever.....	172
Disease Synergy.....	173
Management Actions.....	173
<i>Human-caused Mortality.....</i>	<i>175</i>
Unregulated Harvest and/or Overharvest.....	175
Vehicle Collisions.....	175
Human-bison Conflicts.....	176
<i>Habitat Loss and Deterioration.....</i>	<i>176</i>
Diminishing Flood/Drawdown Cycles.....	176
Fire Suppression.....	177
<i>Low Genetic Diversity.....</i>	<i>178</i>
Inbreeding Depression.....	179
Genetic Drift.....	179
<i>Hybridization and Outbreeding Depression.....</i>	<i>180</i>
<i>Drowning.....</i>	<i>181</i>
<i>Adverse Snow Conditions.....</i>	<i>181</i>
<i>Predation.....</i>	<i>182</i>
POSITIVE INFLUENCES.....	184
<i>Managing Disease.....</i>	<i>184</i>
<i>Efforts to Reduce Human-caused Mortality.....</i>	<i>185</i>
Harvest Management.....	185
Other Management Actions.....	186
<i>Habitat Conservation.....</i>	<i>187</i>

<i>Range Expansion</i>	187
<i>Wildfire</i>	187
<i>Managing Genetic Diversity</i>	188
<i>Interagency Cooperation and Co-management Partnerships</i>	189
ACKNOWLEDGEMENTS	191
AUTHORITIES CONTACTED	192
BIOGRAPHY OF PREPARER	195
STATUS AND RANKS	197
<i>Wood Bison (Bison bison athabascae)</i>	197
INFORMATION SOURCES	198
<i>Indigenous and Community Knowledge Component</i>	198
<i>Scientific Knowledge Component</i>	211
APPENDICES	279
APPENDIX A1 – NAMES AND CLASSIFICATION	279
<i>Bison Evolution</i>	280
<i>Wood Bison Genotype</i>	286
APPENDIX A2 – POPULATION TRENDS AND FLUCTUATIONS	291
<i>IUCN Criterion A Calculator</i>	291
<i>Eruptive Oscillation</i>	293
APPENDIX A3 – HABITAT TRENDS	296
<i>Floodplains</i>	296
<i>Marl lake basins</i>	299
<i>Fens</i>	302
<i>Bogs</i>	303
<i>Salt Plains</i>	304
<i>Karst Terrain</i>	304
<i>Uplands</i>	305
<i>Role of fire</i>	305
APPENDIX A4 – HISTORIC RANGE AND SEARCH EFFORT	308

<i>Historic Range in the NWT</i>	308
Slave River Lowlands	309
Buffalo Lake to Eastern Escarpment	310
Buffalo River to Mackenzie River	310
Great Slave Lake to Lac La Martre	311
Liard River	312
<i>Search Effort</i>	313
APPENDIX A5 – PREDATION	322
<i>Season</i>	322
<i>Age Structure</i>	322
<i>Habitat Heterogeneity</i>	324
<i>Disease Vulnerability</i>	324
<i>Alternate Prey</i>	325
<i>Surplus Carrion</i>	325
<i>Case History: Impacts during an increasing Mackenzie Bison Population (1963-1992)</i>	326
<i>Case History: Impacts during a decreasing Greater Wood Buffalo metapopulation (1971-1999)</i>	327
APPENDIX B – THREATS ASSESSMENT	329
<i>Overall Level of Concern</i>	330
<i>Detailed Threats Assessment</i>	331

List of Tables

Table 1. Biophysical factors influencing bison movements and distribution, from Indigenous and community knowledge interviews conducted by Mitchell (2002)..... 68

Table 2. Wood bison sequence of disappearance from historical distribution 116

Table 3. Summary of reintroduced, free-ranging wood bison populations, listed in chronological order of reintroduction..... 119

Table 4. Global population estimates of free-ranging wood bison (does not include Elk Island population) 145

Table 5. Estimated size of NWT wood bison populations/subpopulations as of 2025, with 95% confidence intervals. Population sizes are estimated using aerial surveys..... 146

Table 6. Wood bison density for Nahanni, Mackenzie, and Slave River Lowlands populations (bison/km²). Population data from Armstrong (2024a; 2024b; 2025) and ECC unpubl. data. (2024b)..... 146

Table 7. Birth rates for each NWT bison population expressed as number of calves per 100 cows. Data from ECC unpubl. data (2025a) unless otherwise indicated.....151

Table 8. Population estimates for NWT wood bison from aerial winter surveys conducted by ECC (Nahanni, Mackenzie, Grand Detour and Hook Lake) between 1983 and 2025 (grey boxes). 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 (white boxes) 158

Table 9. Instantaneous rate of growth (*r*) for NWT bison populations (calculated using a 7-year generation time) during the last three generations and the prior three generations based on survey data and interpolations/extrapolations..... 162

Table 10. Number of wood bison carcasses that tested positive for anthrax during documented outbreaks in the Slave River Lowlands, Wood Buffalo National Park and Mackenzie bison range from 1962 to 2025167

List of Figures

Figure 1. Map of Northwest Territories showing settled land claim and/or reserves, protected/conservation areas, communities and major roadways mentioned in this report. Map produced for SARC. 41

Figure 2. Regional map of Wood Buffalo National Park and the Slave River Lowlands, showing communities, protected and conservation areas, major roads, and other features mentioned in this report. Map produced for SARC. 42

Figure 3. Adult male wood bison near Fort Smith, NWT. Photo credit: A. Bathe. 46

Figure 4. 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 credit: C. Blyth..... 49

Figure 5. Wood bison in Nahanni Butte. Photo credit: A. Bathe..... 51

Figure 6. A wood bison watches as a black bear passes by. Photo credit: P.-E. Chaillon. 54

Figure 7. Current wood bison range in the NWT and adjacent jurisdictions. Map by E. McHugh, GNWT-ECC. 59

Figure 8. Current wood bison range in and around Wood Buffalo National Park (diagonal hatching). Map by E. McHugh, GNWT-ECC. 61

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) 66

Figure 10. Movement corridors and water crossings identified during semi-directed interviews: Hay River study area (between Wood Buffalo National Park and Fort Providence) (Gates et al. 2001a) 67

Figure 11. Map of wood bison observations collected by wildlife monitors in 2022 and 2024 (January-December) along the Tłı̄chǵ Highway (TG and Firelight 2025a)..... 71

Figure 12. Wood bison grazing in a burned area in Wood Buffalo National Park. Photo credit: P.-E. Chaillon..... 75

Figure 13. Wood bison in the Mackenzie Bison Sanctuary. Photo credit: T. Armstrong, GNWT-ECC.... 99

Figure 14. 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)..... 115

Figure 15. Current continental distribution of free-ranging wood bison in North America including wood bison in Elk Island National Park (fully fenced national park). Map by E. McHugh, GNWT-ECC..... 118

Figure 16. NWT wood bison distribution and neighbouring populations. Wood bison have also been observed outside core ranges. Map by E. McHugh, GNWT-ECC..... 121

Figure 17. Distribution of wood bison subpopulations of the Greater Wood Buffalo metapopulation. Map by E. McHugh, GNWT-ECC	122
Figure 18. Extent of Occurrence (EO) and Area of Occupancy (AO) for NWT wood bison, based on the geographic distribution of the entire Nahanni and Mackenzie wood bison populations and the portion of the Greater Wood Buffalo metapopulation occurring at least partly in the NWT (Slave River Lowlands and Nyarling subpopulations). Map by E. McHugh, GNWT-ECC	123
Figure 19. Spatial distribution of the Mackenzie wood bison population in 1975 compared to 2023. Location and count data is based on aerial population surveys conducted by the GNWT. The yellow star denotes the location of Falaise Lake. Figures reproduced with permission from Korosi <i>et al.</i> (2017)	127
Figure 20. Estimated extent of former Glacial Lake Mackenzie. Map by B. Fournier, based on Smith (1992) and Crosbie (1978).....	135
Figure 21. Lacustrine bench within Glacial Lake Mackenzie. Photo credit: T. Chowns	136
Figure 22. Fire history in NWT wood bison ranges from 2015 to 2025. Wildfire history data from ECC unpubl. data (2026b). Map by E. McHugh, GNWT-ECC.....	142
Figure 23. Wood bison abundance for the (a) Mackenzie, (b) Nahanni and (c) Slave River Lowlands populations surveyed by GNWT-ECC.....	157
Figure 24. Estimated total NWT bison numbers, stacked by population/subpopulation (1984-2026) .	161
Figure A2. NWT bison population/subpopulation trends calculated using IUCN Criterion A, exponential assumption, two data point calculator. Trends are calculated for three generations [(a) and (b)] and two generations [(c) and (d)].....	292
Figure A4. Historical records from late 1700s to approximately 1900 of wood bison observations and area of glacial lake basins within the upper Mackenzie drainage of the NWT. Smith (1992; 1994) and Crosbie (1978) should be consulted for the full extent of glacial basins.....	308
Figure A5. Predation and age class.....	323

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, with a regional map (Figure 2) providing further detail for Wood Buffalo National Park and the Slave River Lowlands.

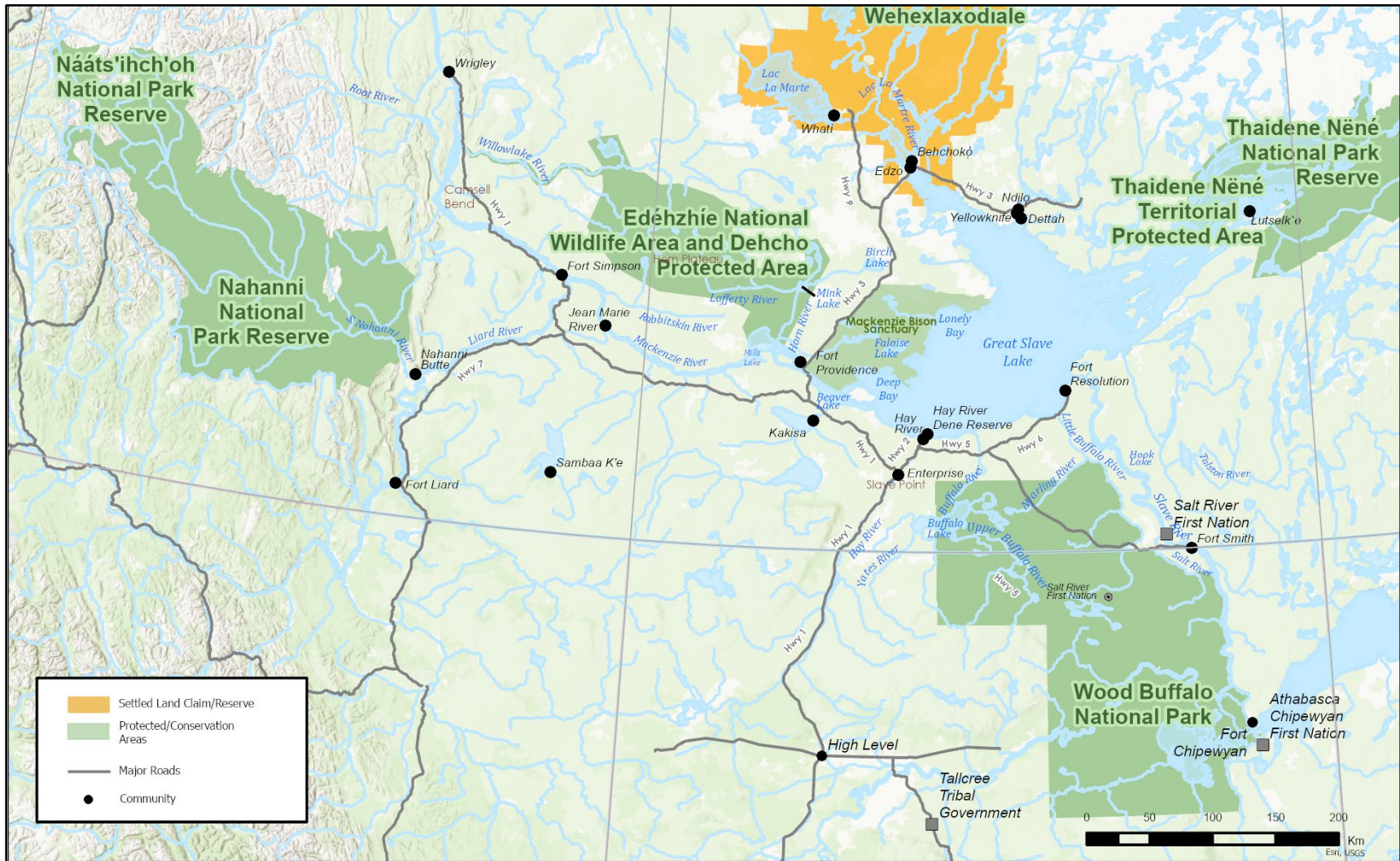


Figure 1. Map of Northwest Territories showing settled land claim and/or reserves, protected/conservation areas, communities and major roadways mentioned in this report. Map produced for SARC.

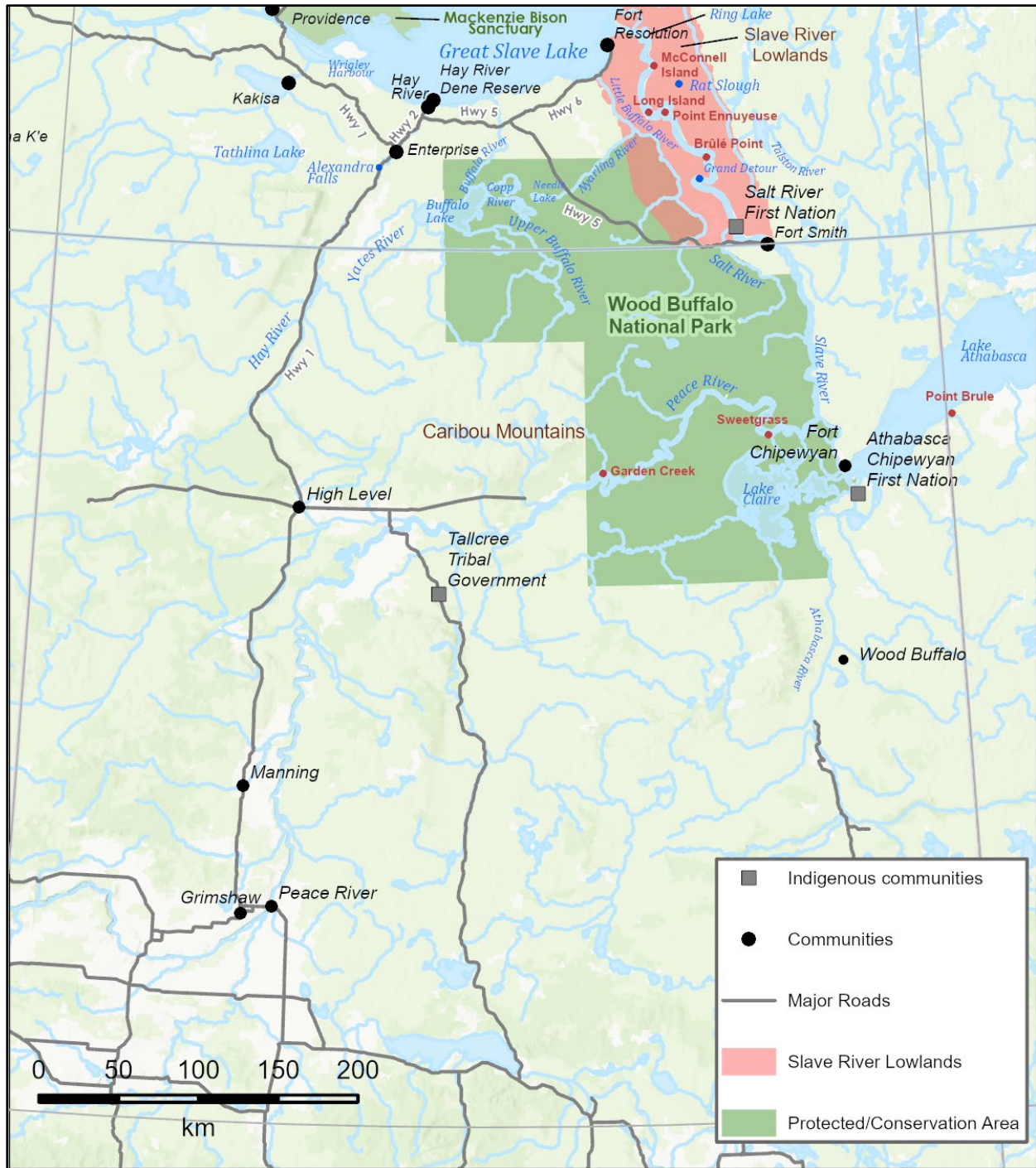


Figure 2. Regional map of Wood Buffalo National Park and the Slave River Lowlands, showing communities, protected and conservation areas, major roads, and other features mentioned in this report. Map produced for SARC.

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 published. 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; Tł̨ch̨ 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 (Tł̨ch̨ 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 populations in the NWT now exist around the Liard and South Nahanni rivers (Nahanni population) and west of Great Slave Lake (Mackenzie population).

There are few sources of recorded traditional, Indigenous or community knowledge about wood bison in areas of the NWT where bison were absent from the landscape for two or more human generations. A greater amount of recorded Indigenous and community knowledge of wood bison is available in areas where bison 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 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), as well as Schramm *et al.* (2002) and Schramm (2005).

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 information, it should be emphasized that that these data represent 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)
- Populations: Wood Buffalo National Park, Slave River Lowlands (includes Grand Detour and Hook Lake subpopulations), Mackenzie, and Nahanni
- Cree: Sakāwmostos (bush bison) (Napier pers. comm. 2024)
- Dené sų́líné/Athabasca Chipewyan First Nation: Dechen yághe ejere (Beaver pers. comm. 2024), Thachin ya n'jere (Marcel *et al.* 2012)
- Denínu Kué Yatié: ʔejëre (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'įj (cow of the forest; Benson 2014)
- Kaska Dene: Łek'aye, łuk'aye, kedä-cho', ejedi (Lotenberg 1996)
- Dene Kədə (North Slavey): Ejuda (Lotenberg 1996)
- Dene Zhatié (South Slavey): Dechįtah goegíé (ECCC 2018), Dechįtah goejidé (SSDEC 2009)
- Tįchq: Dechįta gojie, Enareh gojie, Ejie (cow; bison; buffalo), Ejezaa (calf of cow; goat; bison; buffalo; muskox; Tįchq Online Dictionary 2025)
- Common Name (French): Bison des bois
- Scientific Name: *Bison bison athabascae*

Many 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 by Parks Canada to describe the subpopulations within Wood Buffalo National Park (Figure 8).

Description



Figure 3. Adult male wood bison near Fort Smith, NWT. Photo credit: 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 foreheads, whereas bison horns curve upwards and have no frontal protection (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).

Indigenous and community knowledge sources describe four populations of wood bison in the NWT: within Wood Buffalo National Park, in the Slave River Lowlands (consisting of Grand Detour bison west of the Slave River and Hook Lake bison east of the river), the Mackenzie population northwest of Great Slave Lake, and the Nahanni population in the Liard River valley. See *NWT Distribution* for more detail on wood bison populations in the NWT.

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). The deep historical connection between Fort Denesų́n  and wood bison is documented by ACFN *et al.* (2023).

The relationship between the Denesų́n  (including Athabasca Chipewyan First Nation) and wood bison was strained with the establishment of Wood Buffalo National Park in 1922. The park was established to protect the Peace-Athabasca Delta and the world's largest remaining free-roaming population of wood bison. However, efforts by Parks Canada to ensure the survival of wood bison were at odds with the use and stewardship by the Denesų́n  (ACFN and Willow Springs 2021; ACFN *et al.* 2023; Puppe 2025). Dene oral histories indicate that community members did not consent to the creation, expansion or management of the Park in their territories, and many people did not even know about it (ACFN and Willow Springs 2021; ACFN *et al.* 2023).

“They were robbed of their land, robbed of their traditional land. And for many years, they couldn't even come to the park because only Cree, only Cree Band hunters and trappers were allowed to hunt in the park, right? Allowed to have their trapline in the park. And so, the Chipewyan lost out on that, they lost out in going into the park.” (Lori Stevens in ACFN and Willow Springs 2021: 177)

Members of the K t'odeeche First Nation have also indicated they do not have a strong relationship with bison since hunting bison in their areas has not been permitted since the establishment of Wood Buffalo National Park (Environment Canada 2015d). For other groups, such as the Salt River First Nation, wood bison continue to play an essential role in their livelihood (Environment Canada 2015e). However, even in communities where bison disappeared for many generations and were later reintroduced, stories about bison have persisted. Members of the Acho Dene Koe First Nation in Fort Liard have recalled how they used to travel from communities to their traditional camps using old bison trails, before the reintroduction of bison. Members of the Ttsets' hk' d l 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. *in* SARC 2016: 45).

Harvest

While there are some places in the NWT where hunting wood bison is prohibited (e.g. national parks), for the most part, wood bison are hunted throughout their range in the NWT. Approaches to harvest and harvest rates influenced by animal availability and may differ regionally based on connection to or perceptions of the species (Schramm *et al.* 2002; ENR 2010b; Crosscurrents Associates Ltd. and Maskwa Environmental Services Ltd. 2007; Shury *et al.* 2015; Will 2015; CMA 2019; APTN News 2023).

Relationships between people and 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, Tłı̄chǫ do not generally hunt wood bison; since their extirpation in the late 1800s, wood bison have occupied a more southern range, which did not extend into the Tłı̄chǫ region. A lot of the Indigenous and community knowledge about this species has therefore been lost over time (Environment Canada 2015d). Even as wood bison become more common near Whatı̄, Tłı̄chǫ harvesters have not been harvesting these animals (TG and Firelight 2025b), and wood bison may even be considered an invasive species by some communities where the animals have been reintroduced (Huntington *et al.* 2005).

Similarly, in a limited⁴ 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 (in British Columbia; connecting Fort Liard, NT, to Fort Nelson, B.C.) 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. *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 population 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

⁴ It should be noted that the number of Elders interviewed by Fanni (2014) was small and concerns have been raised that the report may not provide a clear representation of the knowledge in the community of Fort Liard or Acho Dene Koe First Nation as a whole. Further, many Acho Dene Koe First Nation members have traditional hunting or trapping areas in British Columbia, and community knowledge shared in Fanni (2014) may be in reference to bison in B.C., not the NWT.

of wood bison as an alternate meat source. GNWT-ECC has been working with people in Fort Liard and Hananni Butte to help facilitate the use of the meat (CMA 2025).

Reintroduction

The reintroduction and expansion of wood bison into parts of their historic ranges has been a significant conservation effort (Figure 4; see also *NWT Distribution*). While restoring bison to the landscape provides opportunities to revitalize cultural practice, including hunting, storytelling, and community gatherings, reintroductions have been received with conflicting sentiment by nearby communities and there has been significant apprehension about the future management of these populations (Clark *et al.* 2016; Doney *et al.* 2018; ECCC 2018; Jung 2020; Bath *et al.* 2022; Christianson *et al.* 2022).

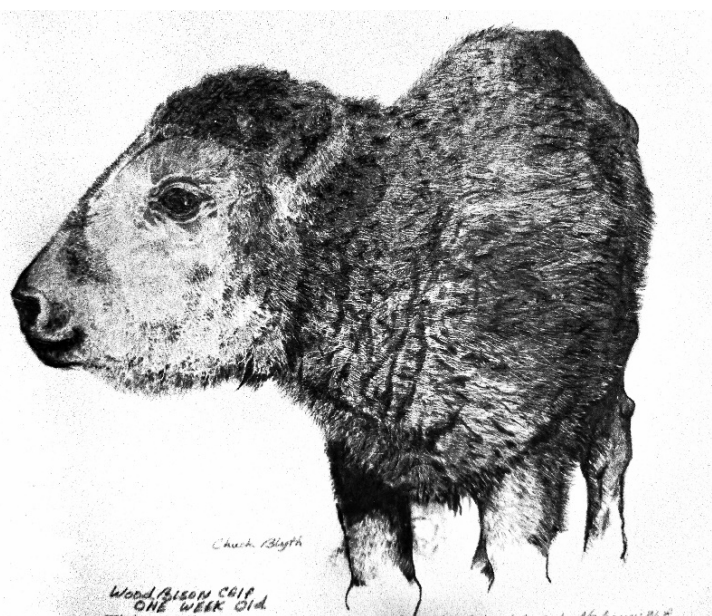


Figure 4. Drawing of a one-week-old calf at Elk Island National Park. The calf was shipped to the NWT as part of the reintroduction of the Nahanni population. Image credit: C. Blyth.

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 (Judge *et al.* 2022; Natcher *et al.* 2022).

Communities within the range of reintroduced wood bison populations in Yukon 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 considered a nuisance in Dehcho and Tłı̄chq̄ 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 Behchok̄ò (MBWG 2018; Cabin Radio 2019). People in Whatì have complained about an increase in bison since the Tłı̄chq̄ Highway (Highway 9) opened in 2021 and preventing wood bison from entering Whatì is a Tłı̄chq̄ Government priority (TG and Firelight 2025a, b).

“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 (Fanni 2014; 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; Jung 2017; 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).

In Yukon, Members of the Champagne and Aishihik First Nations have described emotional impacts from bison damage to important structures such as gravesites:

“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)

Bison are also 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. *in* SARC 2016: 45; Figure 5). 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 several generations (ENR 2008, 2012; Environment Canada 2015a). Dehcho First Nations

members noted that more education for communities regarding the use of bison as a meat resource is needed (ENR 2012).

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

Steps have been taken to manage the impacts of wood bison, including driving the animals out of the community and working with hunters to remove problem animals (ENR 2010b; CBC News 2021; ECC 2023; Krtutko pers. comm. 2026). 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).



Figure 5. Wood bison in Nahanni Butte. Photo credit: A. Bathe.

There is, however, indication that attitudes in some communities are changing. Harvest and consumption of bison meat by people in Fort Liard and Fort Providence has increased following efforts by territorial government representatives to distribute meat harvested from problem bison kills (Danny Allaire pers. comm. *in* SARC 2016: 45). As wood bison move closer to Whatì, some individuals in the Tłı̄chǫ region have expressed interest in seeing local hunters develop skills to harvest and butcher bison to take advantage of increasing numbers of bison along the Tłı̄chǫ highway (TG and Firelight 2025b). Bison also present an economic opportunity for ecological viewing and tourism for smaller communities with limited employment options (MBWG 2018; Krtutko pers. comm. 2026).

Biology and Behaviour

Breeding season (rutting) starts in August (Gates *et al.* 2001a; Mitchell 2002; Schramm 2005; Environment Canada 2015 in SARC 2016: 43). Bison in the Slave River Lowlands often seek high areas between the Little Buffalo River and adjacent large wet meadows to calve (Gates *et al.* 2001a; Mitchell 2002), while wood bison in northern Alberta seek out spruce bluffs where the trees offer shade and cover for calving (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 (Schramm and Krogman 2001). One Garden River resident saw calves born in the fall in Wood Buffalo National Park (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. 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).

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). Bison avoid feeding in open prairies in winter because the wind-blown snow can harden, making it difficult to dig and access food (SRLWG 2024, unpubl. meeting notes). Wood bison frequently graze in newly burned areas and cut blocks, where regrowing vegetation provides fresh forage (Mitchell 2002).

Foraging behaviour of three wood bison populations in northern Alberta are detailed in Schramm *et al.* (2002) (Wentzel Lake, Wabasca and Garden River⁵ 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

⁵ Referred to as the south-western Parks herd in Schramm *et al.* (2002).

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 dry grassy forage, 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 dry grass 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:

“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 and may influence bison movements (SRLWG 2024, unpubl. meeting notes). Wentzel Lake bison 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 the snow away if it is light enough (van Kessel 2002; Schramm 2005). 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 Yukon, wood bison were considered ‘fast runners’ (Lotenberg 1996). Although many groups harvested with bow and arrows or spears, others relied upon a snare system. Bison were considered a dangerous animal to hunt, as they are aggressive or ‘put up a fight’ (Lotenberg 1996; Stephenson *et al.* 2001).

Wentzel Lake wood bison shed their winter hair coats in spring, and use tree trunks, uprooted trees, and shallow depressions in the ground (known as wallows) for relief at that time (Schramm 2005). Bison prefer spruce trees for rubbing their necks, as the smell of the spruce helps mask the bison’s odour and protect it from wolves (Schramm 2005). Wallowing and rubbing continue throughout the insect season in the summer (Schramm 2005); although oral history from Alaska

indicates wood bison are not bothered by mosquitoes like other ungulates, due to their hair coat (Stephenson *et al.* 2001).

Relationship Within and Among Species

Interactions with predators

Wolves are the main predator of wood bison, particularly in and around Wood Buffalo National Park (Carbyn *et al.* 1993). Black bears (Figure 6) and cougars may also prey on wood bison, particularly calves in the spring. Though no direct observations exist, scars suggest possible encounters with these predators (Evans pers. comm. in Fanni 2014: 15).



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

Wolves are known to follow groups of wood bison and are seen as killing more bison than they can eat (Environment Canada 2015e). Members of the Salt River First Nation have reported wolf packs of 100 individuals attacking smaller groups of 30 wood bison around Lake Claire, AB, in Wood Buffalo National Park (Environment Canada 2015e). Wolf population numbers are likely linked with wood bison and moose population numbers: wolf numbers may decrease as ungulate numbers decrease (Schramm 2005).

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. Hunters have seen small groups with very few calves remaining (Schramm 2005). Trappers have reported single wolves tracking and killing lone bulls (Dragon pers. comm. in Carbyn *et al.* 1993: 150); however, they don't 'touch the boss' of the group (Schramm 2005).

One Elder and trapper described how wolves follow bison in this way:

"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. in SARC 2016: 46). 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).

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 usually with several large cows in the back, and the calves in the centre. The animal at the rear will be most vulnerable, particularly if it is a bull, as wolves tend to focus their attack on the genital region (Schramm 2005).

The communities of Fort Chipewyan and Fort Smith urged government to control wolf predation on wood bison through predator control programs starting in the 1930s (Carbyn and Trottier 1988). 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 formal predator control programs (Carbyn and Trottier 1988).

In 2015, community members indicated the wolf population in Wood Buffalo National Park appeared to be on the rise and expressed concerns that low calf survival among bison may be due to wolf predation (Will 2015).

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

Other community members are not concerned about wolves, as they are a natural part of the ecosystem. When bison are doing well there will be lots of wolves, but when bison are in decline, wolves will stop reproducing (SRLWG 2024, unpubl. meeting notes).

In the North Slave region, greater numbers of wolves observed by community members in the mid-2000s were attributed to an increasing Mackenzie wood bison population (Cluff *et al.* 2006). This is considered a threat to other ungulates such as boreal caribou (Cluff *et al.* 2006). Likewise, participants at the 2008 Dehcho Regional Wildlife Workshop noted there were many wolves feeding on bison around the Mackenzie Bison Sanctuary (ENR 2008). Participants suggested incorporating predator management into management plans for wood bison and caribou (ENR 2008).

Interactions with competitors

Community members have expressed concerns about 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 seasonal 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 impacting moose, caribou and sheep in the range of reintroduced Yukon wood bison. Tłı̨chǫ harvesters have expressed concerns about the northward movement of bison towards Whatı, 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 Alberta's Caribou Mountains (Figure 2), although the bison tend to stay in the western portion and the caribou in the east (Schramm *et al.* 2002). 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 explained the mutual avoidance (i.e., 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 lichen, the caribou's preferred food (Fanni 2014). 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.

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 (Schramm 2005).

While some knowledge holders describe a difference in habitat preferences between bison and caribou ("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 many people in 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 as a result are harder to find near Fort Liard than they used to be (Fanni 2014). 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 relatively small number of 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 diet). Directly tying wood bison to a decline in moose may therefore be difficult (Allaire pers. comm. *in* SARC 2016: 48).

PLACE

Historic Distribution

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.

NWT Distribution

Wood bison are currently found the southern NWT (South Slave and Dehcho regions, as well as parts of the North Slave region; Figure 7). 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).

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 (Novakowski 1963).

The Government of the Northwest Territories (GNWT) is the lead agency with responsibility for the Mackenzie, Nahanni and Slave River Lowlands populations, while the Government of Canada (Parks Canada) manages bison in Wood Buffalo National Park.

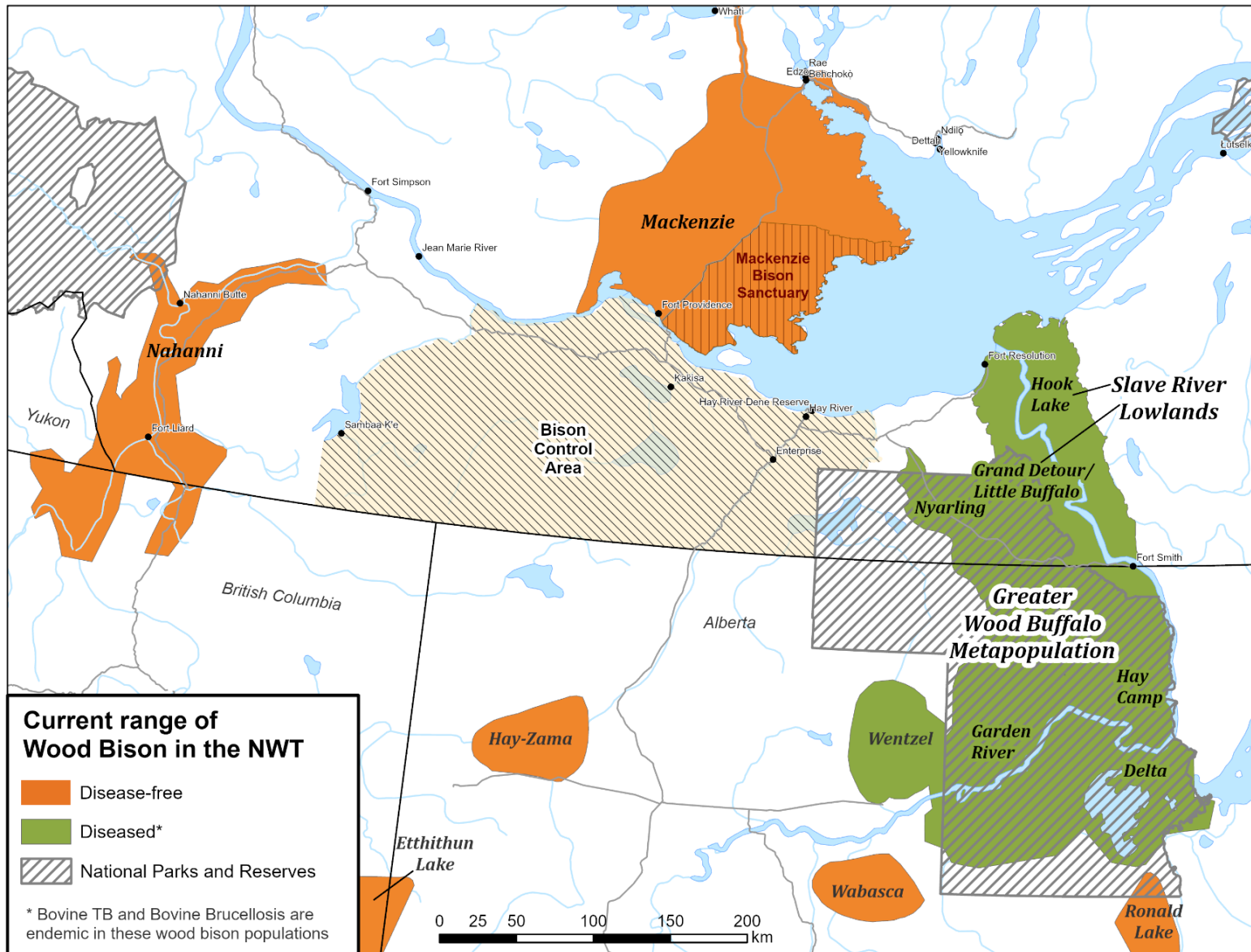


Figure 7. Current wood bison range in the NWT and adjacent jurisdictions. Map by E. McHugh, GNWT-ECC.

Working groups developed management plans for the Mackenzie, Nahanni and Slave River Lowlands wood bison, which provide population-specific management direction (MBWG 2018; NBWG 2019; SRLBWG 2019). The three 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.

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: Delta, Garden River, Hay Camp, and Nyarling River. Of these, only Nyarling River 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 in the section on 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). Kát'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 in Alberta, as well as along the shore of Buffalo Lake (Gates *et al.* 2001a; Mitchell 2002). The English name "Buffalo Lake" comes from the Slavey placename "Ejje Túé," meaning "buffalo's water"—suggesting wood bison have an attraction to this area (Crosscurrents Associates Ltd. and Maskwa Environmental Services Ltd. 2007).

While they are not located in the NWT, the Wentzel Lake and Garden River herds in Alberta are also discussed in this report (Figure 8). Indigenous and community knowledge about these herds provides important information about wood bison biology and behaviour, status and trends, as well as threats relevant to bison in the NWT (e.g., in Schramm *et al.* 2002 and Schramm 2005).

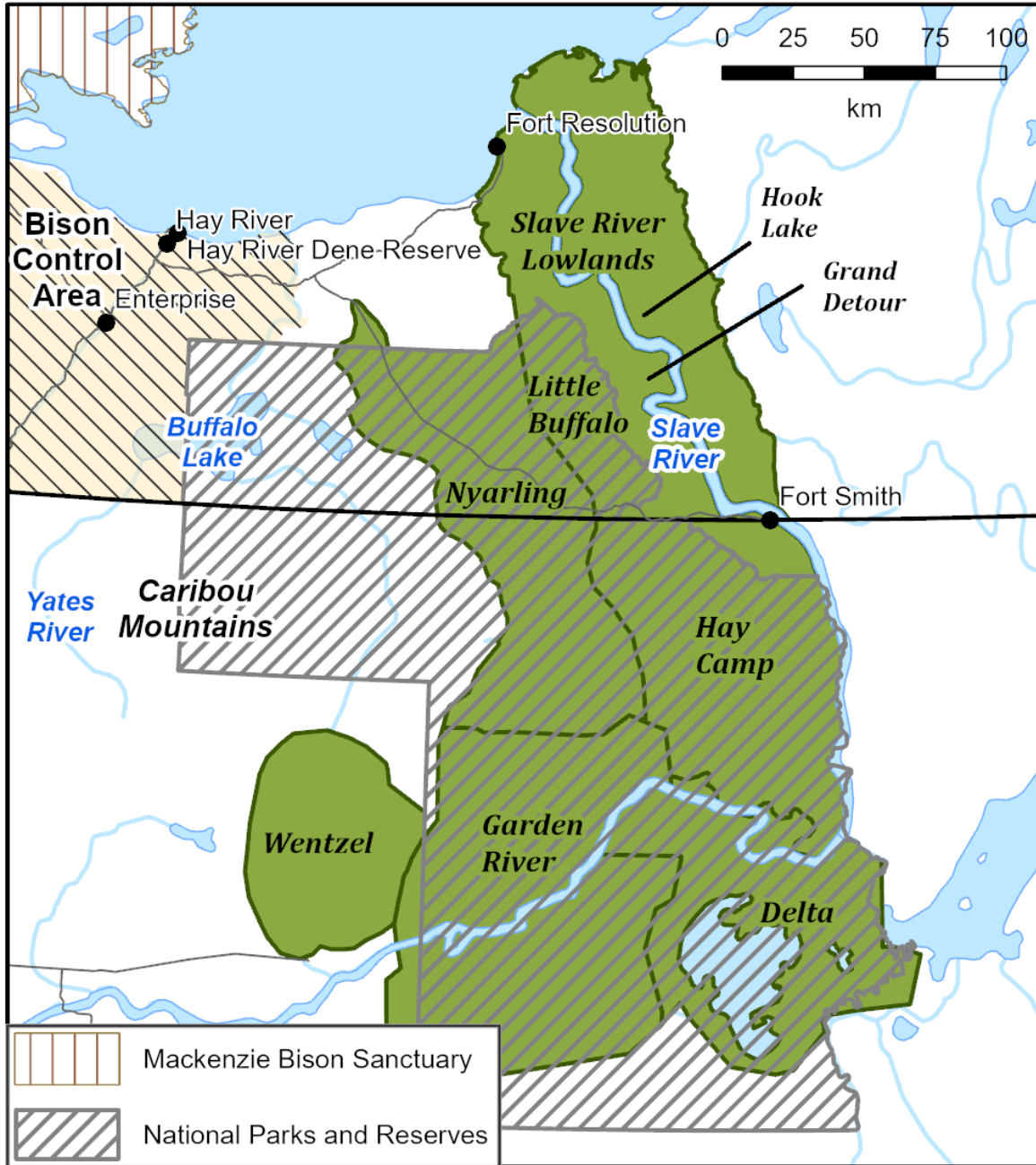


Figure 8. Current wood bison range in and around Wood Buffalo National Park (diagonal hatching). Map by E. McHugh, GNWT-ECC.

Slave River Lowlands Population

The Slave River Lowlands population ranges 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 includes the Grand Detour and Hook Lake subpopulations. The range of the Hook Lake subpopulation is from just inside the northeastern limit of Wood Buffalo National Park to the western portion of the Slave River Lowlands east of the Slave River. The Grand Detour

subpopulation ranges 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 subpopulation 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 (SRLWG 2024, unpubl. meeting notes). 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).

Mackenzie Population

The Mackenzie population is located to the west of Great Slave Lake, including the eastern portion of the Horn Plateau (Figure 7). Although wood bison generally stay on the west side of the North Arm of Great Slave Lake, there are occasional reports of bison on the northern and eastern sides of the North Arm, as well as the eastern portion of the Horn Plateau and along the Horn River drainage and to the north and east (EBA Engineering Consultants Ltd. and Canadian Wildlife Service [CWS] 2006; Phelan 2024).

In the late 1990s or early 2000s, there began to be sightings of wood bison about 30 km south of Behchokò along the Mackenzie Highway (Mitchell 2002; EBA Engineering Consultants Ltd. and CWS 2006; MBWG 2018). Bison have been observed as far north as Whatì along Highway 9 (Tłı̄chq̄ Highway), which connects Yellowknife and Behchokò to Whatì (Judas pers. comm. 2024).

Concerns have been raised by the Edézhíé Management Board, which protects the integrity of Edézhíé, regarding the potential implications of bison moving further up the Horn Plateau (EMB 2024). Members of the Dehcho First Nations are apprehensive about the presence of bison, as they may displace caribou populations and/or attract wolves, thereby increasing the predation risk on caribou (DCFN 2011). There is also a desire to limit bison encroachment onto the Horn Plateau to prevent the possible transmission of disease to caribou (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. *in* SARC 2016: 33), largely in the Fort Liard area and along the Liard River and Highway 7 corridor. Bison regularly enter both Nahanni Butte and Fort Liard, which has resulted in conflicts

between people and bison in communities (NBWG 2019). Most available traditional knowledge of the Nahanni population is derived from ADKFN compilation efforts (Fanni 2014).

Although wood bison historically occupied this area, ADKFN members interviewed by Fanni (2014) stated that, prior to the reintroduction efforts in the 1980s, the species had been absent from their traditional territory for at least four generations.

Other Observations

Wood bison sightings do occur outside of known ranges. Wood bison have been seen along the south shore of Great Slave Lake, although they do not leave the shore area to venture inland (Gates *et al.* 2001a; Mitchell 2002). They have also been known to cross the Mackenzie River at Wrigley Harbour (Environment Canada 2015d; see Figure 2). 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). 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 Sambaa K'e (formerly 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).

In 1987, to control the spread of disease, a Bison Control Area was established to prevent movement between bison in Wood Buffalo National Park and the Mackenzie and Nahanni bison populations. Any bison found within this zone are killed and tested for disease.

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 group of bison 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 dispersal patterns of wood bison are influenced by a variety of ecological and environmental factors, as well as group dynamics. Wood bison bulls and cows exhibit distinct movement behaviours. Bulls are observed at the edge of established ranges, more likely to travel alone, disperse great distances from their group, and 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. 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 groups in the summer and smaller groups 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 a lot of snowfall, larger groups of wood bison are more common. Traveling together helps them move through the snow, which is particularly beneficial to the calves. 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).

The distribution of burned areas on the landscape is also a major factor in bison movement. Bison is one of the first species to enter an area after a wildfire, and Indigenous communities have carried out prescribed burns in areas to attract bison (Schramm *et al.* 2002).

Movement Corridors and Water Crossings

Wood bison are known to establish trails or corridors between favourable habitat patches (Gates *et al.* 2001a; Mitchell 2002). When colonizing an area, trails are quickly formed and 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 support their weight (Gates *et al.* 2001a; Mitchell 2002).

The Little Buffalo River in the Slave River Lowlands area is not considered 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; Gates *et al.* 2001a). Likewise, wood bison groups have frequently been seen swimming across the Liard River (Larter and Allaire 2007). However, 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. For example, the wide Mackenzie River is considered a significant barrier (Figure 10; Gates *et al.* 2001a).

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 (Gates *et al.* 2001a). Wood bison can only cross downstream once the river nears the community of Hay River (Gates *et al.* 2001a). They will cross the Salt River to access the meadows to the north of Wood Buffalo National Park, and some will travel through 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/Brûlé Point on the Slave River (Gates *et al.* 2001a; Mitchell 2002; see Figure 2). 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). 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).

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; see Figure 2). 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).

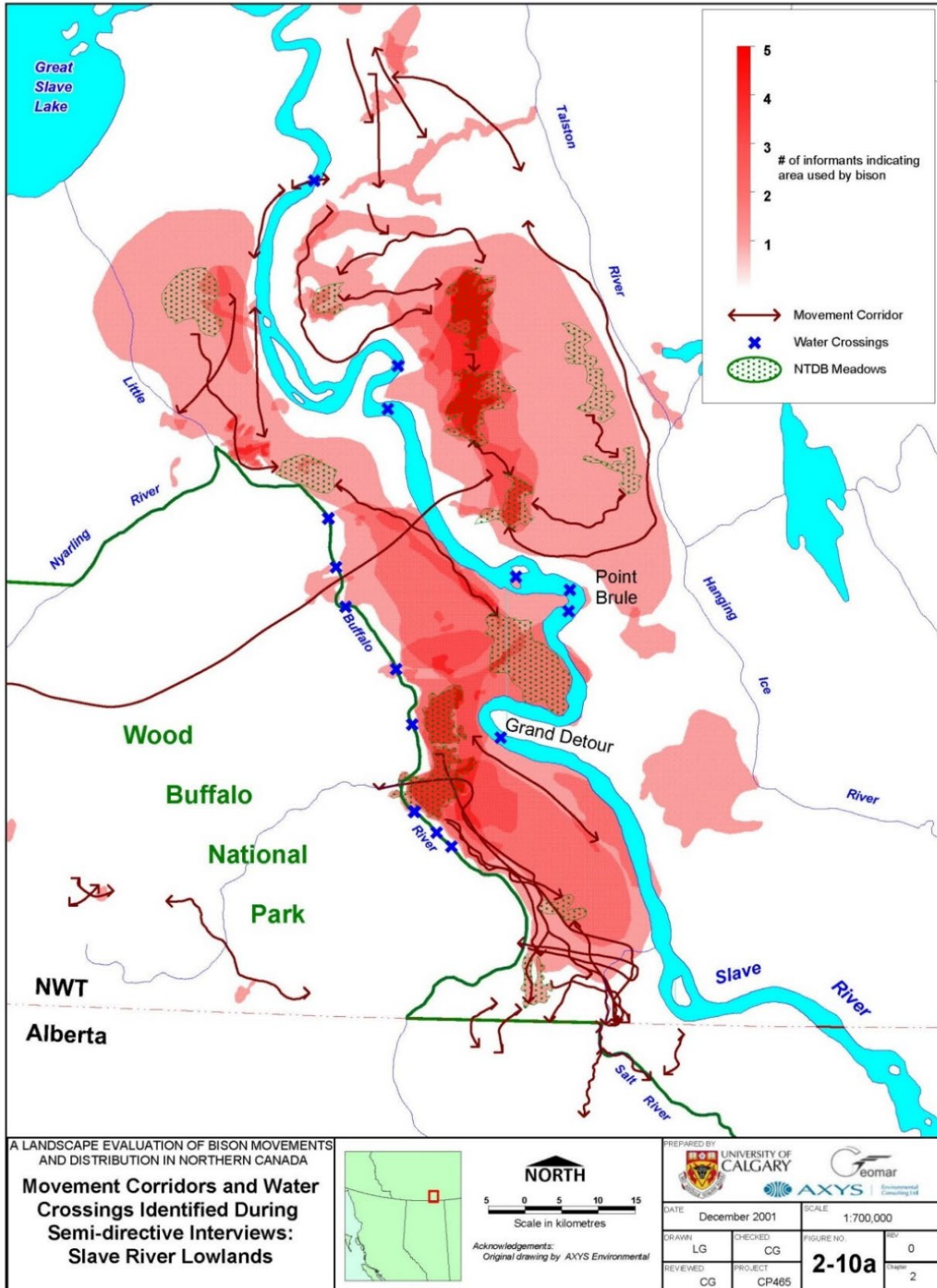


Figure 9. Movement corridors and water crossings identified during semi-directed interviews: Slave River Lowlands study area (Hook Lake and Grand Detour subpopulations) (Gates et al. 2001a). Biophysical layers generated by digital data from the National Topographic Database (NTDB).

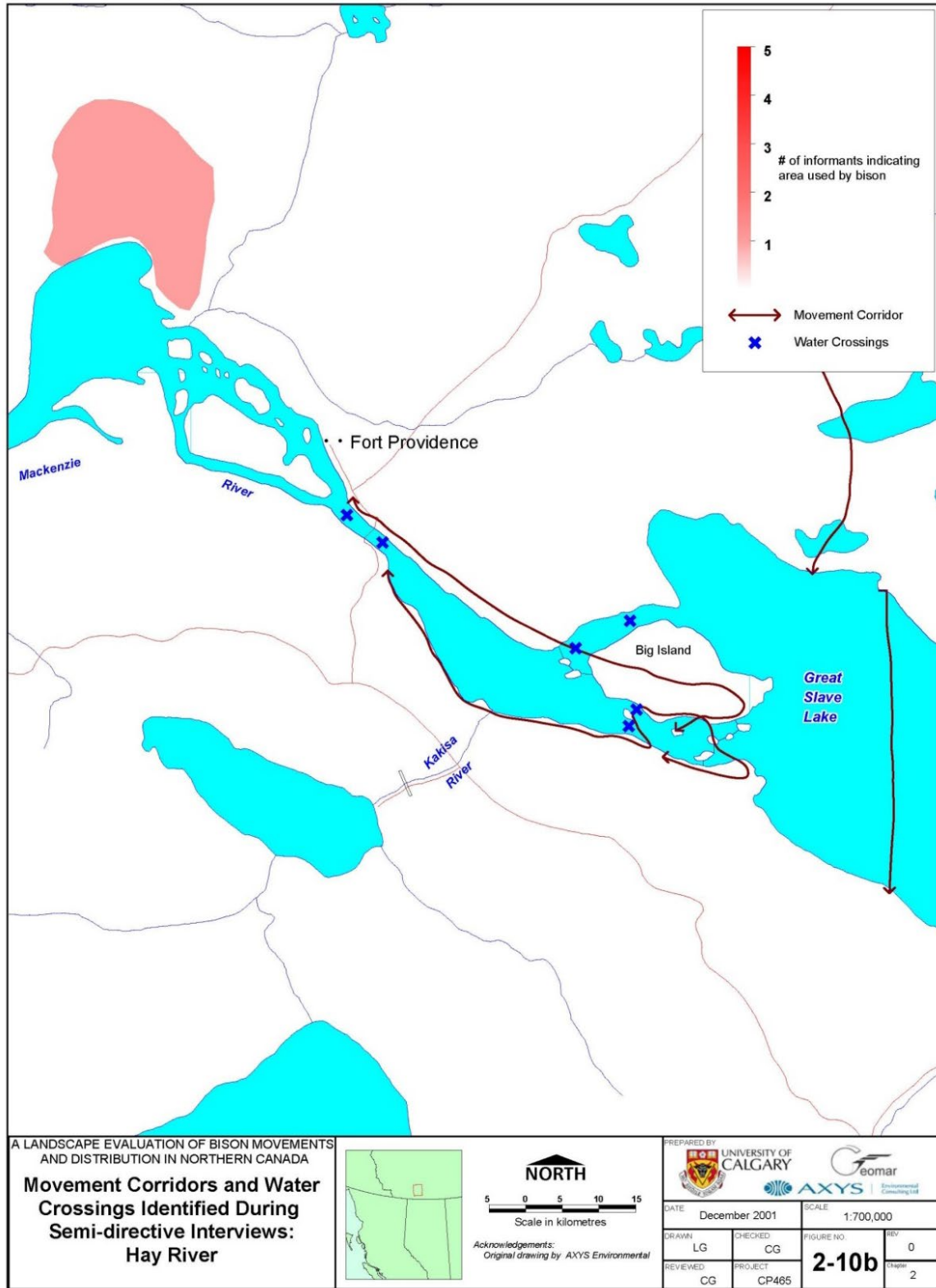


Figure 10. Movement corridors and water crossings identified during semi-directed interviews: Hay River study area (between Wood Buffalo National Park and Fort Providence) (Gates et al. 2001a). Biophysical layers generated by digital data from the National Topographic Database (NTDB).

Residents of Fort Liard and Nahanni Butte often see wood bison swimming across the river. (Larter *et al.* 2003). 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).

ADKFN members have observed bison movements along the Liard River and the Highway 7 corridor (Fanni 2014). These movement routes consist of hard ground, which facilitates movement more than in areas with muskeg or swamp. Animals in the Nahanni population also use all-terrain vehicle (ATV) trails and old seismic cutlines to access Maxhamish Lake, Fisherman Lake and Bovie Lake (Fanni 2014; see Figure 2). While wood bison 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 (Fanni 2014). 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 Indigenous and community knowledge interviews conducted by Mitchell (2002).

Factor	Nature of Effects
Slope	<ul style="list-style-type: none"> • Bison are associated with riparian meadows and avoid steep slopes. • Water crossings occur in areas with shallow banks.
Lake size	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Bison rarely cross wide rivers; however, small rivers are readily crossed.

Factor	Nature of Effects
Habitat as a barrier	<ul style="list-style-type: none"> • Large expanses of muskeg are barriers. • Shield country is a barrier.
Ice conditions	<ul style="list-style-type: none"> • Ice cover provides opportunity for crossing water bodies. • Spongy or weak ice is avoided and, if used, may be a hazard, as drownings may result if the bison fall through the ice. • Rough ice on lakes or rivers is a barrier.
Habitat affinity	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Bison use early seral stage (regrowth after disturbance). • Linear disturbances (seismic lines and road edges) may provide grazing habitat.
Fire	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Corridors are associated with watercourses. • Corridors follow and link graminoid habitat patches.
Cattle	<ul style="list-style-type: none"> • Cattle do not generally influence bison movements.
Fences	<ul style="list-style-type: none"> • Serve as a barrier to movements.
Population density	<ul style="list-style-type: none"> • Area occupied is positively related to density.
Human disturbance	<ul style="list-style-type: none"> • 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 along the winter road right-of-way, and as of 2021, along the newly constructed Tlicho Highway (Highway 9), which provides increased access to the area (Judas pers. comm. 2024; TG and Firelight 2025a and b; Migwi pers. comm. 2026; Figure 11). Members of the North Slave Métis Alliance have also reported wood bison on the eastern side of the North Arm of Great Slave Lake (Phelan 2024). This expansion is not supported by Tłı̄chǫ communities, which are concerned about potential impacts to communities as well as competition with moose and caribou (INF 2023b; TG and Firelight 2025a). 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 Tłı̄chǫ Highway (Highway 9) towards Whatì, some harvesters speculate they are moving north to access better habitat and resources, while others emphasize the lack of good food sources further north (TG and Firelight 2025b). One harvester described seeing wood bison traveling back south because they could not find enough to eat (TG and Firelight 2025b).

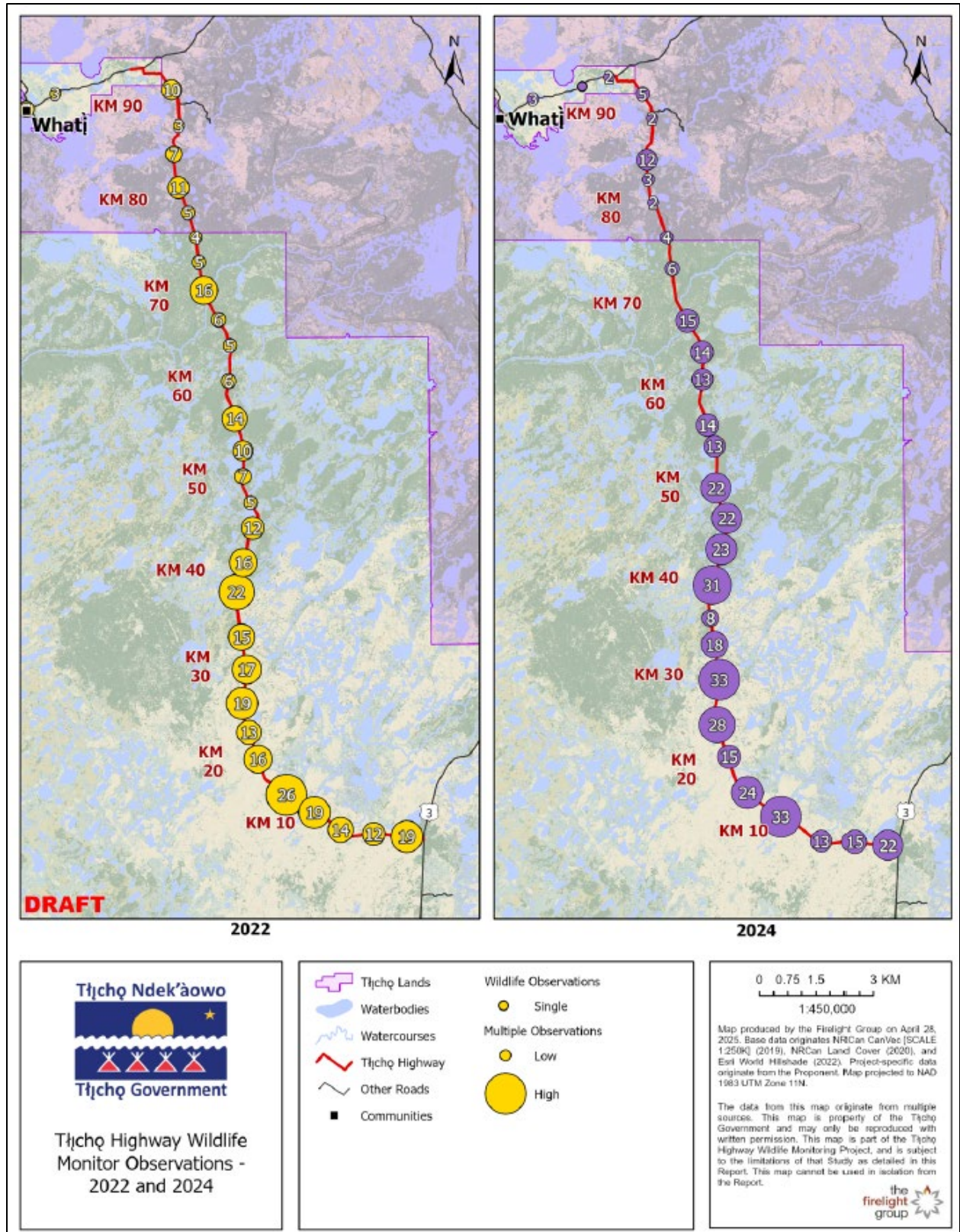


Figure 11. Map of wood bison observations collected by wildlife monitors in 2022 and 2024 (January-December) along the Tłı̨chǫ Highway (TG and Firelight 2025a).

Search Effort and Harvest Patterns

Wood bison distribution around Wood Buffalo National Park is well known by NWT hunters (Northern Diseased Bison Environmental Assessment Panel 1990a, 1990b; Armstrong pers. comm. 2025b). 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.

With the decline of many caribou populations and hunting limitations imposed in the 2000s, some Indigenous leaders are promoting a sustainable bison harvest (GNWT and TG 2025). In 2025, an increase was proposed to the harvest quota for Mackenzie bison to mitigate food security issues (GNWT and TG 2025). The proposed allocation (60 bison per year, with tags divided proportionately across Indigenous governments, Indigenous organizations, and NWT residents) is based on population size and trend as described in the Mackenzie Bison Management Plan (MBWG 2018) and would support communities' values and their timely access to an important source of country food (GNWT and TG 2025).

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 populations (Schramm *et al.* 2002; 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)

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 (Mitchell 2002). For example, the Slave River Lowlands are characterized by a patchwork of wetlands, grasslands, and forested areas that support a wide array of plant species that are vital for wood bison (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).

The Mackenzie Bison Sanctuary is another important area for wood bison, providing a mix of open grasslands, shallow lake basins and forested regions, which are essential for seasonal migration and dispersal patterns (Mitchell 2002). 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).

Meandering rivers with multiple oxbows, such as those found in the Liard River valley, also provide good bison habitat (Gates *et al.* 2001a; Mitchell 2002). Cut blocks may offer open areas of preferred habitat (Schramm 2005), and wood bison will also use burned-out areas (Gates *et al.* 2001a; Mitchell 2002).

Seasonal Habitat Requirements

Spring

In the early spring, wood bison will seek out south-facing slopes, which are snow-free earlier, allowing access to forage (Schramm *et al.* 2002). Wood bison avoid muskeg, dense forest, regions of steep terrain, and areas with deep and crusted snow where forage is less available (Gates *et al.* 2001a; Mitchell 2002; Schramm *et al.* 2002).

Wood bison seek the new growth of grasses and sedges, which they will select in the spring over broad-leaf plants (Schramm 2005). This becomes their dominant food source for the season (Schramm 2005). They may feed on the small new leaves of willows and small willow-like plants (Gates *et al.* 2001a; Schramm 2005). Bison in some areas (e.g. Nahanni and Wentzel Lake populations) also 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 where the ground is solid to make walking easier (Schramm 2005). 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 gravel/sand bars along the Liard River (Nishi, Ellsworth and Konisenta pers. comm. *in* Larter *et al.* 2003: 410).

Fall and Winter

Dry grasses and sedges are the most important winter feed for wood bison (Schramm 2005). Wood bison may forage along riverbanks where dried grasses hanging over the edge of banks may not be covered by snow (Schramm 2005). They also tend to frequent the edges of frozen beaver ponds where grasses and sedges are accessible (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 between January and March (Schramm 2005). While vegetation in wet meadows may lodge and freeze, lichens found in spruce stands will 'stand up' and be accessible beneath lighter snow cover (Schramm and Krogman 2001; Schramm *et al.* 2002; Schramm 2005). In winter, wood bison feed on high-quality forage in the centres of meadows that are inaccessible in the summer; this seasonal shift helps to maintain quality forage in meadows (Gates *et al.* 2001a; Mitchell 2002). Bison have also been known to consume muskrat push-ups in the winter (Schramm *et al.* 2002).

Habitat Trends

In meadow ecosystems, periodic flooding helps to maintain vegetation. However, in the Mackenzie range, increased water levels since the 1990s, perhaps earlier, have flooded former meadows and reduced the availability of grazing habitat for bison (ENR 2010b; Armstrong pers. comm. 2025b).

In the meadows of the Slave River Lowlands there has been an encroachment of willows due to widespread drying (Gates *et al.* 2001a; Mitchell 2002; Schramm 2005; Environment Canada 2015c; Pembina Institute 2016). Brush-dominated habitat is poorer for wood bison compared to open grasslands (Gates *et al.* 2001a). An increase in willows has also been observed by Cree Elders and hunters in areas of northern Alberta where there used to be more open meadows (Schramm 2005). Members of the Slave River Bison Working Group have noted that local flooding of prairies on west side of Slave River have pushed bison away by making those feeding areas inaccessible (SRLWG 2023, unpubl. meeting notes).

The encroachment of willows may also relate to water table changes brought on by the construction of the Bennett Dam (Neil pers. comm. *in* Schramm 2005: 70; Environment Canada 2015c; Pembina Institute 2016) and the cessation of over-bank flooding in some springs due to ice-jams forming on the Peace and Slave rivers (Armstrong pers. comm. *in* SARC 2016: 51). In 2014, the Mikisew Cree First Nation filed a petition to the World Heritage Committee (UNESCO) arguing Wood Buffalo National Park faces serious and immediate threats from hydro-electric regulation of the Peace River and industrial development of Alberta's oil sands (MCFN 2014). Mikisew members documented the precipitous drop in the quantity of certain resources, the drying of the Peace-Athabasca delta, and the contamination of water and wildlife, among other

effects (MCFN 2014). Indigenous communities note that the desired outcomes for the conservation of wood bison are not currently being met and that former bison habitat in the Peace-Athabasca delta has been degraded by the growth of Canadian thistle (Government of Canada 2022).

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 in the early 1900s, 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 400 years (Lotenberg 1996).

Wildfire may encourage the growth of high-quality forage such as grasses and sedges (Figure 12; Mitchell 2002; Schramm 2005; Wells 2014; Christianson *et al.* 2022), which is viewed as good for the local wood bison populations (Beaulieu *pers. comm.* 2024). Wood bison may also find some protection from predators in newly burned areas, 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*).



Figure 12. Wood bison grazing in a burned area in Wood Buffalo National Park. Photo credit: P.-E. Chaillon.

Fire has been used by Indigenous peoples to maintain meadow and forest habitats (Gates *et al.* 2001a; Mitchell 2002). In northeastern British Columbia, Fort Nelson First Nation members have used fire to improve wood bison habitat in their territory (Christianson *et al.* 2020; Christianson *et al.* 2022). Prescribed burns such as those undertaken during the Hook Lake Wood Bison Recovery Project (1992, 1993, and 1995) were also considered to be valuable for the local ecosystem (Mitchell 2002; Schramm 2005). The burns maintained high-quality grassland areas open for use by wood bison and other wildlife (Gates *et al.* 2001a; Mitchell 2002; Schramm 2005). 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 (van Kessel 2002). Community members expressed interest in prescribed burning in the Slave River Lowlands prior to 2023; however, following severe wildfires in the area, plans to pursue prescribed burning were pushed back (SRLWG 2023, unpubl. meeting notes).

Following particularly severe wildfire seasons in 2014 and 2015 in the Mackenzie range, Fort Providence harvesters observed bison moving into recent burn areas to consume the fresh grasses (Environment Canada 2015b). Between 2015 and 2025, approximately 18% of wood bison range in the NWT was burned by wildfires (ECC unpubl. data 2026b). 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 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.

Concerns about changes to wildlife movement patterns have been raised in relation to the development of new all-season highways within the NWT (INF 2023a; TG and Firelight 2025a and b). Specifically, the Tłıchǵ Government is concerned about wood bison moving north along the new Tłıchǵ Highway (Highway 9) towards Whatı (TG and Firelight 2025a). A community-based monitoring program set up to monitor wood bison presence and movement along the highway (2021-2025) recorded bison within 40 km of Whatı (TG and Firelight 2025a). The report suggests bison may be moving further north using the Tłıchǵ Highway as a travel corridor; however, more data is needed to confirm (TG and Firelight 2025a).

POPULATION

Abundance

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

Changes in Population Size

Although the wood bison population in the Slave River Lowlands has not returned to peak numbers observed in the 1970s, the population has been fairly stable over the long term (Environment Canada 2015c, d). Population surveys in the Slave River Lowlands have indicated a declining trend since 2009, and members of the Slave River Lowlands Bison Working Group have been considering ways to mitigate harvest pressure and other human impacts on this population (SRLBWG 2024; 2025).

A similar declining trend has been observed for the bison populations in Wood Buffalo National Park (SRLBWG 2024) and communities around the park have expressed uncertainty about how the bison 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)

In 2016 and 2022, the World Heritage Centre initiated monitoring missions to visit Wood Buffalo National Park to investigate whether the park’s conservation values were in trouble (WHC/IUCN 2022). Although parks staff indicated to the mission that bison numbers in the park were considered “stable and healthy,” some Indigenous Elders expressed concern over the health of the park’s bison population, suggesting that the actual numbers may still be declining (WHC/IUCN 2022).

The Mackenzie wood bison population appears to be steadily increasing following a sharp population decline in 2012 due to a major anthrax outbreak. Members of the Mackenzie Bison Working Group support an increase in available bison hunting tags from 40 to 60 for the 2025/2026 hunting season, indicating the population has surpassed 1,500 animals (MBWG 2025). Wood bison have been observed along NWT the Tłıchq Highway (Highway 9) as far north as Whatì (Judas pers. comm. 2024; TG and Firelight 2025a and b) and in the Dehcho, towards the Horn Plateau (EMB 2024). Community members in Behchokò and in the Dehcho region have expressed concern at the encroachment of wood bison and a perceived rapidly expanding bison population (Cluff *et al.* 2006; EMB 2024; TG 2025).

Changes in populations size of Nahanni wood bison were not covered in the available literature.

Health

Tuberculosis, brucellosis and anthrax are known diseases of wood bison (Ferguson 1989; Schramm *et al.* 2002). 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 that bison in Wood Buffalo National Park may carry certain diseases; however, knowledge about specific diseases, their origins, and symptoms varies among individuals (Will 2015). 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).

“Well that disease [anthrax] 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. Ferguson and Laviolette (1992) document stories of sudden mortality in the Fort Smith area at a time when wood bison were plentiful:

“Then one summer season the wood bison died off so quickly at Foxhole prairie that the bones were almost side by side.” (Laviolette 1989 in Ferguson and Laviolette 1992: 48).

“That big Salt Plain was just black with dead wood buffaloes.” (Louis Brown pers. comm. 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.

For residents of Fort Resolution considering the Hook Lake Wood Bison Recovery Project, there were differing views on the effect of the three key diseases (brucellosis, tuberculosis, and anthrax) on wood bison (van Kessel 2002). 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 (Ferguson 1989; van Kessel 2002). Diseases were described as a natural part of life for wildlife (van Kessel 2002). 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).

Will (2015) found that some believed tuberculosis and brucellosis to have originated from outside the park. According to Will (2015), community members know little 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 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)

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 considered 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).

An anthrax vaccination program was carried out in Wood Buffalo National Park from 1965-1977 in an attempt to control anthrax outbreaks, which involved rounding up thousands of animals (Dragon and Elkin 2001). The program was considered to have been very damaging to the wood bison populations (Schramm *et al.* 2002). 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)

The vaccine itself and the stress of corralling were noted as possibly increasing the likelihood of disease (Ferguson 1989; van Kessel 2002).

Hunters note that a clear sign of a healthy animal is an active animal and multiple years with good growing conditions for forage is good for the general health of bison (Will 2015; Beaulieu pers. comm. 2024). In spring 2022, community members reported 23 wood bison in the Nahanni range that were dead or severely emaciated (Jutha pers. comm. 2026). The majority of reports were noted close to the community of Fort Liard, in the Fisherman's Lake area. The GNWT Wildlife Health Program conducted necropsy investigations and determined the main cause of the mortalities to be nutritional stress/starvation. It was estimated that deep snow for the time of year followed by a rain on snow/icing event led to barriers to access feed by Nahanni bison (Jutha pers. comm. 2026).

Rescue Effects

The possibility of rescue was not covered in available sources. Wood bison occur in Alberta and British Columbia, and long-distance movements are possible (refer to *Movement and Dispersal* for more information). However, barriers to wood bison movements may 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*.

THREATS AND LIMITING FACTORS

Indigenous and community knowledge holders in available sources described various threats to wood bison populations, including disease/disease eradication efforts, overhunting, vehicle collisions, changes to habitat, and human-bison conflicts. 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, including starvation in harsh winter conditions and drowning due to flooding or falling through the ice (Northern Diseased Bison Environmental Assessment Panel 1990a, 1990b).

Disease and Disease Management Efforts

One of the main threats to wood bison populations is the prevalence of diseases such as tuberculosis, brucellosis, and anthrax (Ferguson 1989; Northern Diseased Bison Environmental Assessment Panel 1990a; Schramm *et al.* 2002; 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).

Understanding these health challenges in the context of traditional ecological practices and the historical relationship between people and bison is important (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).

Harvesters may suspect disease in a wood bison carcass if there are observations of 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. Harvesters 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 have indicated that diseased wood bison meat is not consumed (Gates *et al.* 2001b; Will 2015), other hunters have indicated that thoroughly cooked or dried wood bison meat was consumed (Beck pers. comm. *in* SARC 2016: 57; Will 2015).

Community members in northern Alberta express more concern about anthrax than tuberculosis or brucellosis (Schramm 2005; Will 2015). Tuberculosis tends to develop active signs primarily in older bison, which are less targeted by hunters, making encounters with visibly infected animals less likely (Schramm 2005). Bison can also live with tuberculosis and brucellosis for extended periods without dying directly from these diseases (Will 2015). In contrast, anthrax

outbreaks can rapidly kill large numbers of animals, directly impacting hunting activities and food security (Schramm 2005; Will 2015).

“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 considerable threat to bison in Wood Buffalo National Park; however, knowledge of the different diseases, their origins, and symptoms varies (Will 2015). Indigenous hunters and communities have pointed to a lack of clear information about wood bison diseases; how they spread and how or if they can or should be managed as a threat to wood bison (Ferguson 1989; NDBEAP 1990a, 1990b; Will 2015). They have contended that further studies on wood bison and wood bison disease are needed to make informed decisions about disease management (NDBEAP 1990a, 1990b). Mismanagement of diseased wood bison herds, without better information, threatened the herds (Ferguson 1989).

Will (2015) describes frustration towards how disease outbreaks are managed. Some community members see parks officials allowing nature to take its course by not killing what they perceive to be sick bison. They say park officials have also been observed chasing bison back into the park when they step outside the park boundary, which they believe conflicts with the concept of letting nature take its course.

“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 [officials], 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)

In the late 1980s, Indigenous hunters in the South Slave region of the NWT and northern Alberta felt that disease occurrence was over-estimated by scientists (Ferguson 1989). They estimated that only about ten per cent of wood bison in and around Wood Buffalo National Park were diseased; others indicated that Hook Lake bison were disease-free at the time (Ferguson 1989). 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).

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) and eradicating diseased animals and populations is considered a threat to wood bison generally (Ferguson 1989). Historically, 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).

“We believe that the northern buffalo that Agriculture Canada proposes to slaughter will be killed because white agricultural interests want to use these lands for grazing leases and because the white government wants to sell the trees on these lands to foreign pulp mills. As the Indian people of this area, we oppose these uses of the land and this unwarranted slaughter of wildlife.” (Ferguson and Burke 1992: 197)

Tactics for dealing with disease monitoring and prevention were also considered a threat to wood bison in the late 1980s, including driving the animals by helicopter flights, herding, corralling, and other techniques (Ferguson 1989). 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)

Hunters also felt that any of the various proposed disease management 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). Elders often felt that if left alone, wild animals can cure themselves of harmful diseases by eating certain plants (van Kessel 2002).

Bison recovery activities conducted under the Hook Lake Wood Bison Recovery Project, such as corralling wood bison 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 (van Kessel 2002).

Overhunting

Wood bison in larger groups can be relatively easy to find due to their large size and herding behaviour compared to solitary animals (Schramm 2005). Oral history from Alaska indicates that hunting, combined with limited habitat and deep snow, may have been responsible for historic

extirpation of wood bison from that area in the late 1800s or early 1900s (Stephenson *et al.* 2001). However, members of the Kátł'odeeche First Nation question whether the extirpation of wood bison from their region 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'ję First Nation (Fort Providence, NWT) expressed concerns about overharvest by their own people; the species was not specified but may have included wood bison (Mackenzie population) (DFN and RWED 2002).

Today, wood bison in the NWT outside of Wood Buffalo National Park are managed under three population-specific bison management plans. These plans were developed by working groups that include communities in the range of each of the populations (Mackenzie, Nahanni and Slave River Lowlands) and include guidance on setting harvest quotas based on population size (MBWG 2018; NBWG 2019).

Quotas are in place for the Mackenzie and Nahanni populations, with 40 and 7 tags (respectively) distributed annually (CMA 2025). In December 2025, a proposal to increase the harvest to 60 bison was submitted to the Wek'èezhì Renewable Resources Board on the recommendation of the Mackenzie Bison Working Group (GNWT and TG 2025), based on the size of the Mackenzie bison population and increasing trend. The Nahanni population has had a harvest quota in place since 2018; not all tags are used every year ([Big Game Hunting Regulations](#), R-019-92; Armstrong pers. comm. 2026).

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 were distributed among the Deh Gáh Got'ję First Nation, Fort Providence Métis Council, Tłıchǫ Government, NWT Métis Nation, North Slave Métis Alliance, Yellowknives Dene First Nation and through a limited entry draw.

Harvest of wood bison is prohibited inside Wood Buffalo National Park. There is no quota for bison taken by Indigenous harvesters in the Slave River Lowlands and resident hunters are limited to one bison per hunting season ([Big Game Hunting Regulations](#), R-019-92). Reporting for resident hunters is mandatory although not always enforced; any information collected is shared with the working groups for each bison population (Armstrong pers. comm. 2026). 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 have not been publicly reported.

Indigenous hunters in some regions of Alberta have, at times, voluntarily refrained from hunting wood bison in response to declines (Schramm *et al.* 2002; FNFN 2015). In 2024, members of the Slave River Lowlands Bison Working Group discussed concerns about declining bison populations in the Slave River Lowlands and suggested a campaign (posters, social media, radio ads) to increase awareness about population trends and vehicle-bison collisions to help curb hunting (SRLWG 2024, unpubl. meeting notes). The Mackenzie Bison Working Group notes that interest in bison hunting may increase when other species (such as moose or caribou) are not available (MBWG 2018). Members of the working group agreed that hunters should not be encouraged to hunt bison as a replacement for other species that have declined.

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).

Vehicle Collisions

Wood bison are drawn to linear features like roads and seismic lines, which offer easy travel paths through dense forests or wetlands (MBWG 2018). 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 concerns about the number of wood bison being killed on highways; some knowledge holders in the Dehcho and North Slave regions indicated they considered this the most important threat facing wood bison (Environment Canada 2015a and b), noting that these bison mortalities 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 (Highway 9), 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 (TG and Firelight 2025b). 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 Changes

Currently, there is limited industrial development in the NWT portion of the wood bison's range. While the Liard Valley contains significant quantities of shale gas and there has historically been natural gas produced at Cameron Hills west of Highway 1, production has been suspended since 2015 due to low commodity prices and high exploration costs (CER 2017, 2026).

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; Parks Canada 2019; The Narwhal 2023). According to knowledge holders in northern Alberta, logging activity on the south-central and south-eastern slopes of the Caribou Mountains has the potential to negatively affect wood bison (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 m³ of timber per Agreement (ECC 2024). When the agreements were signed, it was assumed that timber 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 (MBWG 2018), 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 Kųę First Nation members (Environment Canada 2015c) during the project permitting consultation phases have been realised.

In the late 1980s-1990, exclusion of Indigenous governments and Indigenous organizations from wood bison management processes was considered a threat (Ferguson 1989; Northern Diseased Bison Environmental Assessment Panel 1990a, 1990b; Environment Canada 2015d). In particular, there was a fear that the approach to wood bison management would 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).

Although fire is recognized as a natural component of the landscape, and small-scale fires can benefit wood bison, the large, intense wildfires experienced in the southern NWT in the last two decades are seen by some community members as a potential threat to wood bison (Environment Canada 2015e). 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 likely due to 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 bison rely on lichen for food during extreme winter weather when dried grasses and sedges are inaccessible (i.e., in the Caribou Mountains in northern Alberta), forest fires can damage the soil and lichen resources (Environment Canada 2015a). Lichens do not regenerate quickly after a forest fire (Schramm 2005).

High water levels can also restrict bison access to important habitat and force them to move to other areas. In the Slave River Lowlands, bison access to prairies for feeding was limited in 2024 because some of these areas were still partly flooded (SRLWG 2024, unpubl. meeting notes).

Human-bison Conflicts

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; MBWG 2018). The Mackenzie Bison Management Plan (MBWG 2018) notes that wood bison have never injured a person in a community, but the potential exists, and most community members would rather not have large, wild animals in town. In communities where bison populations have 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—such as in Fort Liard, Nahanni Butte, and Fort Providence (Clark *et al.* 2016; Doney *et al.* 2018; Jung 2020; CBC News 2021; APTN News 2023; Krutko pers. comm. 2026). Members of the public in Fort Liard have also been known to take matters into their own hands and have harassed and shot bison illegally, occasionally leaving wounded animals (NBWG 2019).

Other Threats

Wood bison are known to die off in periodic extreme winter weather conditions. For example, in 2022, community members from Fort Liard reported finding several weak and dead bison (Gast pers. comm. 2026). Many of the bison showed signs of starvation. This mortality event was attributed to extremely deep snow conditions complicated by a rain on snow event with surface icing (Jutha pers. comm. 2026). Community members in the Slave River Lowlands have also indicated that young animals may starve when there are icing conditions in winter, as they are not strong enough to break through icy snow (SRLWG 2024, unpubl. meeting notes).

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 (Larter *et al.* 2003; Allaire pers. comm. 2015 *in* SARC 2026; Environment Canada 2015c). 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 exemplifies 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).

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; (MBWG 2018; NBWG 2019; SRLBWG 2019). 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 (MBWG 2018; NBWG 2019; SRLBWG 2019). 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 (MBWG 2018; NBWG 2019; SRLBWG 2019).

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).

Harvest Management

Hunting remains an important social, cultural and economic activity, as well as an important means for cultural connections with wildlife (MBWG 2018). Community members on the NWT working groups for bison management have stated that harvesting can have significant effects on wildlife populations (MBWG 2018; NBWG 2019; SRLWG 2019) and harvest management is often one of the few direct actions wildlife managers can take to protect a population (NBWG

2019). In some cases, it may be the most important factor in the dynamics of a wildlife population (MBWG 2018; SRLWG 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). 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 (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)

The management plans for the Mackenzie and Nahanni populations include guidance for sustainable harvest levels based on population size and trend (MBWG 2018; NBWG 2019). All three NWT bison working groups have indicated support for collecting bison harvest data to determine harvest rates (MBWG 2018; NBWG 2019; SRLBWG 2019).

Conservation Planning

Land use and conservation planning initiatives have generally had a positive influence on wood bison. Wood Buffalo National Park was established in 1922 to protect the world’s largest free-roaming population of wood bison from extinction by maintaining original habitat and providing protection from human land-use impacts. However, the park has also been controversial for restricting Indigenous access to harvest and some Indigenous communities blame the park for eroding their relationship with wood bison (Environment Canada 2015d). Some Indigenous communities have also expressed doubt about whether the national park is living up to the conservation values in its World Heritage Site designation (MCFN 2014).

Edézhíe (Dehcho Protected Area), established in 2018, includes the western part of the Mackenzie bison range (Dehcho First Nations and Government of Canada 2018). 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 ([EDDPA 2026](#)). In 2022, Edézhíe was also designated as a National Wildlife Area under federal law, which restricts activities that may interfere with the conservation of wildlife ([Wildlife Area Regulations](#), C.R.C., c. 1609). Indigenous harvesting rights and other traditional activities within Edézhíe are not affected (DFN and Government of Canada 2018).

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 (Wiebe pers. comm. 2025).

There is currently a combination of surface and sub-surface land withdrawals in place in the southern NWT under the *Northwest Territories Lands Act*, which prevent the creation of interests related to certain land-use activities. These areas include large tracts of known bison habitat, including an area of approximately 790 km² on either side of the northern tip of the North Arm of Great Slave Lake known as Dinàgà Wek'èhodì, and portions of the Dehcho region within and around the Bison Control Area.

Fire

Wildfires of moderate intensity can increase bison habitat by encouraging forage such as grasses and sedges (Schramm 2005). Following severe fire seasons in the Mackenzie bison range, Fort Providence harvesters observed bison moving into those burn areas to consume the fresh plant growth (Environment Canada 2015a; 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 carried out a burning program in 2013 to restore wood bison habitat (FNFN 2015).

"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 (1992, 1993 and 1995) 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).

Other Positive Influences

The wood bison-free buffer zone between diseased bison in Wood Buffalo National Park and bison in the Mackenzie Bison Sanctuary was seen as effective (i.e., wood bison-free), in the late 1980s (Ferguson 1989) and community members continue to report sightings (MBWG 2024).

Negative attitudes towards wood bison may be shifting. Among ADKFN members, men and Elders were most likely to articulate negative views towards bison (Fanni 2014). Youth may have more open attitudes (having spent their lives around wood bison); this presents an opportunity to promote acceptance of wood bison (Fanni 2014).

ACKNOWLEDGEMENTS

The Species at Risk Committee (SARC) would like to thank Kristi Benson for her work preparing the original 2016 species status report for wood bison in the NWT (Indigenous and community knowledge component) and Adam Bathe and John Blyth for their 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.

Thank you also to the Species at Risk Secretariat (Joslyn Oosenbrug) for overseeing the preparation and production of this report as well as to Environment and Climate Change – GNWT for GIS support and map development (Nick Wilson and Erin McHugh).

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, Fort Providence, NT
Jessica Jumbo	Director, Lands & Resources, Dehcho First Nations
Jody Pellissey	Executive Director, Wek'èezhìi Renewable Resources Board, Yellowknife, NT
Joseph Judas	Chair, Wek'èezhìi 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, Behchokò, 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	Wildlife Biologist – Bison, 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, Behchokǫ, 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, Behchokǫ, 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

Alicia 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, Blyth and Bathe 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, Blyth and Bathe 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 Tłı̄ch̄o Ekwò Nàxòèhdee K'è, the Imaryuk guardians on the Inuvik to Tuktoyaktuk Highway, the Ni Hadi Xa program, and the Tłı̄ch̄o Caribou Monitoring Program at Mackay Lake, and in numerous communities across the range of wood bison in the NWT.

SCIENTIFIC KNOWLEDGE COMPONENT

ABOUT THE SPECIES

Names and Classification

Scientific name:	<i>Bison bison athabascae</i>
Common Name (English):	Wood bison (subspecies)
Common name (French):	Bison des bois
Population/subpopulation:	Nahanni population Mackenzie population Greater Wood Buffalo metapopulation [Slave River Lowlands (Grand Detour and Hook Lake subpopulations) and Wood Buffalo National Park (Nyarling River and Little Buffalo subpopulations)] ⁶
Synonym:	<i>Bos bison</i> (Linnaeus 1758)
Class:	Mammalia
Order:	Artiodactyla
Family:	Bovidae (horned ruminants)
Species:	American bison (<i>Bison bison</i>)
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. There are two recognized subspecies of American bison: 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.

⁶ Other populations within the Greater Wood Buffalo metapopulation (Hay Camp, Delta, Garden River, and Wentzel Lake) occur within Alberta and are not considered part of the NWT wood bison population.

The Greater Wood Buffalo metapopulation consists of several intermixing subpopulations that range in the Northwest Territories (Hook Lake, Grand Detour/Little Buffalo⁷, and Nyarling) and Alberta (Hay Camp, Delta, Garden River, and Wentzel Lake; Ball *et al.* 2016; Nishi 2017).

Wood Buffalo National Park spans both the NWT and Alberta. Wood bison subpopulations within the park include Nyarling, Little Buffalo, Hay Camp, Delta, and Garden River. For the purposes of this report, the term 'herd' may be used interchangeably with subpopulation when referring to subpopulations in Wood Buffalo National Park.

The Slave River Lowlands population consists of the Hook Lake and Grand Detour subpopulations and ranges in the lowlands of the Slave River from the southern shore of Great Slave Lake to the NWT/Alberta border. The Hook Lake subpopulation ranges east of the Slave River and the Grand Detour subpopulation occurs on the west side of the river, which bison cross infrequently.

Systematic/Taxonomic Clarifications

There have been a series of taxonomic revisions of American bison. Linnaeus (1758) first classified bison in the genus *Bos* with other cattle-like mammals. Hamilton Smith (in Griffith *et al.* 1827) classified bison to a sub-genus (*Bison*) based on morphological distinctiveness, which Knight (1849) then elevated to the level of genus (COSEWIC 2013). 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. McDonald's revision included the American bison species (*Bison bison*; Linnaeus 1758) with two subspecies: wood bison (*Bison bison athabascae*; Rhoads 1897) and plains bison (*Bison bison bison* Linnaeus 1758). This taxonomic structure has been supported by the American Bison Specialist Group (ABSG; Boyd *et al.* 2010a; Plumb *et al.* 2024).

⁷ Within Wood Buffalo National Park, this subpopulation is referred to as Little Buffalo; outside of the park it is known as Grand Detour.

As research into taxonomy continues, genetic distances and degree of relatedness among 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.

Wood bison subspecies distinction 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 wood bison (Raup 1933). These plains bison also carried tuberculosis and brucellosis, two debilitating diseases for bison (see *Threats and Limiting Factors – Disease*).

In 1963, some purportedly pure wood bison from a remote portion of the range near Nyarling River were rounded up in an attempt to rescue the subspecies. Eighteen were sent north of the Mackenzie River to reintroduce a free-roaming, disease-free population, and after another roundup in 1965, 23 were sent to a 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, Van Zyll de Jong (1986) concluded that all extant wild wood bison have had some genetic introgression (genetic mixing) from plains bison. Van Zyll de Jong (1986) 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

Wood bison are characterized by their enormous size, pronounced shoulder hump, long woolly pelage especially on the head and forequarters, wide muzzle, and short, rounded horns that curve upwards from the sides of the head (van Zyll de Jong *et al.* 1995; Figure 13). In mature animals, the coat is generally dark brown and black (van Zyll de Jong *et al.* 1995). Calves have a reddish-tan coat, which becomes darker after a few months when they start to form their hump.



Figure 13. Wood bison in the Mackenzie Bison Sanctuary. Photo credit: T. Armstrong, GNWT-ECC.

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

In Elk Island National Park, wood bison are on average 17 per cent (%) heavier than plains bison (Olson 2006). Wood bison are darker than plains bison, have a more pronounced forward placed hump, less slope along the back to the rump, and a lighter line extending from the crest of the hump to the hindquarters. 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).

Life Cycle and Reproduction

Age Groups

Bison are often 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 between one and two years old of both sexes with spike-shaped horns of 10-30 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 horns on a male 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.

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 the peak is reached in mid-August (Fuller 1966; Larter 1988; Carbyn and Trottier 1987).

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 sex/age groups 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 group unit during the rut to contain 11-30 animals, including more than one bull.

Bison are polygynous as a species; adult males compete for multiple mating opportunities during the breeding season (Garretson 1927, Soper 1941, Fuller, 1966; Halloran 1968; Lott 1972; Meagher 1973; Banfield 1974; Haugen 1974). Access to females is restricted to certain age classes of males, based on selection for body size and aggressive behaviour in males (Jarman 1983). 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 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 group 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 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 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).

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 sex/age groups 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).

Cow-Calf 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). Before calving, a cow may leave the group, although calving is also known to occur within the group (McHugh 1958; Gogan *et al.* 2010; Larter pers. comm. in Gates *et al.* 2010: 41). Soper (1941) noted from warden testimony that the newborn calves are seldom encountered, probably because cows prefer the seclusion of remote wooded areas to have their young.

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 group to give birth. Short excursions away from group may display a conflict between remaining with the group 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 of 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).

Generation Time

Variation in age structure of females in the population affects generation time (Gross *et al.* 2006). A shift to a greater proportion of older cows in a population causes generation time to lengthen. Gross *et al.* (2006) used the Carey (1993) formula to calculate generation times for U.S. National Park Service plains bison populations. 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, estimated generation length for plains bison at eight years.

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 when demands are greatest (Fortin *et al.* 2003; Hecker *et al.* 2021b). *C. atherodes* is also highly profitable in digestible energy relative to the time required for cropping, chewing and swallowing (Hawley *et al.* 1981b; 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; Bernard *et al.* 1988). 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).

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 muskrat push-ups, which offer a valuable source of high-quality forage that bison can use to supplement their winter diet (Clark *et al.* 2016; 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 produce 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). 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 sedges and grasses 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.

Foraging Habits

Although wood bison are primarily grazers, meaning they eat a variety of grasses and sedges according to their abundance (Reynolds *et al.* 1978; Rivals and Semperebon 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 (e.g. sedges and grasses) and eudicotyledonous (e.g. forbs, herbs and browse items), 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). Bison maximized their energy return by avoiding areas with deep snow (>30 cm) that required intensive cratering, even when highly selected forage was accessible beneath (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 km², the Area of Occupancy of NWT wood bison (refer to Figure 18) is quite restricted at approximately 52,012 km². High-quality wood bison habitat tends to be patchier and more insular (isolated) on the landscape. 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. Expansion of the Mackenzie bison population from the original Falaise-Dieppe-Calais lakes core area required decades to reach important habitats

within 50 km to the north and west. Relatively restricted range and slow colonization could be particularly detrimental to wood bison if any parts of their current range were to deteriorate.

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 (i.e. deer, caribou, moose; Telfer and Kelsall 1979, 1984). Because bison have a harder time moving through snow than wolves, extreme snow depths increase their vulnerability to predation (Telfer and Kelsall 1984).

Van Camp (1975) concluded that undisturbed snow deeper than 50-60 cm in Elk Island National Park 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/cm³ 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 in Saskatchewan, Fortin *et al.* (2003) observed that plains 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). In the winter of 2022, 22 Nahanni wood bison were reported to the Department of Environment and Climate Change of various age and sex classes (cows, calves/yearlings, bulls). Six were reported drowned, four reported dead on the B.C. side of border, and others reported dead or severely ill/emaciated near Fort Liard. Many of the bison showed signs of starvation. Other notable findings included heavy parasite burden, pneumonia, dehydration, and jaundice. This mortality event was attributed to extremely deep snow conditions complicated by a rain on snow event with surface icing (Jutha pers. comm. 2026).

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 body weight distribution, with females much lighter than males (Telfer and Kelsall 1984). This gives females an energetic advantage over males in movement over wind-packed snow. Separate winter and summer ranges allow wider use of habitat and less grazing pressure on forage resources. When snow is deep, bison save energy by decreasing movement rates, making trails, switching to higher biomass sedge meadows and coordinating cratering activities (Van Camp 1975; Sheppard *et al.* 2021). 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 rearranging of groupings is quite common (Fuller 1960). Egerton (1962) doubted there was any fixed dominance hierarchy in wood bison because of the instability of the groupings. Cows with calves, yearlings, and young bulls typically occur in large, mixed sex/age groups. Except for during the breeding season, bison bulls are found alone or in small temporary groups. In their analysis of radio tracking data from Wood Buffalo National Park, Chen and Morley (2005) found bison in had 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.

Intraspecific competition for food resources may be positively related to group size because large groups should deplete food faster than small groups. However, maintaining large groups for winter foraging was profitable for plains bison in Prince Albert National Park in Saskatchewan, probably because larger groups strengthened their selection for the highly nutritious awned sedge (*C. atherodes*), and the cooperative behaviour of other bison 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 age groups, 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, groups fragment and larger groups 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 competition for resources 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 also 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 differ 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 Mackenzie 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

Wolves (*Canis lupus*) are the main predator for wood bison. Black bears (*Ursus americanus*) may also be minor predators (Van Camp 1987; Chowns 1987; Carbyn *et al.* 1993). Bears 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 predation 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.

The three classes of bison most vulnerable to predation are calves, older adult bison, and injured or diseased bison (Fuller 1966; Tessaro 1989; Tessaro *et al.* 1992; Carbyn *et al.* 1993). After high early mortality rates, vulnerability of calves gradually decreases through their first year of life; two- to five-year old bison seem to be relatively immune to predation (Carbyn *et al.* 1993; Larter *et al.* 1994). Animals greater than 11 years of age are also killed at a disproportionately higher rate (14-20.8%) than they occur in the population (10.8%; Carbyn *et al.* 1993). Selectivity for weakened prey may be due to slower avoidance behaviour, decreased awareness, reduced stamina, and possibly visual, olfactory, or behavioural cues (Wild *et al.* 2011). For example, bison suffering from disease-induced lameness would be more vulnerable to wolves (Tessaro 1989; Tessaro *et al.* 1992).

Changes in habitat use, vigilance, foraging, aggregation and movement patterns are typical anti-predator behaviours. Large groups provide less per capita danger, and frequent movements diminish the predictability of prey location (Fortin *et al.* 2009). The main anti-predator tactics used by bison seem to be fighting off its attacker or flight to dense forest (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. Bison have much less chance of success against a wolf attack in the open (Fuller 1960; Carbyn *et al.* 1993).

Wolves focus primarily on groups containing calves, rather than lone bison or bull groups (Carbyn *et al.* 1993). Defense strategies employed by calves included running to their mothers, a group, the nearest bull, the front and centre of a stampeding group, 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 groups (Carbyn and Trottier 1987). Bison not under attack usually pay little attention to the presence of the wolves, except in defence of calves (Fuller 1960; Carbyn and Trottier 1988).

Bison have a harder time moving through snow than do wolves, making them easier for wolves to chase in winter (Telfer and Kelsall 1984; Mech and Peterson 2003). Sheppard *et al.* (2021) found that Ronald Lake bison movements decreased during the first 75 days of winter snow accumulation 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. 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).

Insects and Parasites

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, undernourished 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 do 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). To date, there have been no known winter tick infestations in wood bison in the NWT (Jutha pers. comm. 2026). Bison and deer are species that share a long history with winter tick and seem to have evolved a grooming behaviour intended to remove these ectoparasites before they blood-feed (Mooring 2024). 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

Present-day interactions with humans include hunting and collisions with vehicles. During historic times, large scale movements of bison could be controlled by Indigenous people by alternately greening and burning traditional hunting grounds (Pyne 1997).

Wood bison are also subjects of biological study and viewing is generally enjoyed by the 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

Historical Distribution

The two subspecies of North American bison diverged approximately 5,000 years ago (Wilson 1969; McDonald 1981; van Zyll de Jong 1993). The historical 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 (Figure 14; Hind 1860; Allen 1877a; Rhoads 1897; Van Zyll de Jong 1986; Gates *et al.* 1992a; Lotenberg 1996; Stephenson *et al.* 2001).

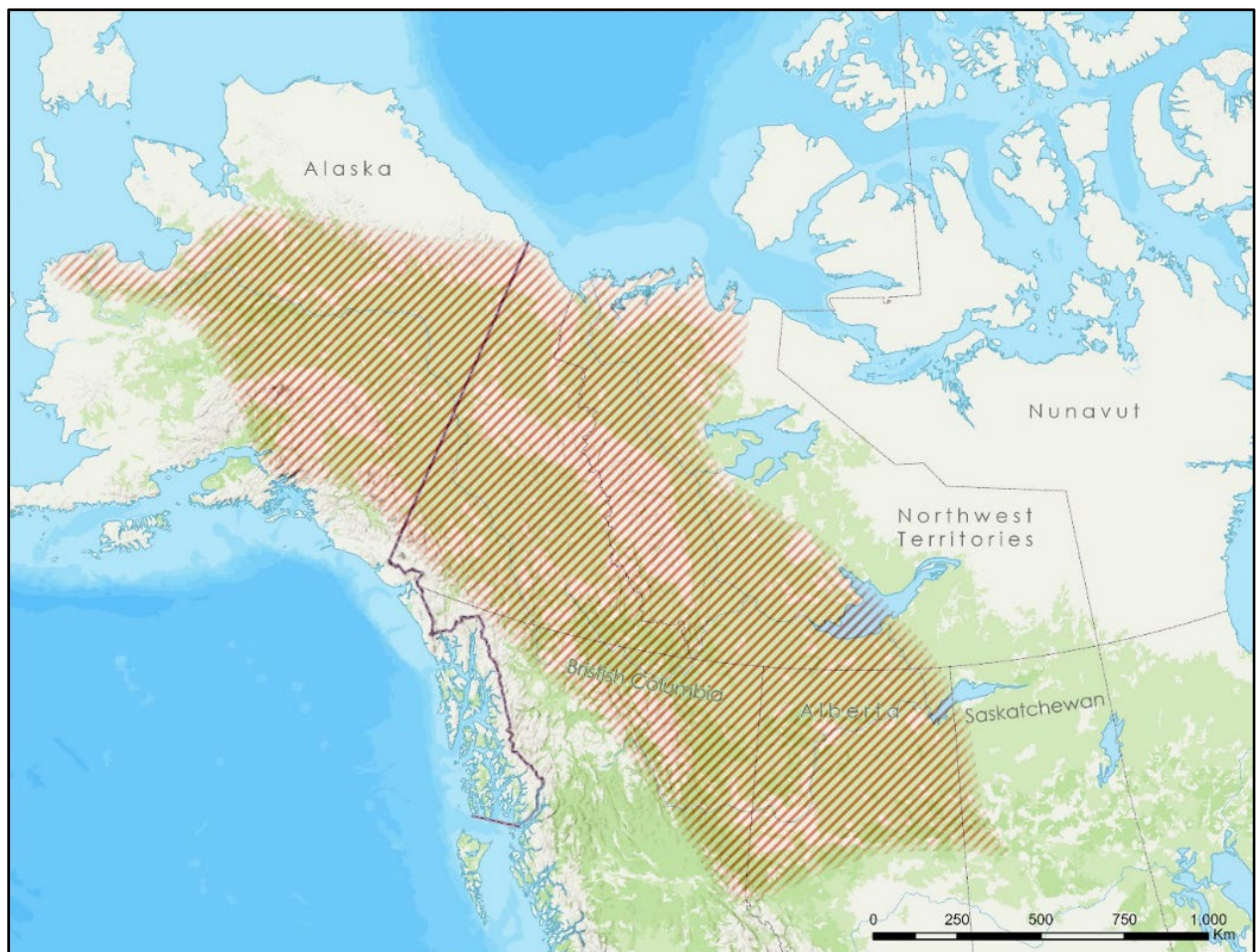


Figure 14. Estimated continental distribution of wood bison over the last 5,000 years, with present day boreal forest represented in green. Map by B. Fournier, based on Stephenson *et al.* (2001).

Up to the 1500s, wood bison occurred across much of the western NWT and possibly as far north as the Arctic coast (Harington 1990). Based on oral history, skeletal remains and radiometric data, 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). However, through the 1800 and 1900s, population declines and local extirpations began to rapidly contract wood bison distribution (Gates *et al.* 2001a; Table 2). Contributing factors to dramatic and rapid declines resulting in extirpations included commercial hunting, indiscriminate slaughter for sport and recreation, as well as disease and competition due to introduced livestock (horses, cattle, sheep; Gates *et al.* 2010).

Table 2. Wood bison sequence of disappearance from historical distribution. For further details, refer to Appendix A4 – Search Effort.

Area	Estimated date of extirpation	Reference
Middle Peace River	1870	Butler 1873
Grande Prairie district	1870s	Dawson 1881
Slave River Lowlands (east of the Slave River)	1880	Radford 1911
West of Great Slave Lake	early 1880s	Blanchet 1926
South shore of Great Slave Lake	early 1880s	Blanchet 1926
Clearwater River (Alberta and Saskatchewan)	1888	Seton 1927
Upper Hay River	1893	McLeod 1908
Lower Athabasca River, Alberta	1896	Jarvis 1897
South of Lower Peace River, Alberta	1898	Radford 1911
Liard-Nahanni rivers	late 1890s	Rhoads 1897
Fort St. John district, B.C.	1906	MacGregor 1952
East of Little Buffalo River	1911-1916	Mulloy 1912; Camsell 1917
Lower Mackenzie River	undetermined	Stephenson <i>et al.</i> 2001
Yukon	undetermined	Lotenberg 1996
Alaska	undetermined	Stephenson <i>et al.</i> 2001

Continental Distribution

The current distribution of wood bison in North America has been greatly influenced by conservation efforts including the establishment of Wood Buffalo National Park and the re-establishment or reintroduction of bison to portions of their historic range (Gates *et al.* 2010; Nishi 2017). All populations presently occur within, or have originated from, the Greater Wood Buffalo metapopulation.

As noted earlier, the Greater Wood Buffalo metapopulation consists of several intermixing subpopulations of wood bison that range in the NWT and Alberta. In addition, several other populations have been re-established. The current continental distribution of all free-roaming populations of wood bison, as well as the captive population at Elk Island National Park, are shown below in Figure 15. Tuberculosis- and brucellosis-free wood bison from the Nyarling population within Wood Buffalo National Park were translocated to the Mackenzie Bison Sanctuary in 1963, and to Elk Island National Park in 1965 (Yukon Department of Renewable Resources 1998; Gates *et al.* 2001b). The Nahanni population was established near Nahanni Butte and Fort Liard in 1980 and augmented with additional bison in 1989 and 1998 (Larter and Allaire 2007; ENR 2019). Elk Island National Park wood bison have contributed to all reintroduced, free-ranging wood bison populations in North America, except the Mackenzie population (Gates *et al.* 2001b).

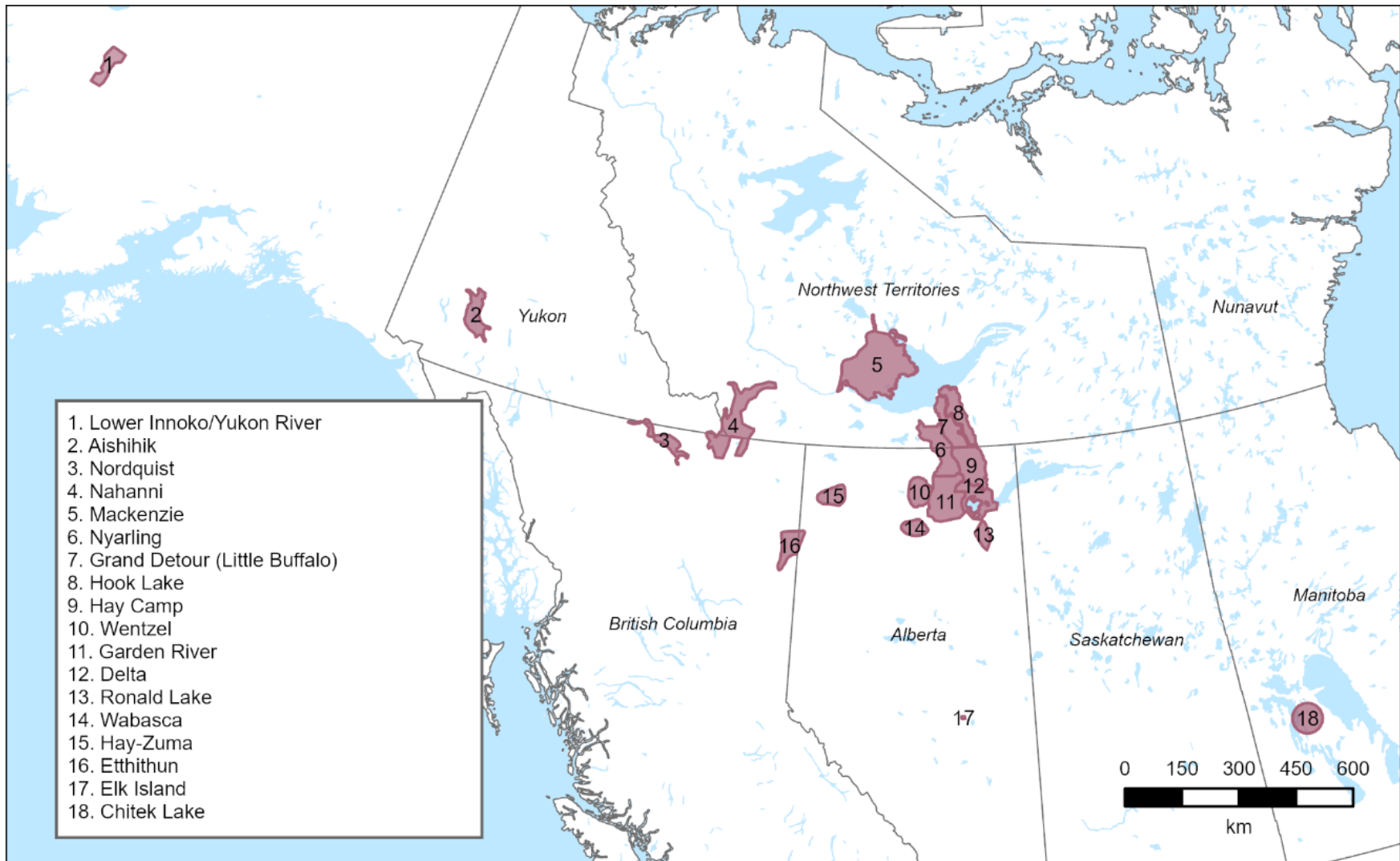


Figure 15. Current continental distribution of free-ranging wood bison in North America including wood bison in Elk Island National Park (fully fenced national park). Map by E. McHugh, GNWT-ECC.

There are eight reintroduced, free-ranging wood bison populations in North America, including: the Lower Innoko/Yukon River population in Alaska (established in 2015; McFarland *et al.* 2018), the Aishihik population in the Yukon (established in 1988; Jung *et al.* 2012; Miller *et al.* 2023), the Nordquist population in British Columbia (established 1995; Rowe 2007; Harper *et al.* 2000; Thiessen 2010), the Nahanni population that occurs in the southern NWT and northern British Columbia (established 1980; Larter and Allaire 2007; ENR 2019), the Mackenzie population in the NWT (established 1963; Novakowski 1963b), the Etthithun population that occurs near Fort St. John in British Columbia and Alberta (established 1999; Rowe and Backmeyer 2006; Nishi 2017; Lewis and Das Gupta 2021), the Hay-Zama population in Alberta (established 1993; Nishi 2017), and the Chitek population in Manitoba (established 1991; Gates *et al.* 2001a; Stock 2005).

To date, seven Canadian reintroductions have been carried out in the NWT, Yukon, British Columbia, Alberta and Manitoba (Table 3). Between 2006 to 2020, wood bison were also translocated to the Republic of Sakha (Yakutia), Russia, in the Sinyaya River basin (Shadrina *et al.* 2022).

Table 3. Summary of reintroduced, free-ranging wood bison populations, listed in chronological order of reintroduction.

Population (Location)	Year Established	Number Transferred	Source of Stock	Release Area	Reference
Mackenzie (NWT)	1963	18	Nyarling River	North of the Mackenzie River near Fort Providence, NWT	Novakowski 1963b
Nahanni (NWT and British Columbia)	1980	28	Elk Island National Park ¹	Near Nahanni Butte and Fort Liard, NWT	Larter and Allaire 2007; ENR 2019
	1989	12			
	1998	59			
Aishihik (Yukon)	1988 to 1993	170	Elk Island National Park ¹ (primarily)	Nestling River Valley, Yukon	Jung <i>et al.</i> 2012; Miller <i>et al.</i> 2023
Chitek Lake (Manitoba)	1991 ³	13	Elk Island National Park ¹	North of the Waterhen Wood Bison Ranch; Chitek Lake (located between Lake Winnipeg and Lake Winnipegosis)	Gates <i>et al.</i> 2001b; Stock 2005
	1996	9			

Population (Location)	Year Established	Number Transferred	Source of Stock	Release Area	Reference
Hay-Zama (Alberta)	1993 ³	49	Elk Island National Park ¹	Habay in northwestern Alberta in the Hay-Zama Lakes area, AB	Nishi 2017
Nordquist (British Columbia and Yukon)	1995	49	Elk Island National Park ¹	Aline Lake on Nordquist Flats, BC	Harper <i>et al.</i> 2000; Rowe 2007; Thiessen 2010
Etthithun (Alberta and British Columbia)	2003 ⁴	43	Elk Island National Park ¹	Etthithun Lake area north of Fort St. John, BC	Rowe and Backmeyer 2006; Nishi 2017; Harper <i>et al.</i> 2000; Lewis and Das Gupta 2021
Sinyaya River basin (Yakutia, Russia)	2006 to 2020	4 groups of 30 wood bison	Elk Island National Park ¹	Lenskie Stolby National Park, Republic of Sakha (Central Yakutia), Russia	Safronov <i>et al.</i> 2012; Shadrina <i>et al.</i> 2022
Lower Innoko/ Yukon River (Alaska)	2015 ⁵	130	Elk Island National Park ¹	Lower Yukon River area near the community of Shagleuk on the Innoko River	McFarland <i>et al.</i> 2018

¹ In 1965, Elk Island National Park was established from 22 wood bison from the Nyarling River population (Yukon Department of Renewable Resources 1998; Gates *et al.* 2010)

² In 1987, 29 wood bison were transported from EINP to a holding corral. The Hay-Zama population became free-ranging in 1993 (Nishi 2017).

³ In 1991, 13 wood bison were released at Chitek Lake (located between Lake Winnipeg and Lake Winnipegosis). These animals were raised in captivity for commercial purposes at the Skownan (Waterhen) Wood Bison Ranch in Manitoba. The population was supplemented with an additional nine bison in 1996 (Stock 2005).

⁴ Translocated Etthithun bison were initially held in a paddock near Strom Lake; they became free-ranging in 2003 (Nishi 2017).

⁵ Lower Innoko/Yukon River wood bison were cared for in captivity in Portage Alaska for more than a decade prior to release (Alaska Department of Fish and Game 2015; McFarland *et al.* 2018).

NWT Distribution

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 16).

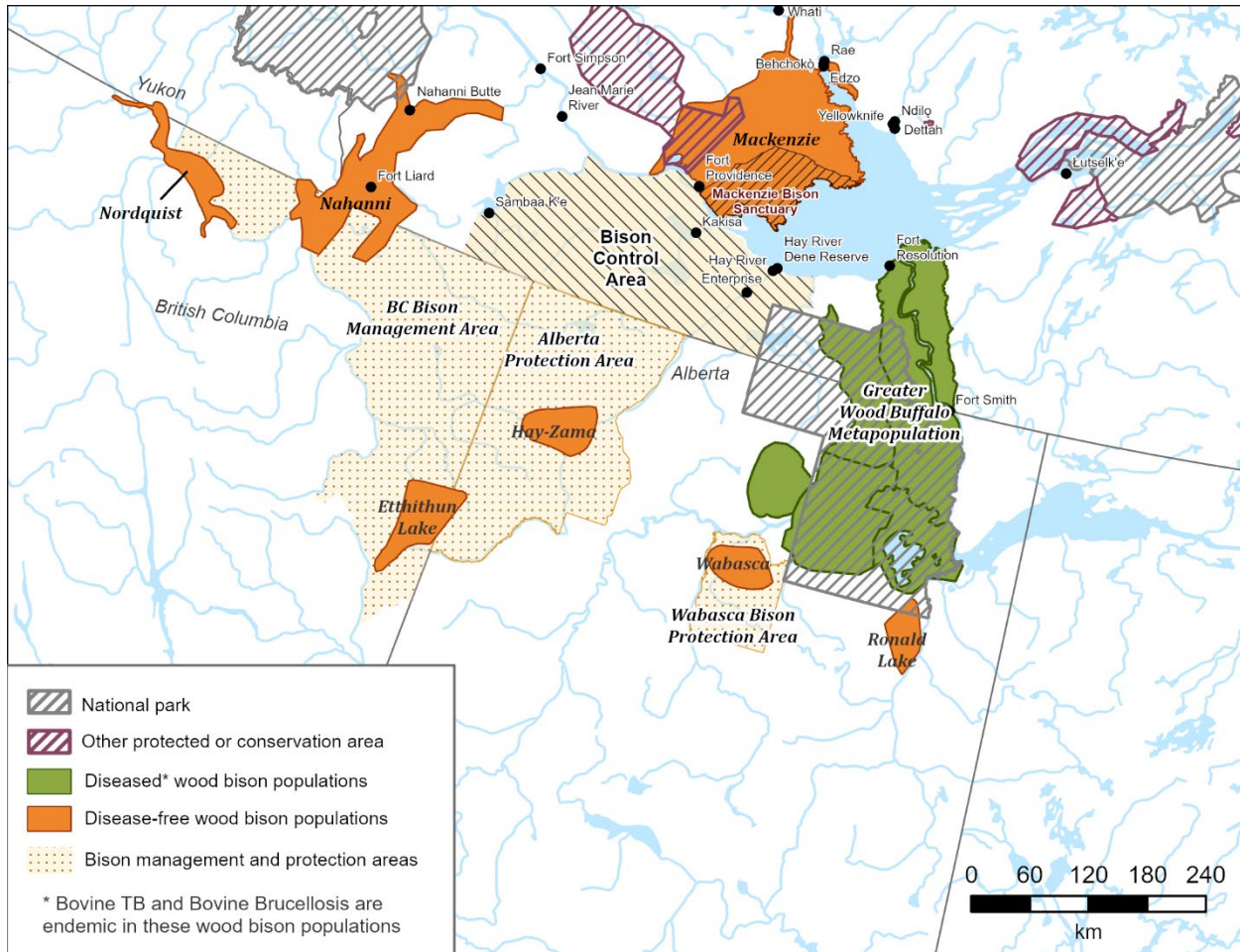


Figure 16. NWT wood bison distribution and neighbouring populations. Wood bison have also been observed outside core ranges. Map by E. McHugh, GNWT-ECC.

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 (see Figure 16). 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 populations. 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).

The Greater Wood Buffalo metapopulation (Figure 17) includes three subpopulations that primarily range into the NWT: Nyarling, Grand Detour/Little Buffalo⁸, and Hook Lake. Most of the Nyarling subpopulation occurs in the NWT within the boundaries of Wood Buffalo National Park. The other two subpopulations 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).

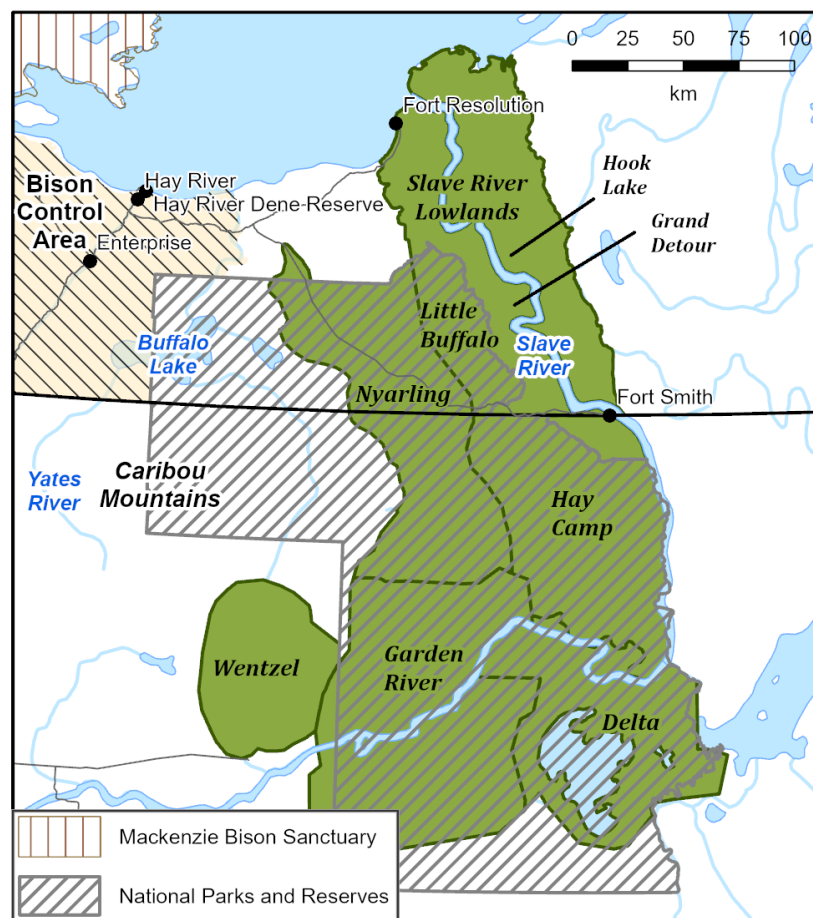


Figure 17. Distribution of wood bison subpopulations of the Greater Wood Buffalo metapopulation. Map by E. McHugh, GNWT-ECC.

⁸ Within Wood Buffalo National Park, this subpopulation is referred to as Little Buffalo; outside of the park it is known as Grand Detour.

The Hook Lake subpopulation occurs east of the Slave River and is outside of the park, while the subpopulation 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).

Extent of Occurrence

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.’ The EO for wood bison is approximately 209,010 km², calculated using a single minimum convex polygon around the range of all three NWT populations (Mackenzie, Nahanni, and the portion of the Greater Wood Buffalo metapopulation that occurs in the NWT (Figure 18). This approach varies from the 2016 wood bison status report (SARC 2016), which calculated the EO using only the portion of the range that occurred in the NWT. Taking this difference into account, the EO for NWT wood bison has increased since 2016 due to observations of Mackenzie bison along the Tłı̄ch̄o Highway (Highway 9) toward Whati/Lac La Martre.

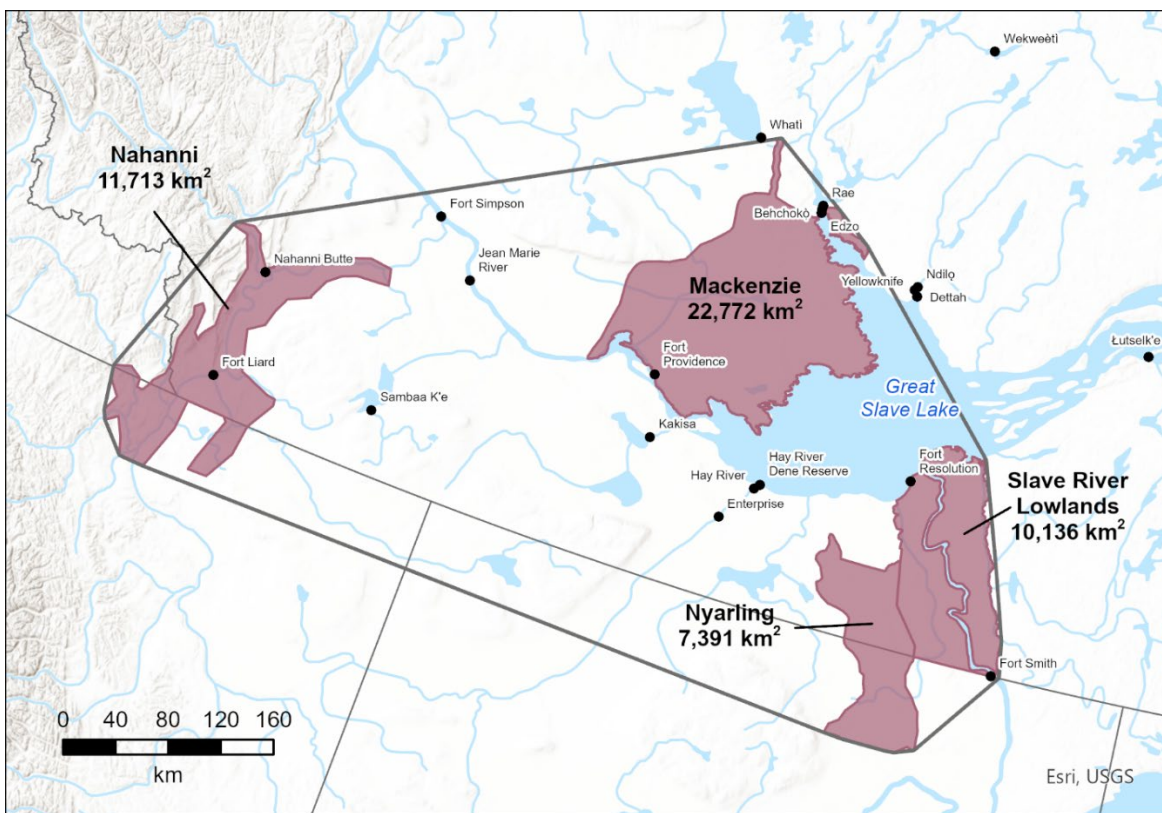


Figure 18. Extent of Occurrence (EO) and Area of Occupancy (AO) for NWT wood bison, based on the geographic distribution of the entire Nahanni and Mackenzie wood bison populations and the portion of the Greater Wood Buffalo metapopulation occurring at least partly in the NWT (Slave River Lowlands and Nyarling subpopulations). Map by E. McHugh, GNWT-ECC.

Area of Occupancy

Area of Occupancy (AO) is defined as 'the area within the extent of occurrence that is occupied by a species, excluding cases of vagrancy' (SARC 2022). Area of occupancy reflects the fact that the extent of occurrence may contain unsuitable or unoccupied habitats. The area of occupancy for NWT wood bison is approximately 52,012 km². This was calculated by summing the area totals of polygons drawn around each of the three NWT wood bison populations (Figure 18). The AO for NWT wood bison has increased since 2016 (SARC 2016), reflecting observations of Mackenzie bison along the Tłchq Highway (Highway 9) toward Whatì/Lac La Martre. There has also been a small increase to the Greater Wood Buffalo metapopulation range in the NWT.

The Index of Area of Occupancy (IAO) is '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).' The IAO of NWT wood bison is approximately 56,676 km².

Locations

SARC defines 'location' as '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 (SARC 2022).

The most serious plausible threats to wood bison in the NWT are diseases (anthrax, tuberculosis, brucellosis) and stochastic events like drowning (see *Threats and Limiting Factors*). Because wood bison populations in the NWT are geographically isolated from one another, it is unlikely that a single threatening event would rapidly affect all individuals. However, it is plausible that a single threatening event could impact a whole population. Therefore, for wood bison there are three locations in the NWT including the Nahanni population, Mackenzie population and the Greater Wood Buffalo metapopulation (including all subpopulations in the Slave River Lowlands and Wood Buffalo National Park).

Search Effort

The ranges of wood bison populations in the NWT are well-defined. Regular aerial surveys are conducted for all three NWT bison populations (including surveys of the Grand Detour and Hook Lake subpopulations by the GNWT and surveys of the Nyarling and Little Buffalo subpopulations by Parks Canada). In addition, the Bison Control Area south of the Mackenzie River to the Alberta border is searched from the ground and air several times a year for the purpose of locating and removing bison (Greig and Cox 2012). Widespread searches of the Slave River

Lowlands and the Mackenzie bison range are also carried out every summer for anthrax surveillance (Dragon and Elkin 2001; Elkin *et al.* 2020).

Growth of the Mackenzie population was documented by total count surveys carried out every year. However, as the population became larger and more dispersed, the study area was stratified into high, medium and low density units, with the main meadows where bison concentrated also covered by total counts (Gates *et al.* 1991). Since 2012, Mackenzie surveys have used distance sampling (Armstrong pers. comm. 2025b). 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. 2025b). Since it opened in the winter of 2021-2022, the Tłı̄ch̄o Highway (NWT Highway 9) towards Lac La Martre has also been patrolled five to seven times per week by Tłı̄ch̄o Highway Monitors who record bison and other wildlife observations (TG and Firelight 2025a). Reports of bison occurrences in 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. 2025b).

The ranges of the Grand Detour and Hook Lake subpopulations are fairly well-established 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. *in* SARC 2016: 73).

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).

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

Distribution Trends

Historically, wood bison in the NWT and adjacent areas were likely part of one extensive metapopulation (Roe 1970; Reynolds *et al.* 2003). Large scale changes to the historical distribution of wood bison including local extirpations were discussed earlier in *Historical Distribution*.

Bison distribution, range expansion and dispersal in northern Canada are strongly influenced by the distribution of meadows and adjacent willow/aspen meadow complexes (Gates *et al.* 2001a). In the Greater Wood Buffalo metapopulation, declining populations through the 19th century

coincided with range retractions to a core area north of the Peace River and west of the Little Buffalo and Salt rivers (Seibert 1925). In the NWT, the Nyarling subpopulation of the Greater Wood Buffalo metapopulation has persisted in the same area (Reynolds and Hawley 1987). 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. By 1949, it appeared the Greater Wood Buffalo metapopulation had reached the limits of its current range, bounded by the Precambrian Shield and Great Slave Lake (Fuller 1950). Westward range expansion is currently limited by disease control measures in the NWT and Alberta (i.e., Bison Control Area; see *Threats and Limiting Factors – Disease and Disease Management*).

Increasing population numbers, wildfire activity, and the Tł̨ch̨ Highway have contributed to the expansion of the Mackenzie wood bison range. Since the reintroduction of wood bison to the Mackenzie Bison Sanctuary in 1963, the range of the Mackenzie population has expanded to the west and north (Figure 19; Reynolds and Hawley 1987; Korosi *et al.* 2017). Shortly after their release, the population was primarily found around Falaise Lake (Gates and Larter 1990). In 1975, the Mackenzie bison population was located entirely within the boundary of the sanctuary (Korosi *et al.* 2017). In 1980, bison moved northwest of Highway 3 and became well established near Mink Lake (Gates and Larter 1990; Korosi *et al.* 2017). By 1987, bison had also expanded to the Mills Lake area closer to Fort Providence (Gates and Larter 1990; MBWG 2018).

The 1994 fire north of Lonely Bay, on the west side of Great Slave Lake, facilitated bison 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 (Chowns 1997). The fire enhanced movements from core areas in the south and facilitated further range expansion northward into unoccupied habitat (Chowns pers. comm. 2025).

By 2008, there was a greater number of bison along the margins and to the west and north the sanctuary, compared to the core area of the sanctuary (Korosi *et al.* 2017). By 2012, there were no bison observed at Falaise Lake (Korosi *et al.* 2017). Bison also moved east to cross Frank Channel and were observed between Behchok̨ and Yellowknife, mostly along Highway 3 or the shore of the North Arm of Great Slave Lake (MBWG 2018). Individuals have been found near the Yellowknife city limits, but observations within 40 km of Yellowknife are not common.

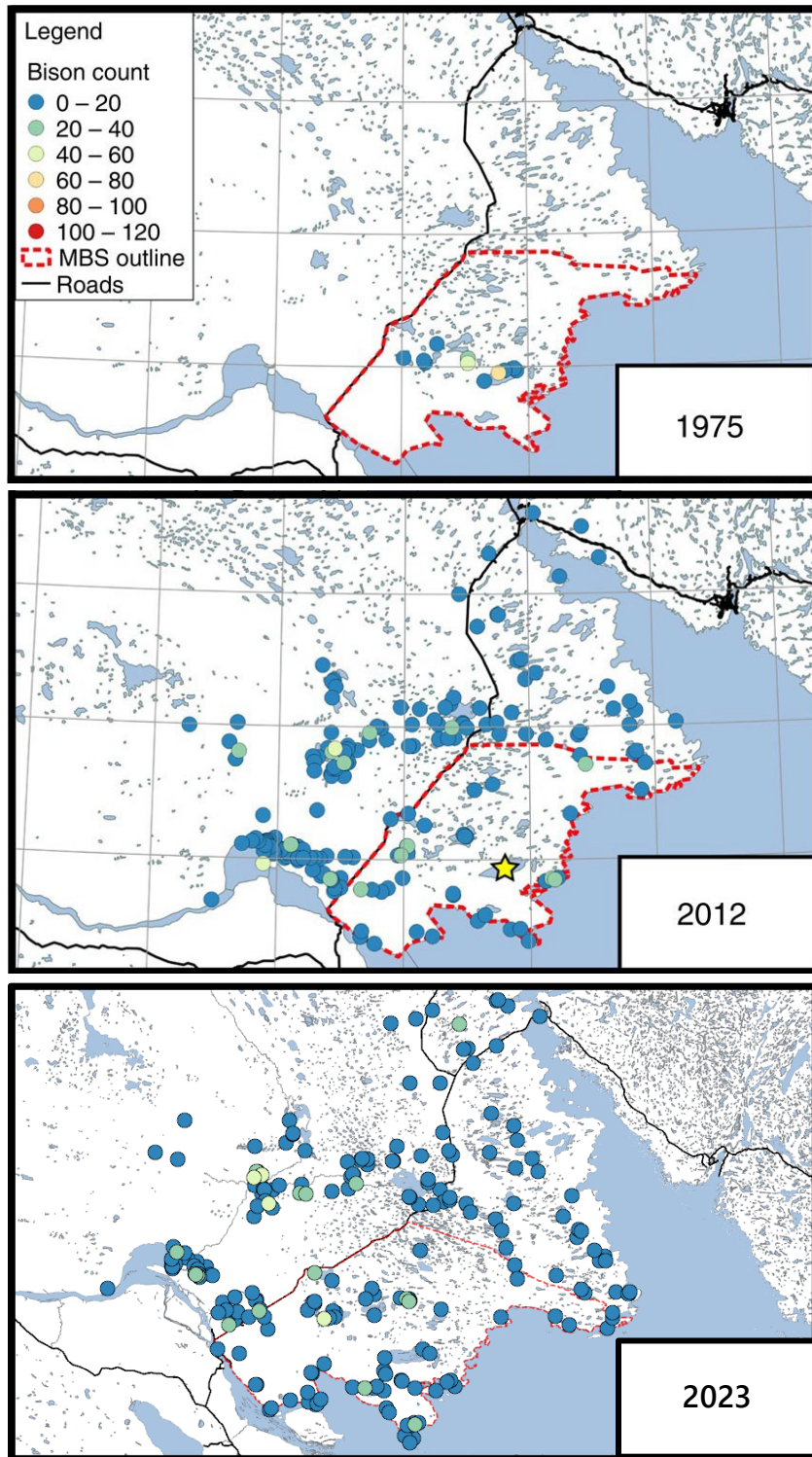


Figure 19. Spatial distribution of the Mackenzie wood bison population in 1975 compared to 2023. Location and count data is based on aerial population surveys conducted by the GNWT. The yellow star denotes the location of Falaise Lake. Geospatial data for basemap from Natural Resources Canada CanVec database. Figures reproduced with permission from Korosi *et al.* (2017).

The Tł̨ch̨ Highway (Highway 9) connecting Whatì to Highway 3 and to the national highway system by all-season road provides ready access to new bison habitat (GNWT 2025). Wildlife monitoring and distribution data show that bison are using the highway as a corridor and are moving north (TG and Firelight 2025a). Although, bison are more commonly observed along the first 40 km of the Tł̨ch̨ Highway, they have also been observed along the northern end of the highway and have appeared approximately 80-90 km down the highway at the Lac La Martre River (Behrens pers. comm. 2024; TG and Firelight 2025a).

The Nahanni population inhabits an area of approximately 12,000 km² in the southwestern NWT, southeastern Yukon and northeastern British Columbia. Since its establishment in 1980, the Nahanni population has increased in the amount of range it occupies (Larter 2021). Before 2014, Nahanni bison were rarely seen north and east of Blackstone River; however, during the summer of 2014, more than 60 animals followed the Liard Highway right-of-way, and remained in the area up to the Poplar River bridge (at km 220 on Highway 7). While there have been other movements northeast along the Liard Highway, there has been no increase in the size of the Nahanni range in the NWT between 2016 and 2026 (see Figure 18).

Movements

Wood bison movements are influenced by their nomadic foraging strategy, where they tend to wander based on grazing conditions (Soper 1941; Gates *et al.* 2010). Bison generally remain in core areas but also have seasonal preferences. Movement and dispersal patterns are influenced by population density and environmental factors, as well as habitat changes including wildfires and roads (Gates *et al.* 2001a).

In Wood Buffalo National Park, the maximum distance traveled by males in a year was an estimated 125 km (mean 46, median 52) and the maximum distance traveled by females was 106 km (mean 44, median 49; APFRAN 1998), although maximum dispersal distance is estimated to be closer to 170 km (Gates *et al.* 2001a). Adult male bison have been shown to disperse independent of density and are usually the first to move to an area during a range expansion (Gates and Larter 1990; Larter and Gates 1994; Larter *et al.* 2000; Gates *et al.* 2001a).

Some movements may be stimulated by predation, availability of forage, adverse snow/ice conditions or flooding. Carbyn *et al.* (1993) tracked bison 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). Under deep snow conditions in the winter of 1996-97, Peacock (1997) documented 1,100 bison moving out of the park in search of food. 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, Saskatchewan, plains 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; nine bison were killed and tested negative for tuberculosis and brucellosis (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 it plays less of a role in maintaining lowland meadow habitat than sporadic flooding, wildfire is also a major factor influencing bison movement (Quinlan *et al.* 2003). Bison are known to prefer recently burned areas and are one of the first species to enter an area after a fire (Knapp *et al.* 1999; Gates *et al.* 2001a). Along the Tłı̨ch̨o Highway (Highway 9), higher numbers of bison are observed along the southern part of the highway, an area that experienced intense wildfires in 2014, compared with the northern portion of the highway (TG and Firelight 2025a). Fire may improve foraging habitat for bison, and, in some areas of the NWT, prescribed burning has been used as a management tool for habitat enhancement (Chowns *et al.* 1997; Gates *et al.* 2010). Prescribed and naturally occurring fires could be an important factor in altering the distribution of bison on the landscape (Gates *et al.* 2001a).

Although bison are capable of swimming across lakes and rivers, they are susceptible to drowning (Larter *et al.* 2003). River crossings occur where banks are low; steep banks and wide rivers impede bison movement, and they avoid crossing large expanses of water (Gates *et al.* 2001a). Drowning events have been recorded in Wood Buffalo National Park, the Mackenzie Bison Sanctuary, and in the Nahanni population (Larter *et al.* 2003). The Mackenzie River is a significant barrier because it is wide, but bison have crossed near the Deh Cho Bridge and near Big Island (Gates *et al.* 2001a). In the Slave River Lowlands, bison rarely cross the Slave River; however, they have crossed from time to time (Calef 1976; Calef and Van Camp 1987; Gates *et al.* 2001a; SRLWG 2025, unpubl. meeting notes). In contrast, the Nahanni bison regularly cross the narrower Liard and South Nahanni rivers year-round, although they prefer to cross when the rivers are ice-free (Larter *et al.* 2003; Larter and Allaire 2007; Thomas *et al.* 2022a).

Bison frequently travel along cutlines and highway rights-of-way which are used as habitat and expansion corridors, but they can make bison vulnerable to collisions (ENR 2010). Information collected by the GNWT 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. During the summer 2014, more than 60 bison from the Nahanni population followed the Liard Highway right-of-way to the Poplar River bridge, approximately 30 km before the juncture with Highway 1 (Mackenzie Highway; Larter 2021). In 2020, a similar number of bison followed the Liard Highway all the way to the Mackenzie Highway, then followed it about 30 km north

towards the Liard River ferry crossing near Fort Simpson (Larter 2021). Mackenzie bison have also been moving towards Yellowknife along Highway 3 and north from Behchokq, along Highway 9 (Tłchq Highway) (Korosi *et al.* 2017; TG and Firelight 2025a).

Habitat Requirements

As the largest land mammal in North America, wood bison require plenty of habitat for foraging, traveling and bedding (Gates *et al.* 2010; Hecker *et al.* 2023). Mackenzie bison have home ranges between 179 to 1,442 km², which is 4 to 100 times larger than those of other North American ungulates (Larter and Gates 1990). Adult females have larger median home ranges size (1,240.5 km²) compared to young-of-the-year (712.2 km²), immature males (706.0 km²), and adult males (younger, 434.5 km, and older, 170.1 km²; Larter and Gates 1994). Based on the size of bison (body mass), the home range for wood bison has been calculated at 1,030 km² (Swihart *et al.* 1988; Larter and Gates 1990).

Wood bison occupy wetland meadow habitats interspersed with forest stands. 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). These dense, moderately impermeable soils flood easily and produce a high biomass of fine fuel loads that can burn frequently, two processes that allow forage preferred by bison (sedges and grasses) to have a competitive advantage over woody plants (Raup 1933; Moss 1953).

Sedges and grasses provide the energy wood bison to meet their food requirements, especially in winter, in the form of carbohydrates (Fortin *et al.* 2003; Hecker *et al.* 2021b). 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). 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).

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 when the substrate is frozen (Campbell and Hinks 1983; Larter 1988; Larter and Gates 1991; Fortin *et al.* 2003; Strong and Gates 2009; Belanger *et al.* 2020; Hecker *et al.* 2021b). Drier sites contain green forage that is most digestible in spring and summer (Larter 1988).

Sedges (*Carex spp.*) were found to be the main source of food for wood bison in the Nahanni area (Larter and Allaire 2007), Slave River Lowlands (Reynolds *et al.* 1978), and Wood Buffalo National Park (Fuller 1966). In the Mackenzie Bison Sanctuary, sedges dominate the winter diet, while

intake of grasses and shrubs increased dramatically during spring green-up (Larter and Gates 1991). Nahanni bison may also consume large amounts of horsetails, particularly in early winter (*Equisetum spp.*; Larter and Allaire 2007). This dietary difference likely reflects forage availability (Larter and Allaire 2007).

Bison most prefer wheat/slough sedge (*Carex atherodes*) and reedgrass, especially bluejoint (*Calamagrostis canadensis*); willows (*Salix spp.*) are also preferred by wood bison at certain times of the year (Reynolds *et al.* 1978; Larter and Gates 1990; Larter and Gates 1991; Reynolds *et al.* 2003; Gogan *et al.* 2010). *C. atherodes* thrives best in areas that are seasonally flooded with shallow water, and neutral to slightly alkaline pH (Jeglum 1971). Reedgrasses are also associated with moist, fertile conditions.

By late August, forested habitats in the Mackenzie Bison Sanctuary provide 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, while forage quantity and quality became more homogeneous during autumn when bison dispersed amongst all habitats (Larter and Gates 1991).

Larter (1988) found that bison used upland habitats more frequently and consumed a greater diversity of forage during the growing season. 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), forest 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).

Bison will select recently burned habitat (less than one year) to access the higher quality forage and nutritional value of new growth (Fuhlendorf *et al.* 2009; Forney and Peacock 2024). Use of burn areas is influenced by the extent a burn; bison prefer smaller burn patches which may be easier for herbivores to maintain an early successional plant community of high nutritional value through grazing (Allred *et al.* 2011; Forney and Peacock 2024). A shifting mosaic of disturbance patches across the landscape is created through this ecological interaction of fire and grazing (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).

Bison require some forest cover to escape predators, as shelter from predation and adverse weather conditions, and for resting (Reynolds *et al.* 1978). During cold temperatures and high

windchill, Fuller (1966) observed that bison split into smaller groups and moved into forested cover. Winter foraging often occurs in protected meadows or sheltered feeding areas where snow depth, density, and hardness are less than in windswept open sites (Raup 1933; Reynolds *et al.* 1978). In the sum snow-free seasons, forests provide shade (Soper 1941; Dancose *et al.* 2011).

Hecker *et al.* (2023) found uplands to be important to bison for traveling, bedding and wallowing. 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).

Wood bison often give birth in woodlands that provide cover for calving (Calef and Van Camp 1987). A pregnant cow may leave the herd to give birth in isolation or calve in the midst of a larger group (McHugh 1958; Larter pers. comm. *in* Gates *et al.* 2010: 41). Ronald Lake bison in Alberta move seasonally out of their core range into upland meadows to calve (Buitrago Gutierrez 2024); however, seasonal movements at this scale have never been reported in the NWT.

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 preferred by bison. 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 spruce.

Bison strongly selected forage-rich graminoid-dominated wetlands (fens) during winter, but less so in summer when there were potential trade-offs with poor footing and biting flies (Thomas *et al.* 2021). In summer, bison selected alternative sources of forage such as herbaceous, shrubby

and fluvial habitats (i.e. riverine islands and gravel bars). The observed association with fluvial habitat may be an adaptation to low forage availability on this landscape (Thomas *et al.* 2021).

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 14, the historical range of wood bison included Lac La Martre (Richardson 1829) and bison are now re-entering this region, particularly along the Tłı̄chǫ Highway (Highway 9), a 97 km all-season road that connects Highway 3 near Behchokǫ to the community of Whatı̄ (Behrens pers. comm. 2024; TG and Firelight 2025a). The highway right-of-way has been severely impacted by wildfires, particularly in the last 10-15 years (TG and Firelight 2025a), which may be favourable to wood bison.

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 km², but most of it is not actually available to bison because of current disease control actions.

The Tetcela basin is bounded by the Ram and Nahanni plateaus on the west and Nahanni Range to the east and may provide potential bison habitat for the Nahanni population (Figure 20). Crosbie (1978) described the Tetcela basin as an extensive lowland, so flat that its central wetlands drain both southward and northward. 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).

Perhaps the largest tract of potential habitat lies within the 12,000 km² former basin of Glacial Lake Mackenzie (Figures 20 and 21), 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 the 'Ramparts' near Fort Good Hope. As with other glacial lakes, dense soils in the former basin and its delta provide favourable conditions for sedge-grass vegetation (Porsild and Cody 1980) and the floodplain and wet sedge fens along the Mackenzie River resemble habitat found in current wood bison range (Ecosystem Classification Group 2007, 2010; Smith 2011). However, dense forest, extensive bogs, and mountains are barriers to reoccupation by existing wood bison populations.

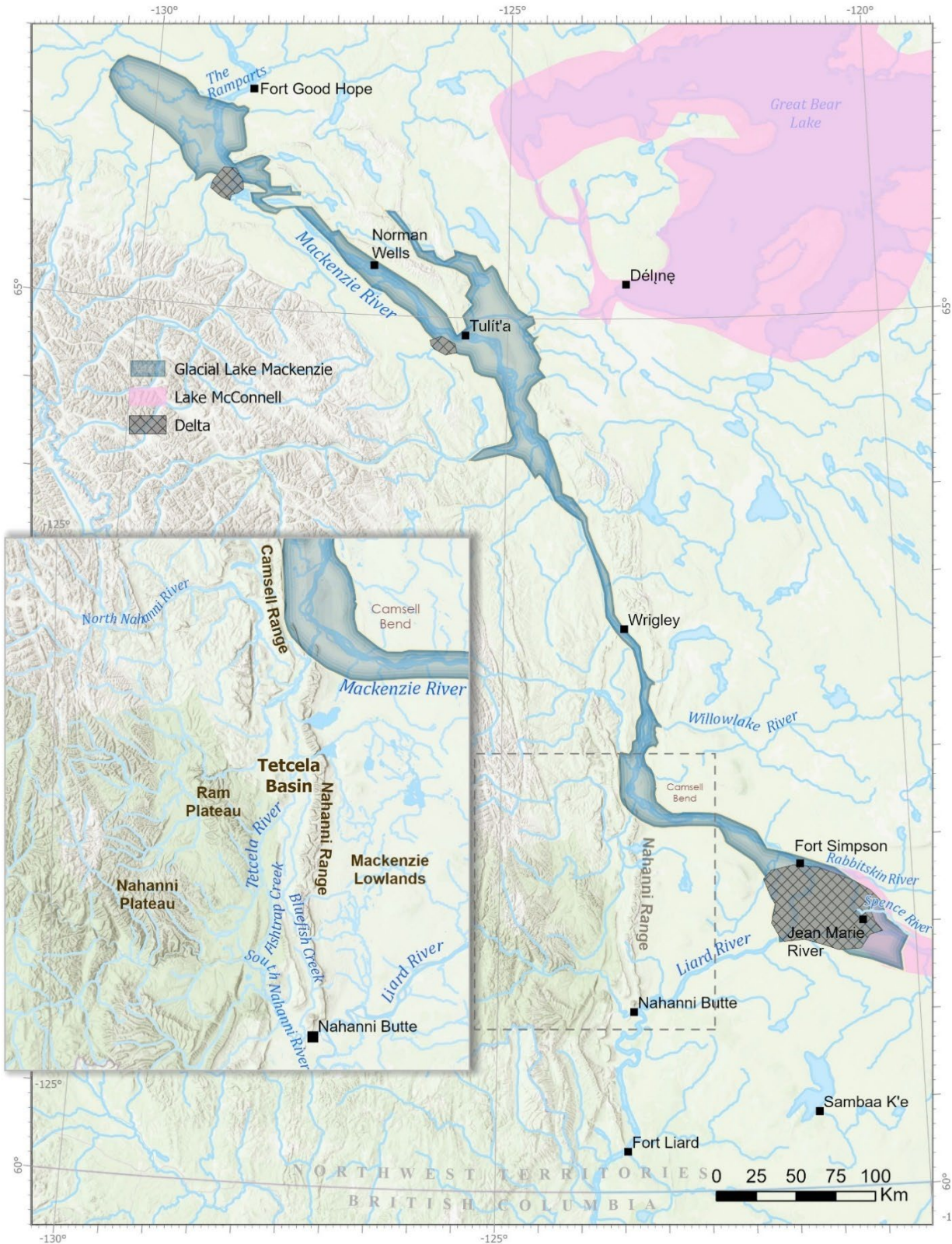


Figure 20. Estimated extent of former Glacial Lake Mackenzie. Map by B. Fournier, based on Smith (1992) and Crosbie (1978).



Figure 21. Lacustrine bench within Glacial Lake Mackenzie. Photo credit: T. Chowns.

None of the potential habitats listed above have ever been evaluated for suitability. 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. Ancestors of modern bison (steppe 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 Tłı̨ch̨ Government has expressed a desire to prevent bison from crossing the Lac La Martre River (Behrens pers. comm. 2024; TG and Firelight 2025a and b).

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 (Knapp *et al.* 1999). When moisture levels are most favourable, sedge meadows provide the greatest volume of high-quality bison forage; however, sedge meadows and grasslands in wood bison range are inherently unstable (Carbyn *et al.* 1998). These early stages of vegetation succession must be revitalized and maintained by frequent cycles of floods and drawdowns, and fires (Singer and Lee 2021). Prolonged flooding or prolonged absence of floods can be detrimental to wood bison (Carbyn *et al.* 1993).

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). 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; Baltzer *et al.* 2025). 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; Baltzer *et al.* 2025).

For more information on *Habitat Trends*, refer to *Appendix A3*.

Flooding Frequency

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). However, if desiccation is prolonged, woody perennials often invade. Sedge growth is also particularly sensitive to mean monthly temperature (Gorham 1974).

Low-lying flat land adjacent to rivers and lakes 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.

Bison frequently use the Liard River shoreline, sand bars and islands and this pattern of use is influenced by water level and rate of flow (NBWG 2019). 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).

Marl lake basins in wood bison range typically 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. By 1987, precipitation started increasing in the Mackenzie Bison Sanctuary (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 regularly used to sustain this bison population through the winter also began to drown. 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).

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.

Historical reconstructions of marl lake level using proxy data from sediment cores permitted Korosi *et al.* (2017) to demonstrate that lake expansion in the Mackenzie Bison Sanctuary post-1986 has been unprecedented over a multi-century time period. The surface area of Falaise Lake, formerly the core of Mackenzie bison habitat, increased by a total 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).

The high precipitation that flooded the marl lake basins also affected the fens in the Mackenzie Bison Sanctuary. 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.

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). 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.

Over the last 50 years, the average annual temperature in the Peace-Athabasca Delta has increased by 2°C and the average winter temperature has increased by 4°C (Parks Canada 2019). These warmer temperatures have resulted in earlier spring thaw and later fall freeze up and a shorter duration of seasonal ice cover, which influence the amount and timing of spring run-off and peak river flows (Parks Canada 2019). Future climate changes in the Peace-Athabasca Delta over the next thirty-plus years are expected to result in less available surface water, and what will be available will reach water bodies earlier in the spring than at present. Increased temperatures will potentially produce thinner snowpack in the headwater and tributary areas of the Delta, which in turn will result in reduced average annual peak, spring peak, and summer flows (Independent Environmental Consultants 2018).

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. However, 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). Decreased snowpack would also benefit bison, which have to work harder to find food in deep snow and are more vulnerable to wolves and hunters (Telfer and Kelsall 1984; Mech and Peterson 2003).

Role of Fire

Regular disturbance from fires is integral to building suitable habitat for wood bison (Singer and Lee 2021). Fire improves bison range by removing low quality plant material 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.

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 (Belanger *et al.* 2020; Hecker *et al.* 2021).

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 below 190 m elevation (33 years), than the upland sector (46 years). 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.

Over the past two centuries, there has been considerable variability in fire occurrence. This may be explained partly by annual precipitation levels (i.e., more extensive fires in drought years) and fuel connectivity across the landscape. 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.

Drought conditions allow fire to penetrate deep into the peat, burning out entire root systems of trees, willows and dwarf birch, permitting sedges and grasses to invade. Rowe and Scotter (1973) found that *Calamagostis canadensis* and various sedge species frequently move into newly 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.

Wildfire also affects the expansion and drainage of lakes and ponds, alongside permafrost thaw. 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). Lakes associated with higher ground ice content are more likely to increase, due to the acceleration of permafrost thaw by climate change (Travers-Smith *et al.* 2022). However, lakes impacted by wildfire (including those in NWT bison range) consistently decreased in area from 1985-2020. Deeper and faster permafrost thaw driven by fire and loss of organic surface cover seem promote drainage and surface runoff, while trends in precipitation appear to be less important in directly affecting lake levels (Travers-Smith *et al.* 2022; Dieleman and Baltzer 2023). Vegetation impacted by both wildfire and permafrost thaw can have different initial recovery patterns from those only recovering from wildfire and sites impacted by both disturbances may be slower to recover (Bill *et al.* 2023). 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.

In the wake of a prolonged, multi-year drought, extreme fire events in 2014 and 2023 affected the Mackenzie, Nyarling, and Slave River Lowlands bison ranges (Walker *et al.* 2018b; Day *et al.* 2023; Figure 22). 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; Baltzer *et al.* 2025); 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 reburns (Whitman *et al.* 2019; Baltzer *et al.* 2025); and transition from forest to prairie or aspen parkland ecosystems after short interval reburns (Baltzer *et al.* 2025). 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 grasses and sedges are preferred forage for bison (Chowns pers. comm. 2025).

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).

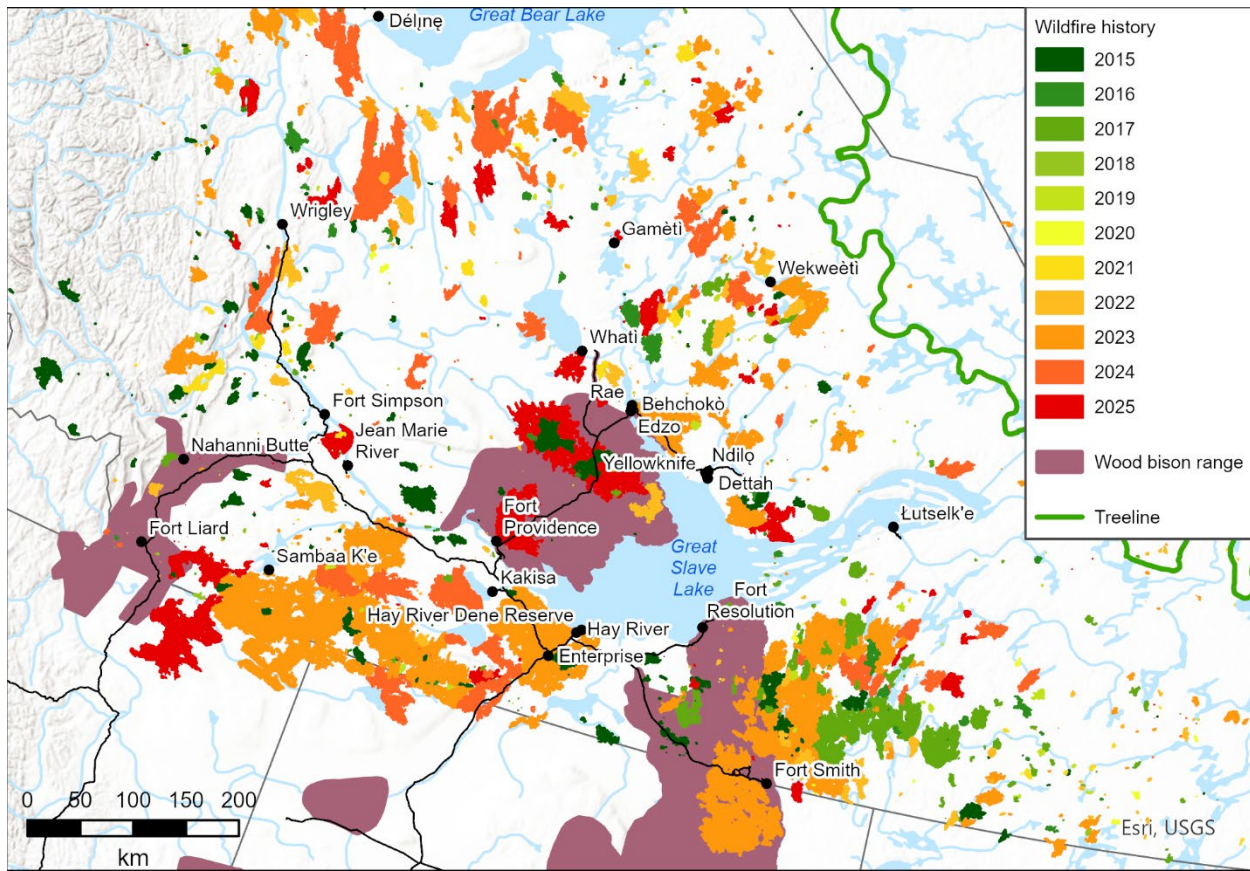


Figure 22. Fire history in NWT wood bison ranges from 2015 to 2025. Wildfire history data from ECC unpubl. data (2026b). Map by E. McHugh, GNWT-ECC.

Human-caused Habitat Changes

Wood bison habitat in Wood Buffalo National Park, while protected from local anthropogenic disturbances, is vulnerable to the impacts of development outside of its boundaries (Parks Canada 2019). Cumulative impacts of a changing climate and development pressures are causing ecological change on a landscape scale within the Peace-Athabasca Delta. Upstream and adjacent developments with the potential to impact the park include flow regulation from hydroelectric projects, oil sands development, pulp and paper production, forestry, agriculture, and municipal development. A strategic environmental assessment for Wood Buffalo National Park found that grassland habitat is declining in extent or quality as a result of changes to the amount of water recharge occurring in the Peace-Athabasca Delta (Independent Environmental Consultants 2018). Seasonal flows in the Athabasca River have declined over the past fifty years due to a combination of increased water withdrawals and a changing climate. Flow rate changes on the Peace River and reduced seasonal flows on the Athabasca River, in conjunction with climate change, have decreased water levels and the extent of open water in the Peace-Athabasca Delta (Independent Environmental Consultants 2018). The Government of Canada has committed to ensuring that all current and future environmental assessments conducted

pursuant to federal environmental assessment legislation explicitly consider potential specific and cumulative impacts of upstream development on Wood Buffalo National Park (Government of Canada 2024). More analysis is needed to understand the impacts on bison of habitat changes in the Peace-Athabasca Delta.

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.

Habitat Fragmentation

Wood bison distribution in the NWT is fragmented as bison occur in three relatively small and isolated populations separated by large distances (Gates *et al.* 2010). Of the total NWT population, approximately 70% of bison occur in the Mackenzie range. While the Greater Wood Buffalo metapopulation as a whole is considered the largest free-ranging bison population in the world, only two small subpopulations occur in the NWT (Nyarling and Slave River Lowlands). Together with Nahanni bison, they make up the remaining 30% of NWT bison (see Table 5).

The clearing of native vegetation for agriculture, timber harvesting, roads, and other human-mediated disturbances and development 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 (DeMars *et al.* 2019). 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 (GNWT 2026). There also is significant potential for natural gas development in the Liard Basin (Nahanni bison range); however, low commodity prices to date have deterred activities related to development in this area.

Extensive tracts of dense forest, muskeg, steep mountains, and large water bodies may cause natural habitat fragmentation (Gates *et al.* 2001a). 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 (Meagher 1973). They create their own trails as the easiest and shortest routes to favoured habitat patches throughout their range (Graham 1923). Bison use anthropogenic features such as cutlines and highway

corridors for travel routes (ENR 2010; DeMars *et al.* 2019). They do not cross large expanses of water, including wide rivers (Gates *et al.* 2001a).

The Mackenzie and Nahanni populations are isolated from each other geographically by the Mackenzie River, and from the Greater Wood Buffalo metapopulation by the Bison Control Area (BCA; see Figure 16). Bison that enter this zone are removed to prevent the spread of tuberculosis and brucellosis (Reynolds and Gates 1991). The BCA 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). Potential contact between disease-free populations in northwestern Alberta and Wood Buffalo National Park (Hay-Zama and Etthithun Lake populations) is managed through regulated harvest and removals (Government of Alberta 2025b). In Yukon, the establishment of new domestic bison farms in the core range of wild herds is discouraged and new bison control areas that limit the proximity of wild bison and new bison farms are under consideration (ECCC 2025). Efforts are also in place to ensure wood bison and plains bison are isolated from each other to prevent future hybridisation (Harper *et al.* 2000; Gates *et al.* 2010; ECCC 2025).

POPULATION

Abundance

Bison generally have a clumped distribution on the landscape due to their social behaviour and their tendency to use open meadow habitats, which may be clumped within their range (Armstrong 2025). This may result in many transects with no observations and a few with a large number of bison. The presence of a single large group not only has a strong influence on the estimate of abundance, but it also produces population estimates with wide confidence intervals indicating reduced precision of the estimate (Armstrong 2025).

Based on survey data between 2012 and 2025, there are a total of approximately 8,447–8,697 free-ranging wood bison in populations from the NWT, Alberta, Yukon, British Columbia, Manitoba, Alaska and Russia (see Table 5). Additional wood bison occur in a fully-enclosed national park (Elk Island National Park), privately-owned commercial productions, zoos, and wildlife parks – however, they are not considered within the scope of this report (ECCC 2018).

Table 4. Global population estimates of free-ranging wood bison (does not include Elk Island population).

Jurisdiction (population)	Estimated Number of Bison (Year)	References
Northwest Territories	2,764	See Table 5
Alberta	Wood Buffalo National Park – 2,430 (2024) Hay-Zama – 678 (2025) Ronald Lake – 272 (2021) Wentzel Lake – 120 (unknown) Wabasca – 16 (2019)	Parks Canada 2024 Government of Alberta 2025a Alberta Environment and Parks pers. comm. <i>in</i> Hecker 2022: 4 Alberta Parks 2026 ECCC 2021
Yukon (Aishihik)	1,200-1,400 (2022 and 2024)*	Government of Yukon 2026
British Columbia (Etthithun Lake and Nordquist/Liard)	525 (2021 and 2024)	B.C. Ministry of Water, Land and Resource Stewardship 2024
Manitoba (Chitek Lake)	250-300 (2011)	Joynt pers. comm. <i>in</i> ECCC 2018: 7
Alaska (Lower Yukon /Innoko and Minto Flats)	132 (2024)	ADFG 2024
Russia (Yakutia)	60 (2017/2018)	Shadrina <i>et al.</i> 2022
Total	8,447 – 8,697	

* Aerial surveys of the Aishihik wood bison population were carried out in July 2022 and July 2024, each using a different method. The 2022 mark-resight survey generated an estimated population size of 1,951 bison (95% CI = 1,688–2,295) (Jung *et al.* 2023). The aerial survey conducted in 2024 (Miller *et al.* 2024) generated a minimum count of 632 animals. This method is not as reliable as mark-resight population surveys and Miller *et al.* (2024) expressed a lack of confidence in the results, concluding that most likely “the population remains well above a minimum threshold of 1,000 animals (not including calves).”

The total NWT population of wood bison is estimated at 2,764 (see Table 5). 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). Based on these numbers, the estimated population in the NWT represents approximately 32% of the global population of wood bison.

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 composition survey 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 2,128.

Refer to *Appendix A2 – Population Trends and Fluctuations* and *Appendix A4 – Historic Range and Search Effort* for more detail on population survey methods.

Table 5. Estimated size of NWT wood bison populations/subpopulations as of 2025, with 95% confidence intervals. Population sizes are estimated using aerial surveys.

Population	Estimate	95% CI	Year	Reference
Nahanni	563	387-750	2025	Armstrong 2025
Mackenzie	1,945	1,327-2,849	2023	Armstrong 2024a
Greater Wood Buffalo (Slave River Lowlands subpopulation)	256	153-431	2024	Armstrong 2024b
Total	2,764			

Density

Animal size can be a powerful factor in predicting density of herbivorous mammals (Peters and Raelson 1984). 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.

NWT bison densities have been calculated in Table 6 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 6, *maximum population* refers to the maximum number a population has ever attained based on past surveys. *Maximum density* is calculated based on the area of occupancy (AO) and the maximum population.

The density all NWT bison populations are well below allometric projections of 0.24 bison/km². For Mackenzie bison, this may reflect limited high-quality sedge-grass meadows habitat across their range, often separated by tens of kilometres of marginally productive forest (Mychasiw 1987; Larter and Gates 1990; Matthews 1991; Armstrong pers. comm. in SARC 2016: 98).

Table 6. Wood bison density for Nahanni, Mackenzie, and Slave River Lowlands populations (bison/km²). Population data from Armstrong (2024a; 2024b; 2025) and ECC unpubl. data. (2024b).

Population/ Subpopulation	AO (km ²)	Current Population	Current Density	Maximum Population	Maximum Density	Allometric Density ¹	Allometric Estimate ²
Nahanni	11,713	563	0.05	962	0.08	0.24	2,811
Mackenzie	22,772	1,945	0.09	2,431	0.11	0.24	5,465
Slave River Lowlands	10,136	256	0.03	1,790	0.18	0.24	2,405

¹ Allometric density was calculated as $D = 67.9(W)^{-0.882}$ (Peters and Raelson, 1981) where D = density in bison/km² and W = body mass in kg. Bison body mass of 590 kg (from Olson 2002) was used here.

² Allometric estimates were calculated by multiplying the allometric density prediction by AO.

Immediately prior to dispersal episodes, densities have been reported to exceed 0.70 bison/km² for the Mackenzie population (Gates and Larter 1990; Larter *et al.* 2000). Until 1968, the Mackenzie 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/ km². 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.

Refer to *Appendix A2 – Population Trends and Fluctuations* for more detail on periods of eruptive oscillation in wood bison populations.

Carrying Capacity

Ecological carrying capacity is defined as the population size at which the population no longer increase (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 close to exceeding what the range can support.

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. 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.

Population Dynamics

Age at Maturity and Longevity

Fuller (1961, 1966) investigated bison in Wood Buffalo National Park and found that most bison breed by the time they are two to three years old. The study found 40% of two-year-old females and 52% of three-year-old females had bred for the first time, while few bison cows conceive as yearlings (Fuller 1961, 1966). Of the few male bison studied, 1 of 6 yearlings, 3 of 8 two-year-olds and all 6 three-year-olds had reached 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.

At Elk Island National Park, the weight of female bison levels off (asymptotic body weight) by seven years of age; female bison achieved their maximum body weight (567 kg) at 12 years (Olson 2002; Reynolds *et al.* 2003). Male bison reached an asymptotic body weight at eight years and maximum body weight (910 kg) by 13 years (Olson 2002; Reynolds *et al.* 2003).

American bison are estimated to live up to a maximum of 25 years in the wild and may live more than 33 years in captivity (Fuller 1966; Meagher 1973; Korec *et al.* 2019). Median lifespan of female American bison in captivity (6.6 years old; $n = 1,612$) exceeded more than three times the lifespan of male bison in captivity (2.1 years; $n = 1,300$; Korec *et al.* 2019). Based on tooth cementum aging, the oldest Nahanni bison was 20 years (Matson 1981; Larter pers. comm. 2025). In a free-ranging, hunted population in the Yukon (Aishihik population), the median longevity of adult bison was 5.0 years old ($n = 1,586$); the mean age-at-death of adult female bison (≥ 2 years old; $n = 638$) of 6.3 years old, while that of males was 5.3 years old ($n = 948$; Jung

2020). The same study found that the maximum longevity of free-ranging male and female bison was 22 years and 25 years, respectively (Jung 2020).

Dietary differences may also factor into the longevity of wood bison. Lifespan is shortened when bison cannot meet nutritional requirements due to tooth wear. Among bison in Wood Buffalo National Park bison, tooth wear was found to be much lower than in plains bison (Haynes 1984). Grasses, the main food of plains bison, contain more abrasive silica than the sedges 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).

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. Nutritional condition has a direct effect on the fecundity of bison. For example, McHugh (1958) reported an average pregnancy rate for mature plains bison 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.

Mature wood bison females usually do not breed every year (Fuller 1966; Soper 1941). In Yellowstone National Park, approximately half of sexually mature cows produced calves each year with most females producing calves every other year (Meagher 1973; Kirkpatrick *et al.* 1996). This 2- or 3-year calving pattern may be due to the nutritional cost of producing calves (Soper 1941; Meagher 1973; Kirkpatrick *et al.* 1993; Berger and Cunningham 1994; Wilson *et al.* 2002).

Kirkpatrick *et al.* (1996) 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 populations subjected to harsh environments or poor nutrition. Adverse environmental conditions, such as winter severity, appeared to contribute to prolonged lactation and delayed ovulation the following season, and these effects were more pronounced for younger cows (Kirkpatrick *et al.* 1996).

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 re-introduction (26%). Reynolds *et al.* (2003) reported a negative relationship between density and fecundity in bison at Elk Island National Park.

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. McHugh (1958) and Wilson *et al.* (2002) reported a significant decrease in pregnancy after age 12, although females may continue to breed until more than 16 years of age (Green 1990).

Birth Rate

Estimating the number of births 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 number of calves from aerial surveys was only 20-25% of the total number of animals counted. With adult cows apparently outnumbering bulls, Fuller expected the observed number of calves to be higher at 35-40%. He considered abortion in late pregnancy and postnatal mortality as explanations for this discrepancy.

Calving rates for mature female bison vary considerably in free-ranging populations throughout North America, ranging from a low of 35% to a high of 88% (Reynolds *et al.* 2003). 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.

Table 7 summarizes the high, low, average, and most recent available birth rates for NWT bison populations. The estimated average birth rate for the Mackenzie bison population from 1984 to 1998 was 41 calves: 100 cows (Larter *et al.* 2000). 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 (ECC unpubl. data 2025a). From 1999-2024, the birth rate averaged 39 calves: 100 cows (ECC unpubl. data 2025a).

Table 7. Birth rates for each NWT bison population expressed as number of calves per 100 cows. Data from ECC unpubl. data (2025a) unless otherwise indicated.

Population	Birth Rate (calves: 100 cows)			
	Low	Average	High	Recent (Year)
Mackenzie	11: 100 (2013)	39: 100 (1999-2024)	57: 100 (2024)	57: 100 (2024)
Nahanni	18: 100 (2022)	43: 100 (1999-2024)	88: 100² (2024)	88: 100² (2024)
Wood Buffalo National Park	N/A	N/A	55: 100³ (2024)	50:100⁴ (2025)
Slave River Lowlands	28: 100¹ (1986-1989)	35: 100 (1999-2025)	64: 100 (2004)	40: 100 (2025)

¹ From Bradley and Wilmshurst 2005.

² Estimate based on small sample size of only 32 cows.

³ SRLWG 2024, unpubl. meeting notes

⁴ SRLWG 2025, unpubl. meeting notes

The mean birth rate for the Nahanni population was 43 calves: 100 cows for 2002-2018; there are little comparative data prior to 2002 (ECC unpubl. data 2025a). If the only other data point from 1999 is added, 42 calves: 100 cows would be the mean, with a range of 20-65 calves: 100 cows (ECC unpubl. data 2025a). In 2024, the birth rate was 88 calves: 100 cows, but this was based on a small sample size of only 32 cows (ECC unpubl. data 2025a).

In Wood Buffalo National Park, the calf to cow ratio trended from approximately 28 calves: 100 cows (1986-1989), upward to 38 calves: 100 cows (1989-2003) (Bradley and Wilmshurst 2005). In 2024, the birth rate was 55 calves: 100 cows across the park; the highest ratio found since these surveys were initiated in the 1980s (Parks Canada 2024; SRLWG 2024, unpubl. meeting notes). The birth rate for 2025 was slightly lower (50 calves: 100 cows) but still considered healthy (stable).

Classification survey results from the Slave River Lowlands in 2025 indicated a ratio of 40 calves: 100 cows, with the long-term average being 35 calves: 100 cows (ECC unpubl. data 2025a). This is lower than the average for the Mackenzie and Nahanni populations, but not low enough to suggest reproduction and calf survival are driving population declines in these subpopulations (SRLWG 2024, unpubl. meeting notes).

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.

Juvenile survival in large herbivores from contrasting environments often varies greatly from year to year and can strongly influence population trends (Gaillard *et al.* 1998). Factors such as habitat conditions, predation, timing and size at birth, growth rate of calves, genetic factors, and immunocompetence of calves can affect juvenile survival in ungulates (Gaillard *et al.* 1998).

Between 1950 and 1953, yearlings made up an average of 7.6% of the total bison population in Wood Buffalo National Park from slaughtered animals (Fuller 1961, 1966). During this period, bison population were 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). Data from 2024 shows that bison in the park are producing a healthy number of calves and an increasing proportion are surviving their first year of life (recruitment rate of 69%; Parks Canada 2024). 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 (ECC unpubl. data 2025a). Average yearling ratio for the Slave River Lowlands subpopulation is 16.8 yearlings: 100 cows (1999-2025; ECC unpubl. data 2025a).

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 (8 yearlings: 100 cows). From 18 surveys between 1999 and 2025, 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 (ECC unpubl. data 2025a).

For the Nahanni population, the estimated recruitment was 22 yearlings: 100 cows with a range between 10 and 31 yearlings: 100 cows from 2002 to 2018 (ECC unpubl. data 2025a). 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 from 2002-03 to 2017-18 has been 53% (range 22.8-88.5%) (ECC unpubl. data 2025a).

Adult Survival

There is little variation in annual survival of adult females in large mammals across populations (Gaillard *et al.* 1998). Survival rates for adult wood bison in the NWT are uncertain due to small sample sizes, short collection periods, and limited data from marked individuals.

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). More recent adult survival rates were not available.

Sex Ratio

A postmortem examination of 840 mature females that were slaughtered at Wood Buffalo National Park found 53% male fetuses in utero (Fuller 1960, 1961, 1966). Palmer (1916) calculated a similar ratio of 54% males from a sample of 460 bison. The adult sex ratio is difficult to determine as accurately because composition surveys usually sample groups in open habitats and are more likely to encounter groups of mixed sex and age, while bull only groups that spend more time in forest cover are more likely to escape detection (Jung 2020). The males of many ungulate species often have higher rates of early mortality than females (Owen-Smith 1993). 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 (Komers *et al.* 1993; Gates *et al.* 2010, Jung 2021).

Van Camp and Calef (1987), in a study of bison population dynamics in the Slave River Lowlands between 1974 and 1983, reported that the Slave River Lowlands population had a ratio of 32 males:100 females (24% males). They suggested that hunting in this population may favour higher survival of females if males are selected for their size and trophy value. An aerial photo survey in 2025 estimated a bull:cow ratio of 63 males:100 females, which is lower than the long-term average of 93 males:100 females (2000-2025; SRLWG 2025, unpubl. meeting notes).

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, where the 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).

Since 1999, the sex ratio in the Mackenzie bison population has averaged 86 males:100 females (46% males) and ranged between 66 and 105 males:100 females (40-51% males) (Armstrong 2013a). As mature males are disproportionately infected in anthrax outbreaks (Aune *et al.* 2010; Gates *et al.* 2010; Bakhteeva and Timofeev 2022), the ratio of males to females may be lower following an outbreak (e.g., 1993 and 2012).

From surveys in 1999 and 2002-2018 (n=18), the sex ratio in the Nahanni population averaged 85 males:100 females (46% males) and ranged between 65 and 121 males:100 females (39-55% males) (Larter and Allaire 2007, Larter unpubl. data 2025).

The sex ratio in the Slave River Lowlands in 2025 was 63 males:100 females (39% males), which was lower than the long-term average of 93 males:100 females (48% males) from surveys between 1999-2025 (n=16) (SRLWG 2025, unpubl. meeting notes).

Immigration and Emigration

There has been no evidence of immigration or emigration other than among the subpopulations of the Greater Wood Buffalo metapopulation. Gene flow throughout the Greater Wood Buffalo metapopulation is significant, but not enough to totally obscure genetic differences and there are no significant trends regarding interchange among any subpopulations (Wilson and Strobeck 1999; Joly 2001). 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 (Calef and Van Camp 1987). None of the thousands of tagged animals at the Hook Lake anthrax roundups from 1965 to the mid-70s reappeared at any Wood Buffalo National Park roundups, or vice-versa (Calef 1976) and wildlife managers believed mixing between the park and Hook Lake bison occurred only occasionally (Dragon and Elkin 2001). An anomaly was reported 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 (Calef and Van Camp 1987).

There is potential for movement between the Nahanni and Mackenzie populations, although geographical barriers do exist and movement between these populations has not been observed.

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 (SARC 2022). Wood bison occurs in Alberta, British Columbia and Yukon, and some populations are shared between jurisdictions. However, the movement of bison, and therefore rescue effect, is limited due to efforts to manage tuberculosis and brucellosis (see *Threats – Disease and Disease Management*).

The NWT Bison Control Area is maintained to prevent the spread of diseases from the Greater Wood Buffalo metapopulation to the Nahanni and Mackenzie populations by restricting movement of bison between these areas (Reynolds and Gates 1991; Gates *et al.* 1992b). While this exclusion zone provides important protection against infection of disease-free bison, it also stifles gene flow and reduces possibility of rescue, as well as limiting the potential for range expansion into unoccupied habitat.

If the Slave River Lowlands subpopulations should disappear or experience a decline, the likelihood of rescue from other subpopulations in the Greater Wood Buffalo metapopulation is high. However, it is improbable that dispersal from elsewhere could re-establish the Mackenzie population because the Bison Control Area is designed to manage and prevent such dispersal, and the Mackenzie range is too remote from any other bison populations (including the Nahanni bison range, which is separated by the Mackenzie River) for immigration to be a factor. Even if bison from the Mackenzie and Nahanni populations were to reach each other, they were founded from different source populations (Mackenzie from Nyarling River and Nahanni from Elk Island National Park; see Table 3), and therefore the loss of one population and rescue by another could still result in the loss of important genetic diversity.

The likelihood of the Nahanni population being rescued by dispersal from elsewhere is also remote even though it is not far from the Nordquist bison population in northern British Columbia. The relatively small Nordquist population has the lowest projected population viability analysis of any wood bison population and there has been no known or reported movement between the two populations (McFarlane (Zittlau) *et al.* 2006; NBWG 2019; 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.

Trends and Fluctuations

Historical Decline

The introduction of firearms and advances in rifle technology led to excessive hunting which 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; Ogilvie 1893; Shaw 1995). Both plains and wood bison have slowly started to recover from these severe reductions through protection and reintroductions.

Population Changes

Changes in abundance of NWT wood bison populations/subpopulations estimated from aerial surveys conducted by GNWT-ECC are depicted in Figure 23a-c. Population data for

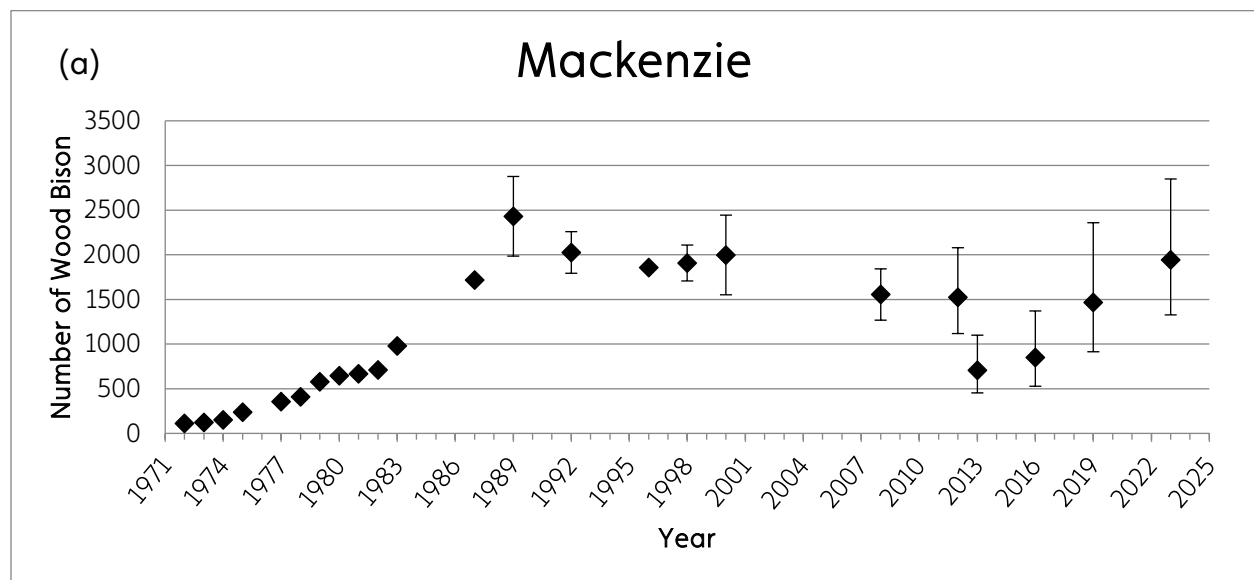
subpopulations in Wood Buffalo National Park surveyed by Parks Canada (Nyarling and Little Buffalo) were not available.

The Mackenzie bison population experienced a large decline from 2012 to 2013, due primarily to an anthrax outbreak in summer 2012, but appears to be recovering (Figure 23a). Mackenzie bison continue to expand their range north and east along Highway 3 (Yellowknife Highway) and Highway 9 (Tłıchǫ Highway). Recent monitoring along the Tłıchǫ Highway (TG and Firelight 2025a) includes wood bison observations recorded within 50 km of Whatı.

The Nahanni bison population increased to 962 animals in 2017 (Figure 23b). The population subsequently declined to 544 animals in 2021. Despite experiencing the loss of at least 22 animals over the winter of 2021-22 due to deep snow, harsh weather conditions and starvation, the Nahanni population remained stable through 2025 (563 animals).

Bison populations in the Slave River Lowlands (Hook Lake and Grand Detour) have experienced a steady decline since 2009 (Figure 23c). However, these bison are part of the larger Greater Wood Buffalo metapopulation and some of the decline may be due to movements into other areas.

In Wood Buffalo National Park, the Little Buffalo and Nyarling subpopulations have also declined since the mid-2000s. These subpopulations are considered low but still within the range of historical counts (Parks Canada 2024). The overall population of bison in Wood Buffalo National Park has also decreased in size from 10 years ago (Parks Canada 2024).



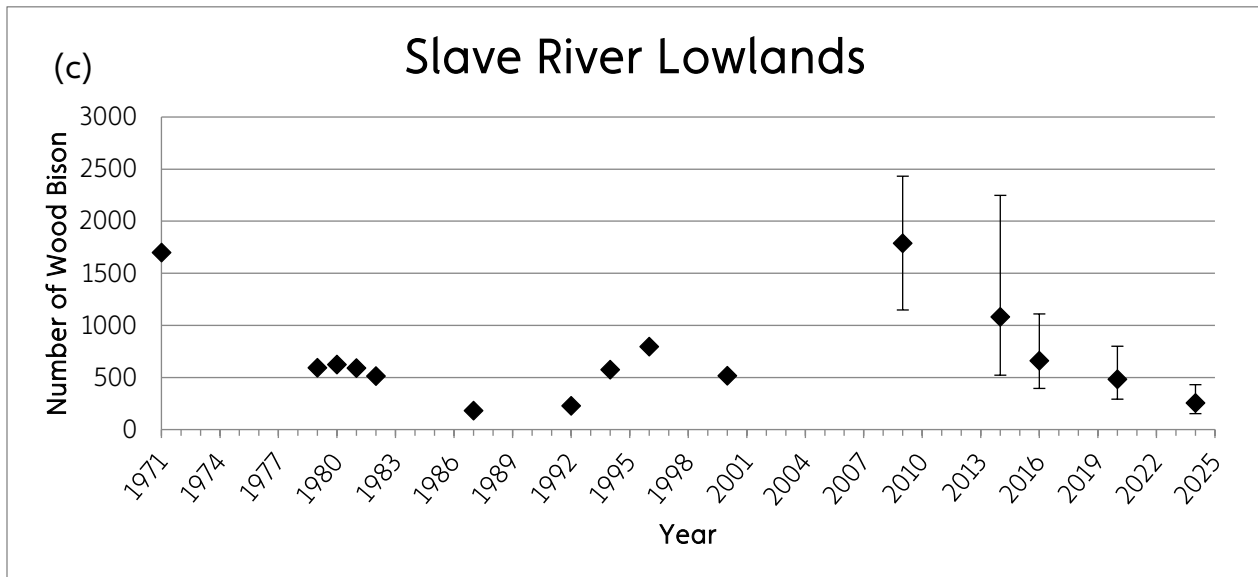
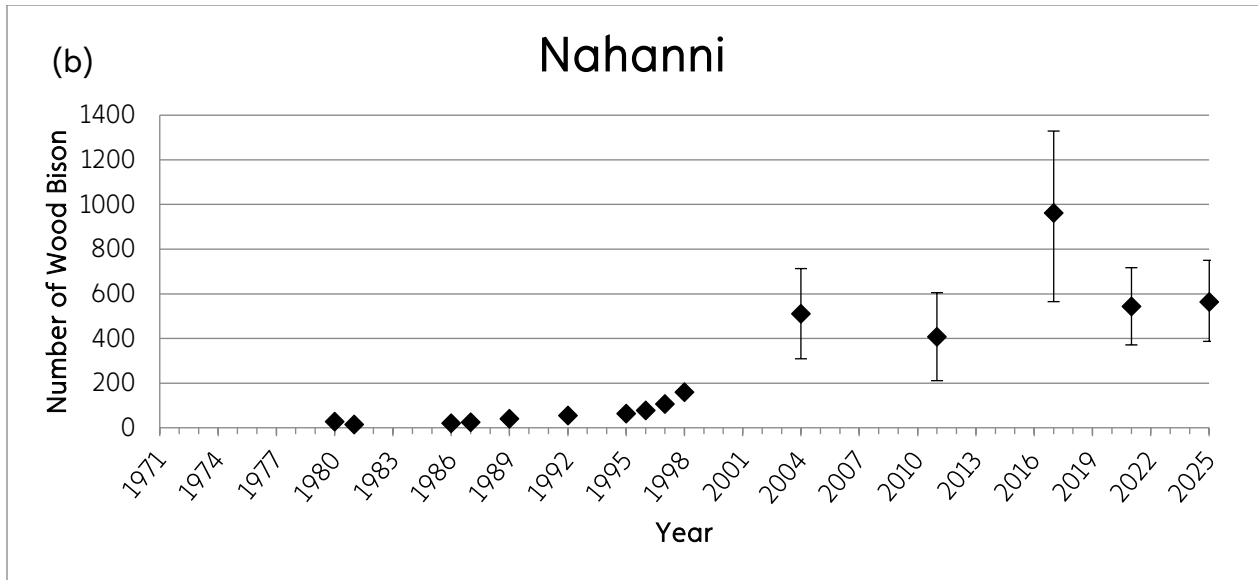


Figure 23. Wood bison abundance for the (a) Mackenzie, (b) Nahanni and (c) Slave River Lowlands populations surveyed by GNWT-ECC. Data obtained from Baker (1974), Jacobson (1974), Calef (1976), Jalkotzy (1979), Calef (1984), Chowns and Graf (1987), Gates and Larter (1990), Graf *et al.* (1990), Gates *et al.* (1991), Larter *et al.* (2000), Gates *et al.* (2001b), Larter *et al.* (2007), Armstrong (2011), Armstrong (2012), Armstrong (2013b), Larter and Allaire (2013), Armstrong (2014), Armstrong (2016a and 2016b), Armstrong and Boulanger (2016a,b), Larter (2017), Armstrong (2020), Armstrong (2021), Larter (2021), Armstrong (2024a,b), ECC unpubl. data (2024b), and Armstrong 2025. Data for the Nyarling and Little Buffalo subpopulations were not available.

With respect to the estimate of population trends for all NWT wood bison combined, 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 (up to

2025) were collected for all populations/subpopulations; these are the values in the table shaded in grey.

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 on the table in white. 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. Population estimates for NWT wood bison from aerial winter surveys conducted by ECC (Nahanni, Mackenzie, Grand Detour and Hook Lake) between 1983 and 2025 (grey boxes). 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 (white boxes). 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); Larter *et al.* (2007); Armstrong (2011); Armstrong (2012); Armstrong (2013b); Larter and Allaire (2013); Armstrong (2014); Armstrong and Boulanger (2016a,b); Larter (2017); Armstrong (2020); Larter (2021); Armstrong (2024a,b); ECC unpubl. data (2024b); Armstrong (2025).

Year	Nahanni	Mackenzie	Grand Detour	Hook Lake	Nyarling and Little Buffalo ⁹	Total
1983	16	980	198	316	N/A	1,510
1984	17	1,165	144	283	N/A	1,609
1985	19	1,349	58	250	N/A	1,676
1986	20	1,534	32	216	N/A	1,802
1987	25	1,718	6	183	N/A	1,932
1988	38	2,075	71	192	N/A	2,376
1989	40	2,431	118	201	N/A	2,790
1990	45	2,296	56	210	N/A	2,607
1991	50	2,161	3	219	N/A	2,433
1992	55	2,026	4	228	N/A	2,313

⁹ Population estimates were not available for wood bison in Wood Buffalo National Park (Nyarling and Little Buffalo subpopulations).

Year	Nahanni	Mackenzie	Grand Detour	Hook Lake	Nyarling and Little Buffalo ⁹	Total
1993	58	1,984	234	220	N/A	2,496
1994	61	1,942	463	212	N/A	2,678
1995	64	1,899	356	360	N/A	2,679
1996	78	1,857	288	508	N/A	2,731
1997	107	1,883	282	452	N/A	2,724
1998	160	1,908	148	396	N/A	2,612
1999	219	1,953	95	339	N/A	2,606
2000	277	1,998	235	283	N/A	2,793
2001	336	1,943	308	352	N/A	2,939
2002	394	1,887	380	421	N/A	3,082
2003	453	1,832	453	489	N/A	3,227
2004	511	1,776	525	558	N/A	3,370
2005	496	1,721	598	627	N/A	3,442
2006	482	1,666	670	696	N/A	3,514
2007	467	1,610	743	764	N/A	3,584
2008	452	1,555	815	833	N/A	3,655
2009	437	1,548	888	902	N/A	3,775
2010	423	1,540	784	865	N/A	3,612
2011	408	1,533	680	827	N/A	3,448
2012	500	1,525	576	790	N/A	3,391
2013	593	706	472	752	N/A	2,523
2014	685	754	368	715	N/A	2,522
2015	777	803	316	557	N/A	2,453
2016	870	851	263	399	N/A	2,383

Year	Nahanni	Mackenzie	Grand Detour	Hook Lake	Nyarling and Little Buffalo ⁹	Total
2017	962	1,057	240	378	N/A	2,637
2018	854	1,262	216	357	N/A	2,689
2019	765	1,468	193	336	N/A	2,762
2020	667	1,587	169	315	N/A	2,738
2021	568	1,707	139	288	N/A	2,702
2022	567	1,826	109	261	N/A	2,763
2023	566	1,945	79	234	N/A	2,824
2024	564	2,064	49	207	N/A	2,884
2025	563	2,183	19	180	N/A	2,945
2026	562	2,302	N/A	153	N/A	3,017

Figure 24 (below) provides for an examination of overall NWT bison populations trends, broken down into the last six generations (approximately 7-year periods). For the first three generations, from 1984-2005, the overall population of wood bison increased by 51% (1984-1991), 7% (1991-1998), and 32% (1998-2005), calculated using the linear annual growth rate between successive known population estimates. This time period included additional reintroductions to the Nahanni population in 1989 and 1998.

These three generations were followed by declines of 1% and 19% from 2005-2012 and 2012-2019, respectively. A linear population increase of 9% is estimated over the last generation (2019-2026). Based on these census data and derived values, there has been an overall population decline of approximately 12% in the last three generations (2005-2026) and 11% in the last two generations (2012-2026).

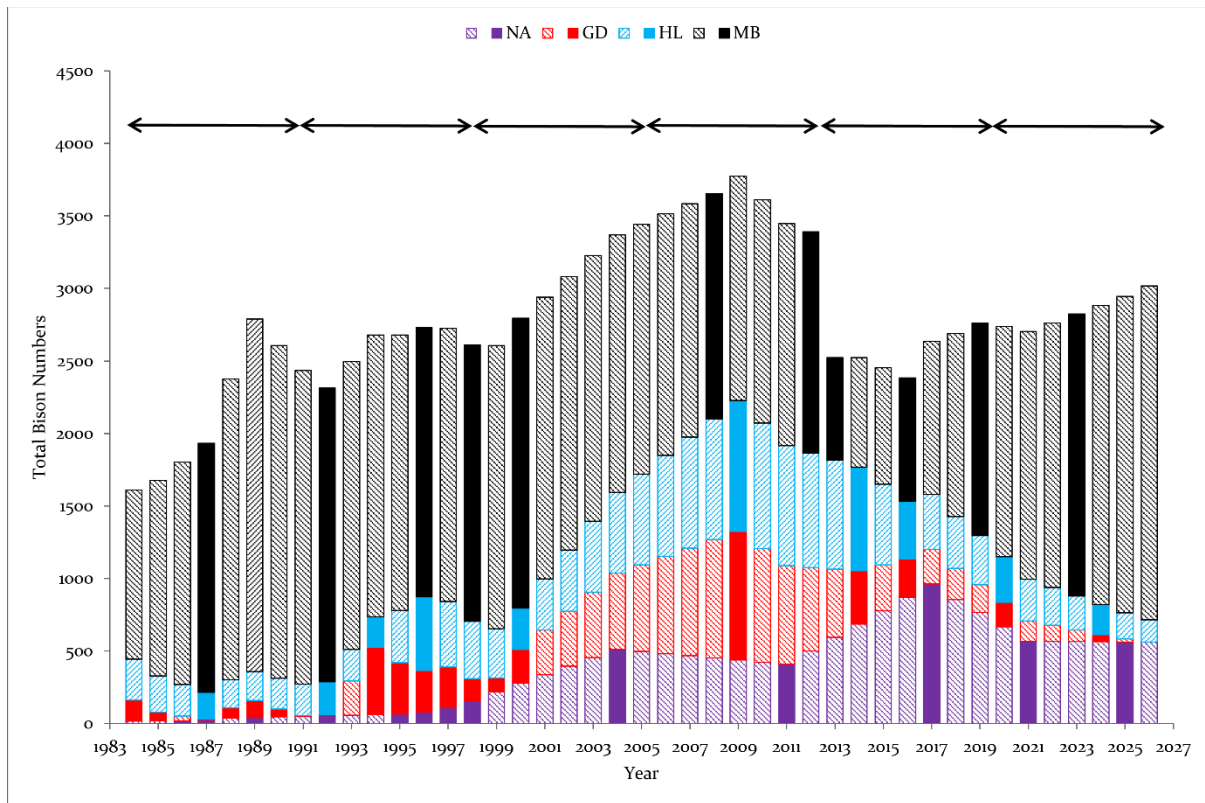


Figure 24. Estimated total NWT bison numbers, stacked by population/subpopulation (1984-2026) (NA = Nahanni population, GD = Grand Detour subpopulation, HL = Hook Lake subpopulation, and MB = Mackenzie population). Numbers from surveys are shown with solid fill and interpolated numbers are shown with hatched fill. The 7-year periods shown with arrows indicate approximate bison generations. Data for the Nyarling and Little Buffalo subpopulations were not available.

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 Nahanni and Mackenzie populations, to be in decline over the last three generations (2005-2026; 7-year generation time). However, no populations have been in continuous decline from the previous three generations (1984-2005). Overall, NWT bison underwent negative population growth ($r = -0.013$) during the last three generations, following positive population growth ($r = 0.047$) during the prior three generations. Instantaneous rate of growth for just the last generation (2019-2026) has been positive ($r = 0.003$).

Table 9. Instantaneous rate of growth (r) for NWT bison populations (calculated using a 7-year generation time) during the last three generations and the prior three generations based on survey data and interpolations/extrapolations.

Population/ Subpopulation	Prior 3 Generations (1984-2005)	Last 3 Generations (2005-2026)
Nahanni	0.161	0.006
Mackenzie	0.019	0.014
Slave River Lowlands (Grand Detour)	0.062	-0.304
Slave River Lowlands (Hook Lake)	0.038	-0.067
Total	0.047	-0.013

The International Union for the Conservation of Nature (IUCN) provides a calculator to determine the three-generational rate of change (IUCN 2026). 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 2005 and 2026, or the closest census year, the rate of decline over three generations is estimated at 49% for a 7-year generation time (2005-2026). If generation time is 8 years, the rate of decline is estimated at 8% (between 2002-2026).

Using the same approach, a decline in the NWT wood bison population was also calculated over the last two bison generations. The decline is estimated between 20% (if calculated using a 7-year generation time) and 22% (if calculated using an 8-year generation time).

Refer to Appendix A2 (*Population Trends and Fluctuations*) for further details on these calculations.

Population Viability Analysis

Although metapopulations may be large, subpopulations colonizing new areas are usually small and face significant risks. Stochastic (haphazard) events are capable of causing extinctions in small numbers of individuals 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.* (2008), based on modeling studies performed to estimate the loss of genetic diversity in wood bison populations over time. The minimum local population size of 1,000 bison was adopted as a long-term population objective in the Recovery Strategy for the Wood Bison (*Bison bison athabascae*) in Canada (ECCC 2018).

Sanderson *et al.* (2008) also argued that bison restoration should ideally encompass the interactions between bison and their environment. Few bison populations 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.* 2008). 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 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. 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 subpopulations within Wood Buffalo National Park, plus the Hook Lake subpopulation and Mackenzie population.

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 A2*.

THREATS AND LIMITING FACTORS

Overhunting and disease management actions, such as vaccination roundups and culls for disease control, represent important historical threats to wood bison, from which they are still recovering. Today, infectious diseases and actions taken to mitigate or prevent the impacts of disease are among the biggest threats to wood bison and their recovery (ECCC 2021). Human-caused mortality, vehicle collisions, habitat loss and deterioration (e.g., diminishing flood/drawdown cycles), low genetic diversity, and episodic catastrophes (e.g., drowning, extreme winter weather) are also considered important threats to wood bison in the NWT. These are discussed in more detail in the following pages.

Disease and Disease Management

The American Bison Specialist Group recognizes nine federally listed diseases of concern for bison conservation (Aune *et al.* 2010; Gates *et al.* 2010): anaplasmosis, anthrax, bluetongue bovine spongiform encephalopathy, bovine brucellosis, bovine tuberculosis, bovine viral diarrhoea, Johne's disease, and malignant catarrhal fever. Of the diseases that occur in the NWT, anthrax and bovine tuberculosis have the most serious implications for wood bison (Aune *et al.* 2010; Gates *et al.* 2010). Bovine brucellosis and the causal bacterium for Johne's disease are also known to occur in NWT bison; the GNWT monitors for malignant catarrhal fever and anaplasmosis (Jutha pers. comm. 2026).

The role of disease in regulating bison populations remains unclear, as the interactive effects of disease, habitat and predation on bison at the individual and population level are complex and poorly understood (ECCC 2021). Population growth rates of herds in Wood Buffalo National Park infected with tuberculosis and brucellosis are considered similar to non-diseased herds, suggesting that population level effects may be minimal. However, the presence of the two diseases on the landscape, and the resultant management actions taken, have been identified as major obstacles to wood bison recovery, and the overall effects of disease on long-term trends in the Greater Wood Buffalo metapopulation remain unclear (COSEWIC 2016; ECCC 2021).

Management interventions for these diseases are primarily discussed under *Positive Influences*; however, it is important to note that current disease control measures may limit or place additional pressure on populations by reducing population growth, size, and distribution. Past practices, such as mass slaughters to eliminate disease or roundups of wild populations for the purposes of vaccination, are no longer carried out due to net negative impacts.

Anthrax

Anthrax is a naturally occurring infectious disease caused by the bacterium *Bacillus anthracis* (Elkin *et al.* 2020). *Bacillus anthracis* spores can be dormant (inactive) in soil for many years until certain environmental conditions trigger the active infectious form (Aune *et al.* 2010; Gates *et al.* 2010; Salb *et al.* 2014). When bison are exposed to the active spores via inhalation, ingestion, or hematophagous (blood-eating) insects, spores germinate and the bacterium replicates in the bloodstream, releasing toxins that cause septicaemia and death (Dragon and Rennie 1995; Gates *et al.* 2001b; Aune *et al.* 2010; Gates *et al.* 2010; Elkin *et al.* 2020).

There is uncertainty about how and when anthrax became endemic in North American bison (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.

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). Anthrax has not been detected in the Nahanni population (CMA 2025). 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).

Between 1962 and 2025, there were 15 recorded outbreaks in Wood Buffalo National Park (one or more mortalities); nine in the Slave River Lowlands (outside of the park); and three in the Mackenzie bison range. These events have killed a total of at least 2,357 bison (Table 10); a further 1,426 bison, at minimum, were killed during disease management efforts (Novakowski 1965b; Dragon and Elkin 2001; Aune and Gates 2010; Gates *et al.* 2010; New *et al.* 2017; CMA 2025). Additional outbreaks and anthrax cases have likely gone undetected (New *et al.* 2017; Elkin *et al.* 2020).

In 2012, the largest recorded outbreak of anthrax occurred in the Mackenzie bison range where 451 carcasses were recorded, including 293 adults, 39 subadults, 27 yearlings, and 41 calves (New *et al.* 2017). The 2012 anthrax outbreak has been the most serious to date and had a significant impact on the total population size: it is estimated that the Mackenzie population declined by 54% and approximately 26% of the adult bison in the population died in the outbreak (New *et al.* 2017). The Mackenzie population had recovered to pre-outbreak population levels by 2020 (see Table 8 in *Trends and Fluctuations*).

Table 10. Number of wood bison carcasses that tested positive for anthrax during documented outbreaks in the Slave River Lowlands, Wood Buffalo National Park and Mackenzie bison range from 1962 to 2025 (New *et al.* 2017; Elkin pers. comm. *in* SARC 2016; Elkin *et al.* 2020; Parks Canada unpubl. data 2024; ECC unpubl. data 2024a; Armstrong pers. comm. 2025a). No cases were detected in 1965-1966, 1969-1970, 1972-1977, 1979-1990, 1992, 1994-1999, 2002-2005, 2008-2009, 2011, 2014, 2016-2021, 2024 and 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*	-	-
2023	30	11	-	41
Total	1,027	698	632	2,357

* Several bison mortalities in addition to the 50 confirmed anthrax cases were discovered in spring 2023 in the southwest portion of Wood Buffalo National Park. Due to intense fire in the area, cause of death for these mortalities could not be confirmed.

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 leave the carcass and enter the soil where warm temperatures, oxygen and desiccation stimulate the organism to transform into highly resistant spores (Minett 1950; Choquette and Broughton 1981; Titball and Manchee 1987; Hugh-Jones and de Vos 2002; Bakhteeva and Timofeev 2022). Insects (e.g., blowflies, horse flies, mosquitoes) facilitate the spread of anthrax spores when they feed on and/or reproduce in the body fluids of anthrax victims by physically spreading spores or transmitting infection via biting insects (Braack and De Vos. 1990; Turnbull *et al.* 2008b; Elkin *et al.* 2020). Carnivores, omnivores and birds are quite resistant to anthrax; however, they are important agents spreading spores into the environment (Elkin *et al.* 2020; Bakhteeva and Timofeev 2022).

Anthrax spores may live between 3 to 10 years in surface soil (top 6 inches) and for decades or even hundreds of years in deeper soils (De Vos 1998; Elkin *et al.* 2020; Barandongo *et al.* 2023; Hsieh and Stewart 2023). The survival, viability and virulence of anthrax spores in soil are influenced by acidity or microbial competition (Turnbull 1996; Hugh-Jones and de Vos 2002; Hugh-Jones and Blackburn 2009). Water movement or depressions (i.e., pot holds, wallows) may concentrate spores and become storage sites for anthrax (Dragon and Rennie 1995; Hugh Jones and Blackburn 2009).

Anthrax is an extremely lethal pathogen; the subacute form of the disease often goes undetected and progresses very quickly with death occurring in a matter of hours (Bagamian *et al.* 2013; Elkin *et al.* 2020). 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).

Despite mass deaths and susceptibility of all age and gender groups, anthrax predominately affects mature males (Aune *et al.* 2010; Gates *et al.* 2010; Bakhteeva and Timofeev 2022). The larger males may have a higher likelihood of infection than smaller females due to higher food consumption, 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). The lower incidence of anthrax in young animals may also be related to feeding behaviour and the developing gastrointestinal tract of calves (Turnbull *et al.* 2001; Bakhteeva and Timofeev 2022). The gastrointestinal tract of young herbivores is adapted for digesting dairy, with a smaller volume, shorter length, lower pH, greater digestive enzyme activity, and a higher rate of digestion compared to adults, therefore the gut of young animals is not an ideal environment for anthrax (Bakhteeva and Timofeev 2022). There also is evidence of maternal antibodies being passed on to young calves through the colostrum (Turnbull *et al.* 2001); calves feeding on milk rather than vegetation also reduces exposure to soil-borne spores (Bakhteeva and Timofeev 2022).

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 anthrax epidemic.

Bovine Tuberculosis

Bovine tuberculosis is caused by the bacterium *Mycobacterium bovis* (Tessaro *et al.* 1990). In the NWT, tuberculosis is only endemic in and near Wood Buffalo National Park, where it was introduced with translocated plains bison during the 1920s (Gates *et al.* 2010). It has not been found in either the Mackenzie or Nahanni populations.

Bovine tuberculosis is a chronic disease that causes yellow to tan lumps, most often found in the lungs or the lining of the ribcage (GNWT 2017). Lymph nodes in the head and neck may also be swollen or necrotic. It is a progressive disease that leads to debilitation and emaciation (Greig *et al.* 2012); advanced cases are fatal (FEARO 1990; Gates *et al.* 2010). Infection is transmitted primarily through inhalation and ingestion and occasionally from mother to offspring via the placenta or milk (Tessaro *et al.* 1990; Tessaro 1992; Aune *et al.* 2010).

In the 1950s, there was a tuberculosis testing program where bison that tested positive were slaughtered, and their meat was distributed for consumption (Fuller 1966; 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). Overall annual bison mortality from tuberculosis has been estimated at 4-6% for Wood Buffalo National Park (Fuller 1961, 1966; Tessaro 1987). However, studies have shown that bison that tested positive for both tuberculosis and brucellosis had lower winter

survival and reproductive rates than bison that tested positive for one or neither disease (ECCC 2021). 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. Animals weakened by disease are at greater mortality risk from predation and other causes, which should be taken into account (Tessaro 1987).

From 1,508 bison examined at Hay Camp in Wood Buffalo National Park in the 1950s, Fuller (1961, 1966) noted the incidence of tuberculosis to be 40%, but it was about 10% 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 was not considered. 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.

Joly and Messier live-captured bison in Wood Buffalo National Park for disease testing from 1997 to 1999 (n=342) (Joly and Messier 2001; 2004a). They found an overall incidence of tuberculosis of 49%, with males showing a higher prevalence of tuberculosis than females. Prevalence also increased with age for all bison, although at a higher rate in males (1.26 times for each additional year of age) than females (1.1 times with each year of age).

In the Greater Wood Buffalo metapopulation, it is likely that all bison have been potentially exposed and are susceptible to infection and the risk of disease transfer in close proximity to Wood Buffalo National Park is considered high (ECCC 2021). The Mackenzie and Nahanni populations are pathogen-naïve, meaning that they have not yet been exposed to these pathogens thus lack immune responses. If the pathogens were introduced into Mackenzie or Nahanni populations, they may have a greater impact than in the Greater Wood Buffalo metapopulation.

Tuberculosis levels in the Greater Wood Buffalo metapopulation 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 definitive method for eradicating tuberculosis from a population seems to be the removal of all infected animals, as well as all exposed susceptible animals (FEARO 1990; Animal and Plant Health Inspection Service – United States Department of Agriculture [APHIS USDA] 2005; Aune *et al.* 2010; CFIA 2012).

Bovine Brucellosis

Bovine brucellosis is caused by the bacterium *Brucella abortus* (O'Brien *et al.* 2017). Brucellosis arrived in North America with European cattle in the 1500s (Bierer 1974; Aguirre and Starkey 1994). Although the disease was not discovered in Wood Buffalo National Park until 1956, it has likely been present since the 1920s, when infected plains bison were moved to the park from Wainwright, AB (Fuller 1966; Fuller 2002; Aune *et al.* 2010; Gates *et al.* 2010). Bovine brucellosis has not been found in either the Mackenzie or Nahanni bison population.

Bovine brucellosis 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 (Tessaro 1992). Animals may also be susceptible to swollen joints and arthritis resulting in lameness, and possibly increased vulnerability to predation (Tessaro 1989; Tessaro 1992).

The disease may be transmitted through oral contact with aborted fetuses, 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. Brucellosis can be difficult to diagnose, as a bison that tests seropositive does not necessarily have the disease, simply that antibodies are present that indicate an acquired resistance or immunity (Aune *et al.* 2010). 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 suggest that brucellosis eradication would result in a 29% increase in population growth rate for that bison population because of higher birth rates (Fuller *et al.* 2007).

Bison in and around Wood Buffalo National Park were found to be 31.2% seropositive for brucellosis (n = 2,365 from 1959 to 1974; Choquette *et al.* 1978) and 30.9% (n = 342 from 1997 to 1999; Joly and Messier 2004a), suggesting the seropositive rate has been fairly constant over a 40-year time span. However, comparing these rates to the potential effects of brucellosis eradication on Yellowstone National Park bison is complicated by the fact that 10% of these animals test positive for both brucellosis and tuberculosis and the two populations have a much different relationship with predators (Joly and Messier 2001).

Dobson and Meagher (1996) suggested that brucellosis needs a population threshold of 200 bison to persist; others have suggested the disease can persist at much lower numbers and without management intervention will remain in the population indefinitely (Joly and Messier 2004a).

Johne's Disease

Johne's disease is caused by the bacterium *Mycobacterium avium* subsp. *Paratuberculosis* (MAP) (Aune and Gates 2010; Gates *et al.* 2010). It occurs in a variety of domestic and wild ruminants including bison, cattle, and sheep (Buergelt *et al.* 2000; Williams 2001; Aune and Gates 2010; Gates *et al.* 2010). Johne's disease may cause diarrhoea, weight loss, decreased milk production, and mortality (Aune and Gates 2010; Gates *et al.* 2010).

Clinical signs of Johne's disease have been observed, and the presence of MAP has been confirmed diagnostically in commercial/captive bison operations (Elkin *et al.* 2006; Aune and Gates 2010; Gates *et al.* 2010; Forde *et al.* 2013). Although clinical cases of Johne's disease have never been documented in free-ranging wood or plains bison (Aune and Gates 2010; Gates *et al.* 2010), MAP DNA has been confirmed in feces from wood bison populations across northern Canada, including in Wood Buffalo National Park and the Slave River Lowlands (Elkin *et al.* 2006; Forde *et al.* 2013). The origin of infections in wood bison is uncertain (Elkin *et al.* 2006).

The population level impact of MAP and Johne's disease on wild bison populations is unknown (Forde *et al.* 2013). Clinically affected animals may be removed from the population through predation before being detected by wildlife managers (Forde *et al.* 2013). Although it is unlikely that Johne's disease causes a high level of mortality in wood bison, chronic diseases can have important impacts to populations by reducing survival and reproduction, and lower resilience of a population (Forde *et al.* 2013).

Malignant Catarrhal Fever

An additional threat that has been identified to wood bison in the NWT is malignant catarrhal fever (MCF). The disease is caused by OHV-2 (ovine herpesvirus type 2), which infects domestic sheep without major health impacts. However, if contracted by susceptible species like bison, the disease can be serious and often fatal (Heuschele and Reid 2001; Gates *et al.* 2010). MCF is considered one of the most infectious diseases of bison, especially at high densities (Heuschele and Reid 2001).

MCF is expressed in two forms, acute and chronic, but regardless, death ensues in most cases. In the acute form, bison usually die within 7–10 days of infection or within 48 hr of becoming symptomatic. Alternatively, death may ensue as American Bison: Status Survey and Conservation Guidelines 2010 33 long as 156 days post-infection.

Direct contact between bison and domestic sheep is considered the most likely source of infection (Gates *et al.* 2010). Bison with MCF do not transmit MCF to other bison (Berezowski *et al.* 2005). There is no effective treatment for MCF and the best way to control this disease is to minimise contact with reservoir hosts (i.e., domestic sheep; O'Toole *et al.* 2000; Gates *et al.* 2010).

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). For example, 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.

Management Actions

Anthrax

Unsuccessful attempts were made between November 1964 and March 1965 to control anthrax from spreading throughout Wood Buffalo National Park (Novakowski 1965b). During this time, 598 bison were slaughtered from the Grand Detour subpopulation in the Slave River Lowlands (Dragon and Elkin 2001). At Hook Lake and in Wood Buffalo National Park, large scale annual roundups were also carried out from 1965 to 1977, where animals were gathered to administer anthrax vaccinations (Millette and Sturko 1977). Roundups are very disruptive, especially at critical times when calves are young; the average mortality from these roundups was estimated at 2% of the animals handled and at least 828 animals were estimated to have died (Millette and Sturko 1977; Dragon and Elkin 2001).

Vaccination roundups and culls are no longer carried out in the NWT to control the spread of anthrax and are not part of NWT's Anthrax Emergency Response Plan (Elkin *et al.* 2020). In the case of suspected or confirmed anthrax-caused wildlife deaths, GNWT increases surveillance efforts to locate dead animals and implements measures to minimize environmental contamination by spores released from carcasses (New *et al.* 2017; Elkin *et al.* 2020). Carcasses detected during outbreaks are burned on site, and soil contaminated by leaked body fluids is treated with chemical sporicide (Hugh-Jones and de Vos 2002; Elkin *et al.* 2020). Incineration has been shown to be a highly effective means of anthrax spore destruction, if done thoroughly (Elkin *et al.* 2020). Parks Canada conducts aerial and ground patrols of Wood Buffalo National

Park (e.g., 5 aerial and 1 ground anthrax patrol in 2024). Carcasses found during an outbreak are burned and treated if the outbreak is in a publicly accessible area (Beer pers. comm. *in* SRLBWG 2024).

Bovine Tuberculosis and Brucellosis

Although bison populations in Wood Buffalo National Park persist in the presence of these diseases, the management actions taken to control disease spread to livestock, ranched bison and disease-free wood bison herds greatly limits wood bison recovery (ECCC 2001). Historical approaches to disease management have included segregation, testing, and mass slaughters to reduce numbers of infected animals and prevent spread (Wobeser 2009).

A Bison Control Area (BCA) was established in 1987 to prevent the spread of diseases (e.g., tuberculosis and brucellosis) from the Wood Buffalo National Park area to the Mackenzie and Nahanni populations. The *Northwest Territories Nuisance Bison Control Regulations* (NWT Nuisance Bison Control Regulation, R-040-92) permit residents with a General Hunting License to hunt bison in the BCA without a tag. Reports of bison in the BCA are investigated by wildlife officers and any bison found in the BCA are destroyed and tested for disease (CMA 2025). No bison were detected or reported in the BCA between 2020-2023. From 2024-2025, five male bison were located in the BCA and destroyed; all five animals were confirmed tuberculosis and brucellosis free (Jutha pers. comm. 2026).

Similarly, in Alberta, surveillance activities are undertaken to protect the Hay-Zama population in the northwestern part of the province from contact with infected populations in and around Wood Buffalo National Park. Any wild bison detected in the surveillance areas are removed (ECCC 2021).

In 1996, the Hook Lake Wood Bison Recovery Project was launched by the Deninu Kųę First Nation, the Fort Resolution Aboriginal Wildlife Harvesters Committee and the GNWT. It was 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). In 2006, the entire captive Hook Lake Wood Bison Recovery Project local population was destroyed after bovine tuberculosis was detected in the local population (Lutze-Wallace *et al.* 2006).

In addition to the mortalities resulting from these management efforts, bison control measures restrict expansion of existing populations, thereby reducing the area that can be effectively occupied by bison and maintaining genetic isolation between populations (ECCC 2021). This is an important big-picture limitation on the recovery of wood bison in the NWT.

Human-caused Mortality

Bison may be killed as the result of vehicle collisions, destroyed to preserve community safety, or hunted for meat. Numbers of bison harvested from the Slave River Lowlands subpopulation are unknown as the harvest is largely unregulated.

Unregulated Harvest and/or Overharvest

There is little data available on current harvest levels of wood bison in the NWT. There are quotas in place for the Mackenzie and Nahanni populations (40 and 7 bison, respectively); although reporting is required by law, it is not known if all tags are filled every year.

For the Greater Wood Buffalo metapopulation, no reporting is required for Indigenous harvesters in the Slave River Lowlands (Armstrong pers. comm. 2026). Resident hunters are required to report on their harvest; however, this does not always occur. Bison hunts that are reported are tracked by the Department of Environment and Climate Change; an average of four bison per year in the Slave River Lowlands were reported from 2013-2026 (ECC unpubl. data 2026a). Overall, most resident harvesters take bulls (SRLWG 2024, unpubl. meeting notes).

Due to the lack of available data, it is impossible to determine to what extent overharvest may constitute a threat to wood bison. However, given relatively low numbers in the NWT and the role of overhunting in past declines (Calef 1976), unregulated harvest may be considered a potential threat.

Furthermore, in a study of harvest in the Yukon, Jung *et al.* 2026 suggest that changes in overall hunting activity on the landscape may affect bison stress physiology and limit the potential for bison to access high quality forage. Impacts of increased hunting pressure could have additional costs on fitness not typically accounted for in harvest management (Jung *et al.* 2026).

Vehicle Collisions

Wood bison are frequently observed along roads where they graze on vegetation and use roadways as corridors for movement. This behaviour makes them susceptible to vehicle collisions, which is an important cause of mortality for wood bison in the NWT (CMA 2019). The annual mortality rate is typically less than 1% for each population but has been as high as 1.6% in the range of the Mackenzie bison, where up to 89% of vehicle-bison collisions in the NWT occur (CMA 2025). An average of 12 vehicle-bison collisions are reported to GNWT-ECC each year, with a record high of 31 collisions reported in 2020 (CMA 2025). While most vehicle collisions involve a single bison, multiple animals are sometimes involved. Adult females are most often killed, followed by calves and then adult males (Wildlife Collision Prevention Program 2016).

Collisions occur most frequently between August and December, and between dusk and dawn (CMA 2019). Factors that increase the likelihood of vehicle-bison collisions include vehicle speed, traffic volume, and highway conditions. Nighttime travel (9pm to 6am) along Highway 3 has increased overall since the placement of the Deh Cho Bridge near Fort Providence in 2012, although there have been significant year-to-year fluctuations (INF unpubl. data 2026).

Bison prefer to travel along roads and through clearings associated with resource development (Thomas *et al.* 2021). In the Mackenzie range, bison are expected to continue to move northward along the Tłı̄ch̄o Highway (Highway 9), thereby increasing the likelihood of vehicle-bison collisions (INF 2023b). While collisions with Nahanni bison do occur along the Liard Highway (Highway 7) and in and around Wood Buffalo National Park (Highway 5; Great Wood Buffalo metapopulation), these areas have a much lower collision rate than Highway 3, which runs through core range of the Mackenzie population (INF unpubl. data 2024). The number of bison-vehicle collisions in Nahanni bison range average less than one collision a year for 1989-2023, while collisions in the Slave River Lowlands average one collision every three years (0.35/year; ECC unpubl. data 2024c).

Human-bison Conflicts

Another source of direct human-caused mortality occurs when bison enter communities. These human-bison conflicts may result in the bison being killed to avoid causing damage or injury. These mortalities are not considered part of a total allowable harvest or community quota.

Mortalities due to human-bison conflicts are very infrequent. Officers will try to chase bison from the community (by truck and ATV, using rubber bullets or other deterrents), sometimes multiple times over a period of weeks (Gast pers. comm. 2026; Krutko pers. comm. 2026). In Fort Providence, there have been two removals of Mackenzie bison in the last five years (2021-2025); a male bison was killed in 2021 and a calf with a broken leg was euthanized in 2023 (Krutko pers. comm. 2026). Residents that hold tags are encouraged to harvest bison that persistently enter the community (Krutko pers. comm. 2026; Gast pers. comm. 2026). The last record of a bison removed from Fort Liard was in 2020 (Gast pers. comm. 2026).

Habitat Loss and Deterioration

Diminishing Flood/Drawdown Cycles

As discussed in *Habitat Trends*, water levels and timing/extent of flooding and drawdown can have major impacts on the availability of bison habitat. Environmental changes caused by upstream hydroelectric development, which favour growth of woody plants along riparian corridors over grasses and sedges, is likely to decrease quality of this habitat (Singer and Lee 2021). 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).

UNESCO conducted two inspections of Wood Buffalo National Park, in 2016 and 2022, following concerns expressed by First Nations and Métis communities in and around the park about the impacts of upstream development on the hydrology of the Peace-Athabasca Delta (MCFN 2014). 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.

Fire Suppression

As described in the section on *Habitat Trends*, fire influences wood bison habitat. 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).

At the turn of the 20th century, a pervasive belief emerged that fire was destructive to bison and threatening their range. Locating and extinguishing fires throughout bison range, both lightning and human-caused, became a top priority (Janzen 1990). The unintended consequence was that upland habitats may have started to deteriorate in the 1910s, contributing to a regional reduction in carrying capacity of wood bison in northern Alberta (McCormack 1992; Strong and Gates 2009). Northern sedge-grass habitat preferred by bison were replaced by forests resulting from fire suppression programs and new European-based land use patterns such as agriculture and timber harvesting (McCormack 1992).

Over the years, the natural role of fire in ecosystems has become better understood and is reflected in the NWT's *Forest Fire Management Policy* (GNWT 2005), and the Parks Canada policy on ecosystem-based management (Parks Canada 2015), which state that fires should be allowed

to burn except where a need for intervention has been demonstrated. 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).

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.

Low Genetic Diversity

The maintenance of genetic diversity within a species is considered critical for species viability and adaptation to changing environmental conditions (ECCC 2021). The historic decline in population size for wood bison from thousands to hundreds (Soper 1941) would have reduced the genetic integrity of wood bison. All reintroduced bison populations have been derived from remnants of much larger populations and the original gene pools may be poorly represented (Boyd *et al.* 2010a).

McFarlane (Zittlau) *et al.* (2006) found that of five wood bison populations analyzed, Wood Buffalo National Park and Hook Lake 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, indicating that Greater Wood Buffalo metapopulation bison are not very diverse by normal genetic standards.

The disease problem (see *Disease and Disease Management*) and the lack of genetic diversity among wood bison 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 in Texas but is suspected in the Badlands National Park bison 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. Over the long-term, loss of subpopulations could affect the genetic variability within the species, thereby affecting the resiliency of wood bison to adapt to environmental change (ECCC 2021).

Genetic Drift

Genetic drift is the loss of genetic variation by chance and is intensified when populations remain small and isolated for many generations. The number of gene variants (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 populations have independently undergone genetic drift over several generations resulting in substantial differentiation among them (Halbert and Derr 2008). Even though the wood bison of Mackenzie and Elk Island National Park 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 population (Wilson and Strobeck 1999). Both the founder effect and genetic drift are probably responsible for the genetic status of these two populations.

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 (MHC) 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 MHC 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 diversity of MHC genes 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 diversity in these genes has been retained by bison through the population bottleneck that they experienced in the late 19th century (Mikko *et al.* 1997). Nevertheless, the number of MHC alleles has undoubtedly been reduced to a small fraction of the alleles present before the bottlenecks.

Hybridization and Outbreeding Depression

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 (Frankham *et al.* 2011). Outbreeding depression may become particularly acute when the populations are separate species (e.g. hybridization), have 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, and the introduction of cattle genes to NWT wood bison is unlikely to occur.

Presently, the most imminent hybridization threat to NWT wood bison is between the expanding Nahanni wood bison population and plains bison in British Columbia. The Pink Mountain plains bison population, once a private herd that escaped into the wild, 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) and Nahanni bison have been found in the vicinity of a domestic bison farm near Fort Nelson, B.C. (Armstrong pers. comm. 2025a). 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 population 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 groups 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). 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. Fourteen Mackenzie bison also 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. 2025b).

In winter 2008-09, 13 bison from the Nahanni population fell through thin ice on a creek east of Wrigley, and an additional 15 Nahanni bison 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).

Boat and barge traffic also represents a potential threat to wood bison in the NWT by causing drowning. 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

Harsh winters may be an important source of bison mortality, and calf survival has been negatively correlated with snowpack (Fuller *et al.* 2007). Adverse climatic conditions may be confined to a single season, or climatic oscillations (e.g., La Niña and El Niño) could have multi-year impacts on bison forage production and availability. 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. MacFarlane (1908) heard testimony about wood bison 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.

In 2013, the Hay-Zama wood bison subpopulation suffered from harsh winter conditions with estimates of calf survival at only 5%. This reduced 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 several bison were found dead near the community. The animals were in very poor condition, and no causal agent was identified from the samples analysed. They were deemed to have starved (Jutha pers. comm. 2026).

Only small changes in snow accumulation are expected across NWT bison ranges in coming decades (up to 2050), as rising temperatures are expected to shorten the period of snow accumulation (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

When the Greater Wood Buffalo metapopulation was in decline after the mid-1970s, food shortage was considered dubious as a cause, 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.

Predation has never become a wildlife management issue regarding the welfare of the Mackenzie population (Calef 1976, Gates 1988, MBWG 2018). Larter *et al.* (2000) stated that this population appears to be regulated by food supply, despite considerable wolf predation on calves. No information sources were available on predation of Nahanni bison.

As numbers of bison decline, wolves may continue to encounter the same number of bison groups containing fewer individuals, because bison group size varies with abundance (Carbyn *et al.* 1993). 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.

The prevalence of disease in a bison population may also increase predation rates. Tessaro *et al.* (1990) proposed that advanced diseases predispose bison to predation, as the availability of substantial numbers of debilitated bison maintains larger numbers of wolves, which would, in turn, result in greater losses of calves because they are the most vulnerable to predation. Population simulations conducted by Joly and Messier (2004b) supported this 'disease-predation hypothesis,' suggesting that disease-free bison populations would persist at high densities regulated by food competition, while a bison population with bovine tuberculosis and brucellosis was likely to decline to low densities, regulated by wolf predation.

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 intake, energetic investment in defensive structures, lower mating success, increased vulnerability to other predators, and emigration.

For more information on wolf-bison dynamics, refer to *Appendix A5*, which contains *Case History: Impacts on an Increasing Mackenzie Bison Population (1963-1992)*, and *Case History: Impacts on a Decreasing Greater Wood Buffalo Metapopulation (1971-1999)*.

POSITIVE INFLUENCES

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 animals, the number considered for a bison population to be ecologically restored (Sanderson *et al.* 2008; see also ECCC 2018). Some have suggested that generations of natural selection ought to be providing some measure of inherent disease resistance (e.g., Carbyn *et al.* 1993); however, based on reported prevalence of tuberculosis in Wood Buffalo National Park (49%; Joly and Messier 2004a), acquired resistance is not evident. New tools are starting to provide a better understanding of the genetic basis for innate resistance or susceptibility (Adams and Schutta 2010).

Since 1987, monitoring and removal of bison in the Bison Control Area between Wood Buffalo National Park and the Mackenzie River has been carried out to reduce the risk of contact between infected and non-infected wild bison populations (CMA 2025). In Alberta, regulated hunting and removal efforts control the movement of uninfected bison from the Northwest Bison Protection Area (Hay-Zama and Etthithun Lake populations) towards Wood Buffalo National Park and vice versa (Government of Alberta 2025b).

Routine aerial anthrax surveillance flights are conducted each summer by the GNWT, supplemented by observations during departmental fieldwork. Parks Canada conducts aerial and ground patrols of Wood Buffalo National Park, and areas with a history of outbreaks are prioritized for monitoring (Parks Canada 2024). When an anthrax outbreak is confirmed, the GNWT implements its Anthrax Emergency Response Plan (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.

Parks Canada, in collaboration with the Government of Alberta, is taking considerable effort to monitor and prevent contact between disease-free populations and populations of Wood Buffalo National Park. In addition to regular surveillance flights to monitor and assess habitat and use of movement corridors, Parks Canada has created a “geo-fence” tool that alerts staff immediately when collared animals move past a pre-established invisible boundary. The Government of Alberta also plans to implement geo-fencing to monitor the movement of the Ronald Lake herd. Both jurisdictions are working together to share information and keep nearby Indigenous partners informed about herd movements. Since beginning active surveillance, the

shortest observed distance between the two herds was 20 km in February 2024 (Government of Canada 2024).

Malignant catarrhal fever can be carried without symptoms by domestic sheep imported into the NWT. While harmless to sheep, the disease is often fatal in bison (Heuschele and Reid 2001; Gates *et al.* 2010). In 2019, to reduce the threat of infection to bison, the GNWT implemented *Wildlife Act* regulations that restrict the movement of domestic sheep through bison habitat and require sheep owners to hold a [domestic animal permit](#) (Wildlife Licences and Permits Regulations, R-027-92; GNWT 2019).

While many disease control measures focus on preventing infection, genetic work led by the University of Saskatchewan and Parks Canada aims to reduce the overall prevalence of tuberculosis and brucellosis in infected populations. The Bison Integrated Genomics (BIG) Project, launched in 2022, is developing new strategies to rapidly diagnose these two diseases and genomic tools to improve gene flow among herds without the risk of introducing disease. The project team is also developing potential vaccines to combat tuberculosis and brucellosis that could be delivered orally to wild bison populations (BIG Project 2024; Shury pers. comm. 2025; Niroula *et al.* 2025). 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).

Efforts to Reduce Human-caused Mortality

Harvest Management

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.

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 population trends (MBWG 2018; NBWG 2019).

Harvest levels of Mackenzie and Nahanni bison are managed through adaptable quotas ([Big Game Hunting Regulations](#), R-019-92; MBWG 2018; NBWG 2019). The Nahanni population

currently 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'ı̨ First Nation under a Wildlife Permit). With population recovery well underway by 2021, the quota for the Mackenzie population was increased to 40 bulls (WRRB 2021; CMA 2025) and a proposal was submitted in December 2025 to further increase the harvest to 60 according to sustainable harvest levels outlined in the Mackenzie Bison Management Plan (GNWT and TG 2025). Not all tags for the Mackenzie and Nahanni bison populations are used every year (Armstrong pers. comm. 2026).

Indigenous harvest from the Slave River Lowlands subpopulations outside of Wood Buffalo National Park (Hook Lake and Grand Detour) is unregulated, and NWT Resident license holders may purchase one bison tag per year for hunting. Resident hunters are required to report their bison hunts; however, this does not always occur in practice. Based on data submitted, resident harvest is estimated at an average of four bison per year (2013-2026; ECC unpubl. data 2026a). Data on Indigenous harvest of bison in the Slave River Lowlands are not collected (Armstrong pers. comm. 2026).

Other Management Actions

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 and along Highway 5 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).

The Tłı̨chq̄ Government has indicated it is concerned about the potential for human-bison conflicts as wood bison move towards Whatı̨ (TG and Firelight 2025a). The Tłı̨chq̄ Highway Wildlife Monitoring Program can help track any northward expansion and inform the need for more targeted mitigation to minimize vehicle-bison collisions (TG and Firelight 2025a).

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). Bison crossed the river where the channel was relatively narrow, preferring to cross near islands and on days when river discharge was low (Thomas *et al.* 2022b). Locations of river crossing hotspots can be used to inform mitigation measures to reduce bison drownings caused by vessel traffic.

Habitat Conservation

Wood Buffalo National Park was established in 1922 to protect the last remaining populations of wood bison (Parks Canada 2019); it is Canada's largest national park and home to the largest free-roaming population of wood bison in the world.

Portions of NWT wood bison range are also in Edézhzié (Dehcho Protected Area and National Wildlife Area) and a small portion of Nahanni National Park Reserve, which ensure harvest and human land-use impacts are carefully managed. Bison habitat is also protected by a land withdrawal for Dinàgà Wek'éhodi, a proposed territorial protected area on the North Arm of Great Slave Lake (Land Withdrawal Order (Dinaga Wek'éhoki (North Arm of Great Slave Lake)), R-054-2014).

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).

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 both 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 or human barriers (i.e., related to population management or disease control).

The Mackenzie population has expanded rapidly to the west and north following its establishment in 1963, while the Nahanni population has primarily expanded to the north and south along the Liard Highway (Highway 7; see *Distribution Trends*). With continued range expansion, the risk of a significant proportion of the population falling victim to a local catastrophe or adverse climate diminishes.

Wildfire

Natural fires have produced some of the greatest results for wood bison habitat but are uncontrollable and difficult to predict. Studies following extreme fire events in 2014 and 2023 describe successional impacts on vegetation that are beneficial to bison (see *Role of Fire* in *Habitat Trends*). Extensive fires in 1994 and 1995 west of Great Slave Lake and on the east side

of the Horn Plateau also led to mass movements of Mackenzie bison into newly burned areas (Chowns pers. comm.2025).

The NWT is expected to see longer fire seasons in the future characterized by more large fires, higher total annual area burned, larger annual area affected by high severity burns, and shorter intervals between re-burns (Wotton and Flannigan 1993; Price *et al.* 2013; Baltzer *et al.* 2025). Under a novel fire regime spurred by climate change, habitat availability for wood bison is expected to increase (Singer and Lee 2021; Baltzer *et al.* 2025).

Burning has been thought to reduce the probability of subsequent fire within the footprint of previously burned areas (Parks *et al.* 2018). However, climate models predict higher average temperatures and precipitation for the NWT in the coming decades (Price *et al.* 2013; Baltzer *et al.* 2025). For every 1°C of warming, a 15% increase in precipitation is required to compensate for the effect on fine fuel flammability (Flannigan *et al.* 2016). Drought increases the susceptibility of fuel-limited young forests to reburning, and 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). Repeated burns may combust the soil organic layer and reproductive structures of trees (cones, rhizomes), shifting conifer forests towards grass/shrublands favoured by wood bison (Larter and Gates 1991; Johnstone *et al.* 2004; Redburn *et al.* 2008; Baltzer *et al.* 2025).

Managing Genetic Diversity

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 populations.

Although low genetic diversity in re-introduced herds remains a concern, bison herds in and around Wood Buffalo National Park, although diseased, harbor important genetic diversity that is critical for the long-term survival of the species (ECCC 2021). Advances in reproductive technology are continuing to find ways to salvage valuable genetic material from these infected populations (e.g., Robison *et al.* 1998; Thundathil *et al.* 2007; Aurini *et al.* 2009; Acevedo and Barfield 2023).

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). These effects increase

probability of extirpation without gene flow between isolated populations (Frankham *et al.* 2011). Through advances in the ability to “wash” gametes the BIG Project hopes to produce disease-free gametes and embryos from infected donor bison, and to restore genetic connectedness among isolated populations using reproductive technology. Using germplasm to increase genetic diversity in isolated disease-free populations may be the most appropriate way to increase genetic diversity without the risk of disease transfer (Shury pers. comm. 2025).

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).

Federally, wood bison have been listed as Threatened in Canada under the *Species at Risk Act* since 2003. The listing has resulted in the completion of a federal recovery strategy for wood bison, published in 2018, which sets goals and provides recommendations for how to conserve bison (ECCC 2018). In the NWT, the federal recovery strategy is implemented in coordination with the NWT wood bison recovery strategy (CMA 2019), through the Conference of Management Authorities (CMA). The CMA is made up of wildlife co-management boards and governments that share responsibility for the listing, conservation, and recovery of wood bison and other species at risk in the NWT (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 (MBWG 2018; NBWG 2019; SRLWG 2019) and implementation is underway through the working groups.

The Edézhíe Management Board was established in 2022 to make decisions and issue permits for activities within Edézhíe (Dehcho Protected Area and National Wildlife Area), including harvest and research (DFN and Government of Canada 2018). The Board has agreed to continue

managing to discuss management of Mackenzie wood bison in Edézhíe based on guidance in the Mackenzie Bison Management Plan (CMA 2025).

GNWT-ECC is a member of the CMA, and continues to collaborate with Parks Canada, ECCC and the governments of Alberta, British Columbia and Yukon on bison issues. A national Technical Advisory Committee and the IUCN Bison Specialist Group also advise on the management and recovery of bison, particularly wild wood bison, with participation from the NWT.

ACKNOWLEDGEMENTS

The Species at Risk Committee thanks Tom Chowns for his work preparing the scientific knowledge component of this status report. This report benefitted from comments received during the review process and we thank all of those who contributed to the content and structure of this report.

The preparer and SARC would also like to acknowledge sources and contributors including staff of the Government of the Northwest Territories, Department of Environment and Climate Change (Terry Armstrong and Joanna Wilson) and the Species at Risk Secretariat (Joslyn Oosenbrug) and staff from Wood Buffalo National Park (Jenna Rabley and Nicolas Comerford). We also acknowledge contributions from GNWT-ECC Spatial Data Analysts (Nick Wilson and Erin McHugh) and Bonnie Fournier of Fauna Boreali who collaborated with the preparer and Secretariat to manage geospatial data, develop maps and figures, and calculate quantitative values.

AUTHORITIES CONTACTED

2026 Update

Indigenous Organizations, Resource Management, and Wildlife Advisory Boards

Stephanie Behrens Wildlife Biologist, Tłıchǫ Government, Behchokǫ
John Nishi Biologist Consultant, Tłıchǫ 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'èezhì Renewable Resources Board,
Yellowknife, NT

Territorial Government Contacts

Alicia 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) ¹⁰ To prioritize	Fine Filter (Status) To provide advice	Legal Listings (Status) To protect under legislation
Global	T ₃ – Vulnerable (NatureServe 2024)	NT – Near Threatened (IUCN Red List 2016)	Appendix II (CITES 2006)
Canada	N ₃ N ₄ – Vulnerable to Apparently Secure (NatureServe 2026)	Special Concern (COSEWIC 2013)	Threatened (SARA 2003)
Northwest Territories	At Risk (NWT General Status Ranking Program 2025) S ₂ – Imperiled (NatureServe 2026)	Threatened (2016)	Threatened (SARA NWT 2017)
Adjacent Jurisdictions			
British Columbia	S ₂ – Imperiled (NatureServe 2026)		Red List
Alberta	S ₂ – Imperiled (NatureServe 2026)	Threatened (2021)	Threatened (<i>Wildlife Act</i> 2021)
Saskatchewan	SX – Presumed Extirpated (NatureServe 2026)		
Manitoba	SNA – Not Applicable (NatureServe 2026)		
Yukon	S ₃ S ₄ – Vulnerable to Apparently Secure (NatureServe 2026)		

¹⁰ All NatureServe codes are as defined in [Definitions of NatureServe Conservation Status Ranks](#).

INFORMATION SOURCES

Indigenous and Community Knowledge Component

- APTN News. 2023. Disputed Bison Hunt Begins in Northern Alberta. Published 15 September 2023, by Danielle Paradis. Website: www.aptnnews.ca/national-news/bison-hunt-northern-alberta-hay-zama [accessed 3 April 2025].
- Armstrong, T., pers. comm. 2025. Comments provided to J. Oosenbrug. Wildlife Biologist (Bison), Department of Environment and Climate Change, Fort Smith, NT.
- Armstrong, T., pers. comm. 2026. Email correspondence with J. Oosenbrug. March 2026. Wildlife Biologist (Bison), Department of Environment and Climate Change, Fort Smith, NT.
- Athabasca Chipewyan First Nation (ACFN) and Willow Springs Strategic Solutions (Willow Springs). 2021. A History of Wood Buffalo National Park's Relations with the Denésuliné: Final Report. 180 pp. Website: www.willowsspringsss.com/case-studies/a-history-of-relations-between-wood-buffalo-national-park-and-athabasca-chipewyan-first-nation-report-release [accessed 6 March 2026].
- Athabasca Chipewyan First Nation (ACFN), S. Trimble, and P. Fortna. 2023. Remembering Our Relations: Dënesųłíné Oral Histories of Wood Buffalo National Park. University of Calgary Press, Calgary, AB. 307 pp.
- Bath, A.J., M.T. Engel, R.C. van der Marel, T.S. Kuhn, and T.S. Jung. 2022. Comparative Views of the Public, Hunters, and Wildlife Managers on the Management of Reintroduced Bison (Bison Bison). *Global Ecology and Conservation* 34 (April 2022), e02015. Website: <https://doi.org/10.1016/j.gecco.2022.e02015>.
- Bayha, W. 2012. Using Indigenous Stories in Caribou Co-Management. *Rangifer* 32 (2): 25–29. Website: <https://doi.org/10.7557/2.32.2.2241>.
- Beaulieu, D., pers. comm. 2024. Telephone conversation with A. Bathe. October 2024. Mayor, Fort Providence, NT.
- Beaver, E., pers. comm. 2024. Telephone conversation with A. Bathe. October 2024. Language specialist, Fort Smith, NT.
- Benson, K. 2014. Ts'iidęjį Gwınoo Gwıñın: Animals From Long Ago. Report produced for the Prince of Wales Northern Heritage Centre, Yellowknife, NT. 24 pp. Website: www.gwichin.ca/sites/default/files/gsci_benson_2014_bison.pdf.

- Berkes, F., J. Colding, and C. Folke. 2000. Rediscovery of Traditional Ecological Knowledge as Adaptive Management. *Ecological Applications* 10 (5): 1251–62. Website: [https://doi.org/10.1890/1051-0761\(2000\)010\[1251:ROTEKA\]2.0.CO;2](https://doi.org/10.1890/1051-0761(2000)010[1251:ROTEKA]2.0.CO;2).
- Big Game Hunting Regulations, NWT Reg 019-92 (*Wildlife Act*).
- Cabin Radio. 2019. Dead Bison and Abandoned Car Found on NWT Highway. Published 22 May 2019, by S. Pruys and O. Williams. Website: <https://cabinradio.ca/16119/news/south-slave/dead-bison-and-abandoned-car-found-on-nwt-highway> [accessed 3 April 2025].
- Cabin Radio. 2022. Northwest Territories' First Wood Bison Season since 2012 Ends. Published 15 March 2022, by S. Sibley. Website: www.cabinradio.ca/87713/news/environment/northwest-territories-first-wood-bison-season-since-2012-ends [accessed 20 March 2026].
- Canada Energy Regulator (CER). 2017. Market Snapshot: Northern Canada rich in natural gas resources, but current production continues to decline. Release date 2 August 2017. Website: www.cer-rec.gc.ca/en/data-analysis/energy-markets/market-snapshots/2017/market-snapshot-northern-canada-rich-in-natural-gas-resources-but-current-production-continues-decline.html [accessed 30 March 2026].
- Canada Energy Regulator (CER). 2026. Northwest Territories Energy Profile. Website: www.cer-rec.gc.ca/en/data-analysis/energy-markets/province-territory-energy-profiles/northwest-territories.html [accessed 30 March 2026].
- Canadian Broadcasting Corporation (CBC News). 2015. 2015 N.W.T. fire season was the 2nd-worst on record. Published 28 August 2015, by CBC News. Website: www.cbc.ca/news/canada/north/2015-n-w-t-fire-season-was-the-2nd-worst-on-record-1.3207053 [accessed 7 May 2025].
- Canadian Broadcasting Corporation (CBC News). 2021. 'They Shouldn't Be in the Community': Fort Liard Resident Sounds Alarm over Bison Herds. Published 1 March 2021, by A. Desmarais. Website: www.cbc.ca/news/canada/north/fort-liard-bison-concerns-1.5930357 [accessed 7 May 2025].
- Carbyn, L.N. and T. Trottier. 1988. Descriptions of wolf attacks on wood bison calves in Wood Buffalo National Park. *Arctic* 41 (4): 297-302.
- Carbyn, L.N., S.M. Oosenbrug, and D.W. Anions. 1993. Wolves, bison and the dynamics related to the Peace-Athabasca Delta in Canada's Wood Buffalo National Park. Circumpolar Research Series No. 4. Canadian Circumpolar Institute, University of Alberta, Edmonton, AB.

- Christianson, Amy, N. Caverley, D.A. Diabo, K. Ellsworth, B. Highway, J. Joe, S. Joudry, L. L'Hirondelle, W. Skead, and M. Vandevord. 2020. Blazing the Trail: Celebrating Indigenous Fire Stewardship. FireSmart Canada. Sherwood Park, AB.
- Christianson, A., C.R. Sutherland, F. Moola, N.G. Bautista, D. Young, and H. MacDonald. 2022. Centering Indigenous Voices: The Role of Fire in the Boreal Forest of North America. *Current Forestry Reports* 8 (3): 257–76. doi:10.1007/s40725-022-00168-9.
- Clark, D.A., L. Workman, and T.S. Jung. 2016. Impacts of Reintroduced Bison on First Nations People in Yukon, Canada: Finding Common Ground through Participatory Research and Social Learning. *Conservation and Society* 14 (1): 1. doi:10.4103/0972-4923.182798.
- Cluff, D., B. Croft, J. Mackenzie, and T.L. Hillis. 2006. Boreal woodland caribou workshops in North Slave communities. Project report prepared for the NWT Cumulative Impact Monitoring Program, March 31, 2006, Yellowknife, NT. 8 pp. Website: https://nwtdiscoveryportal.enr.gov.nt.ca/geoportaldocuments/cimp_Boreal%20Woodland%20Caribou%20Workshops%20in%20North%20Slave%20Communities-2006.pdf.
- Conference of Management Authorities (CMA). 2019. Recovery Strategy for Wood Bison (*Bison Bison Athabascae*) in the Northwest Territories. Conference of Management Authorities, Yellowknife, NT.
- Conference of Management Authorities (CMA). 2025. Progress Report on the Recovery of Wood Bison (*Bison bison athabascae*) in the Northwest Territories (2020-2024). Conference of Management Authorities, Yellowknife, NT.
- Crosscurrents Associates Ltd. and Maskwa Environmental Services Ltd. 2007. Protected Areas Strategy Phase 1 Ecological Assessment of the Buffalo Lake Area of Interest. Kát'odeeche First Nation / Protected Areas Secretariat, Yellowknife, NT. 70 pp. Website: <https://nwtdiscoveryportal.enr.gov.nt.ca/geoportaldocuments/KFN%20PAS%20EA%20-%20Final%20Master.pdf>.
- Dehcho First Nations. 2011. Traditional Knowledge Assessment of Boreal Caribou (Mbedzih) in the Dehcho Region. Prepared by Dehcho First Nations for the Canadian Wildlife Service. Published by the Dehcho First Nations, Fort Simpson, Northwest Territories.
- Dehcho First Nations (DFN) and Government of Canada. 2018. Agreement regarding the establishment of Edézhíe. Website: <https://dehcho.org/docs/Edézhie-Establishment-Agreement.pdf> [accessed 7 May 2025].

- Dehcho First Nations (DFN) and Resources, Wildlife and Economic Development (RWED). 2002. Dehcho Regional Wildlife Workshop, September 23-25, Fort Simpson, NT. Resources, Wildlife and Economic Development, Yellowknife, NT. 72 pp.
- Dehcho Land Use Planning Committee (DLUPC). 2006. NDÉH TS'EDĪCHÁ: Dehcho Ndéh T'áh Ats'et'í K'eh Eghálats'ênda Ts'êh Gondi / RESPECT FOR THE LAND: The Dehcho Land Use Plan Background Report. Website: <https://dehcholands.org/document/background-report-2006>.
- Department of Infrastructure (INF). 2023a. Developer's Assessment Report for the Mackenzie Valley Highway Project (EA1213-02). Department of Infrastructure, Government of the Northwest Territories, Yellowknife, NT. Website: https://documents.reviewboard.ca/w/mvrb/DOC5#!fragment/zoupio-_TocPage1239/BQCwhgziBcwMYgK4DsDWszlQewE4BUBTADwBdoAvbRABwEtsBaAfX2zgAUwBzOgRgBMAZgCcASgAoybKUIQAIokK4AntADk6iREJhcCRcrUAjOhGzJtu-SADKeUgCE1AJQCiAGTcA1AIIA5AGE3CVIwY2gdPQOxMSA
- Department of Infrastructure (INF). 2023b. Wildlife Management and Monitoring Plan for the Tłıchq Highway Project (W2020L8-0001 and W2016E0004) v. 6.2. Prepared for the Wek'èezhìi Land and Water Board and Environment and Climate Change. Department of Infrastructure, Government of the Northwest Territories, Yellowknife, NT. Website: www.gov.nt.ca/ecc/sites/ecc/files/resources/w2016e0004_-_tasr_-_wildlife_management_and_monitoring_plan_-_version_6.2_-_jun_12_23.pdf
- Dodd, W., P. Scott, C. Howard, C. Scott, C. Rose, A. Cunsolo, and J. Orbinski. 2017. Lived experience of a record wildfire season in the Northwest Territories, Canada. *Canadian Journal of Public Health* (2018) 109:327–337. doi.org/10.17269/s41997-018-0070-5.
- Doney, E.D., A.J. Bath, and J.J. Vaske. 2018. Understanding conflict and consensus regarding wood bison management in Alaska, USA. *Wildlife Research*. 45(3). 229-236. 10.1071/WR17056.
- Doney, E.D., J.J. Vaske, A.J. Bath, M.T. Engel, and B. Downer. 2019. Predicting Acceptance of Lethal Management of Wood Bison in Alaska, U.S.A. *AMBIO A Journal of the Human Environment*. 49(1). 10.1007/s13280-019-01173-2.
- Dragon, D.C. and B.T. Elkin. 2001. An Overview of Early Anthrax Outbreaks in Northern Canada: Field Reports of the Health of Animals Branch, Agriculture Canada, 1962–71. *Arctic* 54:32-40.

- EBA Engineering Consultants Ltd. and Canadian Wildlife Service [CWS]. 2006. Ecological Assessment of the Edézhíe Candidate Protected Area. NWT Protected Areas Strategy, Yellowknife, NT. 199 pp.
- Edézhíe Dehcho Dene Protected Area (EDDPA). Edézhíe Guardians Program. Website: <https://edehzhie.com/guardians-program> [accessed 2 March 2026].
- Edézhíe Management Board (EMB). 2024. Draft Edézhíe Management Plan. Edézhíe Management Board, Fort Simpson, NT. Website: https://dehcho.org/wp-content/uploads/2024/11/Draft-Edehzhie-Management-Plan_External-Review_September-5-2024.pdf.
- Environment and Climate Change (ECC). 2023. Report On The 10th Biennial Dehcho Regional Wildlife Workshop. Yellowknife, NT: Government of the Northwest Territories.
- Environment and Climate Change (ECC). 2024. Forest Management Agreements. Information. Government of the Northwest Territories. Website: www.gov.nt.ca/ecc/en/services/forest-resources/forest-management-agreements [accessed 3 November 2024].
- Environment and Climate Change Canada (ECCC). 2018. Recovery Strategy for the Wood Bison (*Bison bison athabascae*) in Canada. Species at Risk Act Recovery Strategy Series. Environment and Climate Change Canada, Ottawa, ON.
- Environment Canada. 2015. Wood Bison Recovery Strategy Development Meeting – Salt River First Nation, NT, unpublished summary of discussions. June 15, 2015. Environment and Climate Change Canada, Yellowknife, NT.
- Environment and Natural Resources (ENR). 2006. Dehcho Regional Wildlife Workshop, Fort Simpson, October 17-18, 2006. Environment and Natural Resources, Yellowknife, NT. 57 pp.
- Environment and Natural Resources (ENR). 2008. Dehcho Regional Wildlife Workshop, Fort Simpson, October 21-22, 2008. Environment and Natural Resources, Yellowknife, NT. 77 pp.
- Environment and Natural Resources (ENR). 2010a. 5th Biennial Dehcho Regional Wildlife Workshop, Fort Simpson, October 19-20, 2010. Environment and Natural Resources, Yellowknife, NT. 91 pp.
- Environment and Natural Resources (ENR). 2010b. Wood Bison Management Strategy for the Northwest Territories. Environment and Natural Resources, Yellowknife, NT. 32 pp.

- Environment and Natural Resources (ENR). 2012. 6th Biennial Dehcho Regional Wildlife Workshop, Fort Simpson, October 16-17, 2012. Environment and Natural Resources, Yellowknife, NT. 85 pp.
- Environment and Natural Resources (ENR). 2015. 2014 NWT fire season review report. Web site: www.gov.nt.ca/sites/ecc/files/web_pdf_fmd_2014_fire_season_review_report_4_may_2015.pdf [accessed 8 May 2025].
- Environment Canada. 2015a. Wood Bison Recovery Strategy development meeting – Behchoko, NT, unpublished summary of discussions. May 20, 2015. Environment Canada, Yellowknife, NT. 16 pp.
- Environment Canada. 2015b. Wood Bison Recovery Strategy development meeting – Fort Providence, NT, unpublished summary of discussions. June 18, 2015. Environment Canada, Yellowknife, NT. 15 pp.
- Environment Canada. 2015c. Wood Bison Recovery Strategy development meeting – Deninu K’ue First Nation, NT, unpublished summary of discussions. July 22, 2015. Environment Canada, Yellowknife, NT. 18 pp.
- Environment Canada. 2015d. Wood Bison Recovery Strategy development meeting – Kátł’odeeche First Nation, NT, unpublished summary of discussions. July 9, 2015. Environment Canada, Yellowknife, NT. 19 pp.
- Environment Canada. 2015e. Wood Bison Recovery Strategy development meeting – Salt River First Nation, NT, unpublished summary of discussions. June 15, 2015. Environment Canada, Yellowknife, NT. 18 pp.
- Evans, E., pers. comm. 2012. Telephone conversation with K. Benson. October 2012. Métis hunter, Fort Smith, NT.
- Fanni, A. 2014. Attitudes by Acho Dene Koe First Nation members towards the Nahanni Wood Bison Population. Unpublished report prepared for Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT. 19 pp.
- Ferguson, T.A. 1989. Native perspectives on the northern diseased bison issue: an outline. Northern Diseased Bison Environmental Assessment Panel, Federal Environmental Review Office, Vancouver, BC. 16 pp.
- Ferguson, T.A. and C. Burke. 1992. Aboriginal Communities and the Northern Buffalo Controversy. Pp. 189-206 in J. Foster, D. Harrison, and I.S. MacLaren (eds.). Buffalo. University of Alberta Press, Edmonton, AB. 258 pp.

- Ferguson, T.A. and F. Laviolette. 1992. A note on historical mortality in a northern wood bison population. *Arctic* 45 (1): 47-50.
- Fort Nelson First Nation and Shifting Mosaics Consulting (FNFN). 2015. Fort Nelson First Nation: Interaction with Fire and Wood Bison. Fort Nelson First Nation, Fort Nelson, BC. Website: https://fortnelsonfirstnation.org/wp-content/uploads/2024/07/dene_fire_project_booklet.pdf [accessed 4 March 2026].
- Gates, C.C., J. Mitchell, J. Wierzchowski, and L. Giles. 2001a. A landscape evaluation of wood bison movements and distribution in northern Canada. Canadian Wood Bison Association, Parks Canada, and the Department of Resources, Wildlife and Economic Development, Government of the Northwest Territories. AXYS Environmental Consulting Ltd. Calgary, AB. 115 pp.
- Gates, C.C., R.O. Stephenson, H.W. Reynolds, C.G. van Zyll de Jong, H. Schwantje, M. Hoefs, J. Nishi, N. Cool, J. Chisholm, A. James, and B. Koonz. 2001b. National Recovery Plan for the Wood Bison (*Bison bison athabascae*). National Recovery Plan No. 21. Recovery of Nationally Endangered Wildlife (RENEW), Ottawa, ON. 50 pp.
- Government of Canada. 2022. Report on the State of Conservation of Wood Buffalo National Park World Heritage Site (Canada), Property ID 256. In response to: World Heritage Committee Decision 44 Com 7B.190. 65 pp.
- Government of the Northwest Territories and Tłı̨cẖ Government. 2025. Government of the Northwest Territories and Tłı̨cẖ Government Joint Proposal on Increased Harvest of Mackenzie Wood Bison. Submitted to the Wek'èezhìi Renewable Resources Board. Website: www.wrrb.ca/sites/default/files/FINAL%20WRRB%20Management%20Proposal%20MackBisonHarvest_2025v.2.pdf
- Gunn, F.E. 2009. Traditional ecological knowledge of boreal woodland caribou in western Wood Buffalo National Park. M.A. dissertation, Royal Roads University, Victoria, BC. Publication No. AAT MR55878. 177 pp. Website: www.collectionscanada.gc.ca/obj/thesecanada/vol2/002/MR55878.PDF?oclc_number=747308269
- Heuer, K., J. Farr, L. Littlebear, and M. Hebblewhite. 2023. Reintroducing Bison to Banff National Park – an Ecocultural Case Study. *Frontiers in Conservation Science*. 4: 10.3389/fcosc.2023.1305932.

- Huntington, H., S. Fox, F. Berkes, I. Krupnik, A. Whiting, M. Zacharof, G. McGlashan, and M. Brubaker. 2005. *The Changing Arctic: Indigenous Perspectives*. Arctic Climate Impact Assessment 64: 61-98. Cambridge University Press, New York. 1042 pp.
- Joint Secretariat. 2015. *Inuvialuit and Nanuq: A Polar Bear Traditional Knowledge Study*. Joint Secretariat, Inuvik, NT. xx + 304 pp.
- Judas, J., pers. comm. 2024. In person conversation with A. Bathe. December 2024. WRRB Board Chair, Yellowknife, NT.
- Judge, C., A. Spring, and K. Skinner. 2022. A Comparative Policy Analysis of Wild Food Policies Across Ontario, Northwest Territories, and Yukon Territory, Canada. *Frontiers in Communication*. 7: 10.3389/fcomm.2022.780391.
- Jung, T.S. 2017. Extralimital movements of reintroduced bison (*Bison bison*): implications for potential range expansion and human-wildlife conflict. *European Journal of Wildlife Research*, 63(2):35.
- Jung, T.S. 2020. Investigating Local Concerns Regarding Large Mammal Restoration: Group Size in a Growing Population of Reintroduced Bison (*Bison bison*). *Global Ecology and Conservation*. Volume 24, December 2020, e01303. doi:10.1016/j.gecco.2020.e01303.
- Jung, T.S., T.M. Hegel, S.A. Stotyn, and S.M. Czetwertynski. 2015. Co-Occurrence of Reintroduced and Resident Ungulates on a Shared Winter Range in Northwestern Canada. *Écoscience*. 22 (1): 7–16. doi:10.1080/11956860.2015.1047133.
- Krutko, M., pers. comm. 2026. Email correspondence with J. Oosenbrug. March 2026. Renewable Resource Officer, Environment and Climate Change, Government of the Northwest Territories, Fort Providence, NT.
- Larter, N.C., pers. comm. 2016. Email correspondence with C. Singer. February and March 2016. Manager, Wildlife Research and Monitoring, Department of Environment and Natural Resources – Dehcho Region, Government of the Northwest Territories, Fort Simpson, NT.
- Larter, N.C. and D.G. Allaire. 2007. History and current status of the Nahanni wood bison population. File Report No. 136. Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT. 44 pp.
- Larter, N.C., A.R.E. Sinclair, T. Ellsworth, J. Nishi, and C.C. Gates. 2000. Dynamics of reintroduction in an indigenous large ungulate: the wood bison of northern Canada. *Animal Conservation* 2: 299–309. <https://doi.org/10.1111/j.1469-1795.2000.tb00115.x>.

- Larter, N.C., J.S. Nishi, T. Ellsworth, D. Johnson, G. More, and D.G. Allaire. 2003. Observations of wood bison swimming across the Liard River, Northwest Territories, Canada. *Arctic* 56:408-412.
- Lotenberg, G. 1996. History of wood bison in the Yukon: a reevaluation based on traditional knowledge and written records. Report submitted to Habitat Section of Yukon's Renewable Resources Department, September 10, 1996. 94 pp.
- Mackenzie Bison Working Group (MBWG). 2018. Mackenzie Bison Management Plan. Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT.
- Mackenzie Bison Working Group (MBWG), unpublished meeting notes. 2024. Mackenzie Bison Working Group meeting, Yellowknife, NT. July 31-August 1, 2024. 10 pp.
- Mackenzie Bison Working Group (MBWG), unpublished meeting notes. 2025. Mackenzie Bison Working Group meeting, Fort Providence, NT. April 8-9, 2025. 8 pp.
- Marcel, P., C. Whittaker, C. Candler, and the Athabasca Chipewyan First Nation Industrial Relations Corporation. 2012. Nih boghodi: We are the stewards of our land. Report produced for the Chipewyan First Nation, AB. 12 pp. Website: https://acfn.com/wp-content/uploads/2023/08/ACFN_Nih_Boghodi_2012_final.pdf [accessed 3 April 2025].
- Migwi, R., pers. comm. 2026. In conversation with the NWT Species at Risk Committee. April 2026. Elder and hunter/trapper, Behchokq, NT.
- Mikisew Cree First Nation (MCFN). 2014. Petition to the World Heritage Committee, Requesting Inclusion of Wood Buffalo National Park on the List of World Heritage in Danger. Government & Industry Relations, Mikisew Cree First Nation. 44 pp.
- Mitchell, J. 2002. A landscape evaluation of bison movements and distribution in northern Canada. M.E.D. Thesis, University of Calgary, Calgary, AB. 155 pp.
- Mitchell-Firth, E., pers. comm. 2025. Email correspondence with J. Oosenbrug. April 2025. Language consultant, E. Firth Business Services, Fort McPherson, NT.
- MNP LLP. 2024. Northwest Territories 2023 Wildfire Response Review – Final Report. Prepared for the Government of the Northwest Territories, Yellowknife, NT. 212 pp. Website: www.gov.nt.ca/sites/flagship/files/documents/1_nwt_wildfire_response_review_report_and_appendices_final_compressed-gk.pdf.
- Nahanni Bison Working Group (NBWG). 2019. Nahanni Bison Management Plan. Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT. File Report No. 153.

- Naiper, K., pers. comm. 2024. Email correspondence conversation with A. Bathe. December 2024. Language specialist, Edmonton, AB.
- Natcher, D., S. Ingraham, and A.M. Bogdan. 2022. Understanding the Nature of Country Food Sales among First Nations in Alberta, Canada. *Human Organization* 81 (4). Routledge: 368–79. doi:10.17730/1938-3525-81.4.368.
- Nishi, J., T.R. Ellsworth, D.W. Balsillie, B.T. Elkin, G.A. Wilson, and J. van Kessel. 2000. An overview of the Hook Lake Wood Bison Recovery Project: where have we come from, where are we now, and where would we like to go? Paper presented at the 2nd International Wood bison Conference. 20 pp.
- Northern Diseased Bison Environmental Assessment Panel. 1990a. Northern Diseased Bison Environmental Assessment Panel community technical: Volume A. Allwest Reporting Ltd., Vancouver, BC. 181 pp.
- Northern Diseased Bison Environmental Assessment Panel. 1990b. Northern Diseased Bison Environmental Assessment Panel community technical: Volume B. Allwest Reporting Ltd., Vancouver, BC. 453 pp.
- Novakowski, N.S. 1963. Wood bison transfer – completion report. Canadian Wildlife Service, Environment Canada, unpublished report. 5 pp.
- O'Connor, D. and Métis Nation of Alberta Association Local 1909 (MNAA). 2015. Métis Nation of Alberta Association Local 1909 Phase 1 Traditional Knowledge and Use Baseline Study Frontier Mine Project. Prepared by Willow Springs Strategic Solutions. 91 pp.
- Pembina Institute. 2016. Vulnerability Assessment of the Slave River and Delta: Summary report for the Community Workshop convened in Fort Smith, January 24-26, 2012. Report prepared by Jennifer Dagg, Pembina Institute for the Slave River and Delta Partnership, April 2016. Vancouver, B.C. 56 pp.
- Phelan, O. 2024. Merging Advanced Technologies with Traditional Knowledge for Species at Risk Protection, 5-year report (2019-2023). North Slave Métis Alliance, Yellowknife, NT. 55 pp.
- Polfus, J., M. Manseau, D. Simmons, M. Neyelle, W. Bayha, F. Andrew, L. Andrew, C. Klütsch, K. Rice, and P. Wilson. 2016. Łeghágots'enetę (Learning Together): The Importance of Indigenous Perspectives in the Identification of Biological Variation. *Ecology and Society*. 21 (2).

- Polfus, J., D. Simmons, M. Neyelle, W. Bayha, F. Andrew, L. Andrew, B. Merkle, K. Rice, and M. Manseau. 2017. Creative Convergence: Exploring Biocultural Diversity through Art. *Ecology and Society*. 22 (2).
- Puppe, I. 2025. Review of Remembering Our Relations: Dënesų́łné Oral Histories of Wood Buffalo National Park by Athabasca Chipewyan First Nation with S. Trimble and P. Fortna. *Canadian Journal of Native Studies*, 42(1). Website: <https://journals.brandonu.ca/cjnsoa/article/download/2877/701> [accessed 12 March 2026].
- Resources, Wildlife and Economic Development (RWED). 2004. Dehcho Regional Wildlife Workshop – Final Report, Fort Simpson, October 19-20, 2004. Resources, Wildlife and Economic Development, Yellowknife, NT. 65 pp.
- Reynolds, H.W., J.R. McGillis, and R. Glaholt. 1980. Range assessment of the Liard-South Nahanni rivers region, N.W.T. as habitat to wood bison. Canadian Wildlife Service, Edmonton, AB. 39 pp.
- Schramm, T. 2005. Woodland Cree traditional environmental knowledge of critical ungulate habitat in the Caribou Mountains of Alberta. Ph.D. Dissertation, University of Alberta, Edmonton, AB. 246 pp.
- Schramm, T. and N. Krogman. 2001. Project Report 2001-8: Caribou Mountains critical wildlife habitat and traditional ecological knowledge study. Sustainable Forest Management Network. University of Alberta, Edmonton, AB. 33 pp.
- Schramm, T., N. Krogman, R.J. Hudson, and M.M.R. Freeman. 2002. Project Report 2002-3: Caribou Mountains critical ungulate habitat and traditional ecological knowledge study: a GIS analysis. Sustainable Forest Management Network, University of Alberta, Edmonton, AB. 37 pp. Website: <https://era.library.ualberta.ca/items/12e8c608-2671-4e07-ae65-c914887e4b44>.
- SENES Consultants Ltd. 2010. Ekwé Hé Naidé: Living with Caribou — Traditional Knowledge Program 2005-2009, Preliminary Review of Management and Policy Implications. Prepared for the Sahtu Renewable Resources Board, Tulita, NT.
- Shury, T.K., J.S. Nishi, B.T. Elkin, and G.A. Wobeser. 2015. Tuberculosis and Brucellosis in Wood Bison (*Bison bison athabascae*) in Northern Canada: A Renewed Need to Develop Options for Future Management. *Journal of Wildlife Diseases*. 51 (3): 543-54.

- Slave River Lowlands Bison Working Group (SRLBWG). 2019. Slave River Lowlands Bison Management Plan. Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT.
- Slave River Lowlands Bison Working Group (SRLBWG), unpublished meeting notes. 2023. Slave River Lowlands Bison Working Group meeting, Fort Smith, NT. November 29, 2023. Environment and Climate Change, Government of the Northwest Territories, Fort Smith, NT. 6 pp.
- Slave River Lowlands Bison Working Group (SRLBWG), unpublished meeting notes. 2024. Slave River Lowlands Bison Working Group meeting, Fort Smith, NT. November 15, 2024. Environment and Climate Change, Government of the Northwest Territories, Fort Smith, NT. 8 pp.
- South Slave Divisional Education Council (SSDEC). 2009. *Dene Yatié K'éé Ahii Yats'uuzi Gha Edhhtléh Kát'odehche: South Slavey Topical Dictionary Kát'odehche Dialect*. Fort Smith, NT.
- South Slave Divisional Education Council (SSDEC). 2012. *Dëne Dédliné Yatié ?erehtíscho Denínu Kué Yatié: Chipewyan Dictionary*. Fort Smith, NT.
- Stephenson, R.O., S.C. Gerlack, R.D. Guthrie, C.R. Harington, G. Hare. 2001. Wood bison in late Holocene Alaska and adjacent Canada: paleontological, archaeological, and historical records. Pp. 125-159. *in* S.C. Gerlach and M. S. Murray (eds.). *People and Wildlife in Northern North America: Essay in Honor of R. Dale Guthrie*. BAR International Series 944, Oxford, UK.
- The Narwhal. 2023. Imminent Logging Threatens Alberta's Rare Bison Herd. Published 23 January 2023, by D. Anderson. Website: <https://thenarwhal.ca/wabasca-bison-habitat-logging-alberta> [accessed 3 April 2025].
- Thorpe, N. 2004. Codifying Knowledge about Caribou: The History of Inuit Qaujimajatuqangit in the Kitikmeot Region of Nunavut, Canada. *In* D.G Anderson and M. Nuttall (Eds.). *Cultivating Arctic Landscapes: Knowing and Managing Animals in the Circumpolar North*, 57–78. New York and Oxford: Berghahn Books.
- Tłıchq̓ Online Dictionary. Website: <https://tlichodictionary.ca> [accessed 9 May 2025].
- Tłıchq̓ Government and Firelight Research Inc. (TG and Firelight). 2025a. Tłıchq̓ Highway Wildlife Monitoring Report, Final Report: December 2021-February 2025. Tłıchq̓ Government, Behchok̓ò, NT. 37 pp.

- Tłıchq Government and Firelight Research Inc. (TG and Firelight). 2025b. Tłıchq Highway Wildlife Monitoring Report, Harvester Interviews. Tłıchq Government, Behchokò, NT. 68 pp.
- Tłıchq Research and Training Institute. 2016. Ekwò zò gha dzò nats'édè - "We Live Here For Caribou" Cumulative Impacts Study on the Bathurst Caribou. Behchokò, NT. 51 pp. Website: https://research.tlicho.ca/sites/default/files/ekwo_zo_gha_dzo_natsede_tk_study.pdf.
- van Kessel, J.C. 2002. Taking care of bison: community perceptions of the Hook Lake Wood Bison Recovery Project in Fort Resolution, NT, Canada. M.A. Thesis, University of Alberta, Edmonton, AB. 165 pp.
- Wells, G. 2014. Traditional Ecological Knowledge: A Model for Modern Fire Management? Joint Fire Science Program Digest, no. 20: 13. Website: www.nwfirescience.org/sites/default/files/publications/FSdigest20-1.pdf.
- Wiebe, H., pers. comm. 2025. Email correspondence to J. Oosenbrug. May 2025. Executive Director, Dehcho Land Use Planning Committee, Yellowknife, NT.
- Wildlife Area Regulations, C.R.C., c. 1609 (*Canada Wildlife Act*).
- Will, A. 2015. Resident Attitudes and Beliefs toward Bison, Disease and Management in Wood Buffalo National Park. PhD Thesis, Memorial University of Newfoundland. <https://research.library.mun.ca/8382/>.
- World Heritage Centre (WHC)/IUCN Reactive Monitoring Mission. 2022. Report on the Joint World Heritage Centre/IUCN Reactive Monitoring Mission to the World Heritage Property Wood Buffalo National Park (Canada). From 18 to 26 August, 2022. Submitted to World Heritage Centre/IUCN. 102 pp.

Scientific Knowledge Component

- Acevedo, C.A. and J.P. Barfield. 2023. Review: Reproductive physiology of bison and application of assisted reproductive technologies to their conservation. *Animal*, 17: 100842.
- Adams, L.G. and C.J. Schutta. 2010. Natural resistance against brucellosis: a review. *The Open Veterinary Science Journal* 4:61-71.
- Adler, P.H., D.C. Currie and D.M. Wood. 2004. *The Black Flies (Simuliidae) of North America*. Cornell University Press, Ithaca, NY. pp. 941.
- Aguirre, A.A., and E.E. Starkey. 1994. Wildlife disease in U.S. National Parks: historical and coevolutionary perspectives. *Conservation Biology*, 8:654–661).
- Agustí, J., L. Cabrera, M. Garces, W. Krijgsman, O. Oms, and J.M. Pares. 2001. A calibrated mammal scale for the Neogene of Western Europe. State of the art. *Earth-Science Review* 52:247-60.
- Alaska Department of Fish and Game (ADFG). 2015. Wood bison news. Website: www.adfg.alaska.gov/static/research/wildlife/species/woodbisonrestoration/pdfs/woodbison_news9_fall_2015.pdf [accessed 21 October 2024].
- Alaska Department of Fish and Game (ADFG). 2023. Wood bison restoration in Alaska, Status of the Herd Updates. Website: www.adfg.alaska.gov/index.cfm?adfg=woodbisonrestoration.herdupdates#woodbison2023 [accessed 21 October 2024].
- Alaska Department of Fish and Game (ADFG). 2024. Re-Wilding Wood Bison: Soft release, anchoring, and lessons learned. Alaska Fish & Wildlife News, Alaska Department of Fish and Game. Website: www.adfg.alaska.gov/index.cfm?adfg=wildlifeneews.view_article&articles_id=4109 [accessed 14 March 2026].
- Alberta Parks. 2026. Caribou Mountains Wildland Provincial Park, Parks Research and Management. Website: www.albertaparks.ca/parks/north/caribou-mountains-wpp/park-research-managemen t [accessed 14 March 2026].
- Allen, J.A. 1876. The American bison: living and extinct, memoirs of the Museum of Comparative Zoology 4(10). Harvard University Press, Cambridge, Massachusetts. 520pp.
- Allen, J.A. 1877. History of the American bison: *Bison americanus*. Washington: U.S. Government Printing Office. 587pp.
- Allen, J.A. 1877b. The northern range of the bison. *American Naturalist* 11:624.

- Animal and Plant Health Inspection Service (APHIS), United States Department of Agriculture. 2005. Bovine Tuberculosis eradication: Uniform methods and rules, effective January 1, 2005. APHIS 91-45-011. Washington, D.C. 28 pp.
- Animal, Plant and Food Risk Analysis Network (APFRAN). 1998. Risk assessment on bovine brucellosis and tuberculosis in Wood Buffalo National Park and area. Animal, Plant and Food Health Risk Assessment Network, Canadian Food Inspection Agency. 44 pp.
- Armstrong, T. 2010. 2008 Mackenzie wood bison population estimate. Unpublished report. Department of Environment and Natural Resources, Government of the Northwest Territories, Fort Smith, NT. 3pp.
- Armstrong, T. 2011. 2009 Slave River Lowlands wood bison population estimate. Unpublished report. Department of Environment and Natural Resources, Government of the Northwest Territories, Fort Smith, NT. 3pp.
- Armstrong, T. 2012. 2012 Survey of the Mackenzie bison population. Unpublished summary report. Letter from T. Armstrong, Bison Ecologist, Environment and Natural Resources, Government of the Northwest Territories, Fort Smith, NT. 2pp.
- Armstrong, T. 2013a. 2013 Mackenzie bison population composition survey. Department of Environment and Natural Resources, Government of the Northwest Territories, unpublished report. 2pp.
- Armstrong, T. 2013b. 2013 Mackenzie bison population estimate. Unpublished summary report. Letter from T. Armstrong, Bison Ecologist, Environment and Natural Resources, Government of the Northwest Territories, Fort Smith, NT. 2pp.
- Armstrong, T. 2014. Slave River Lowlands wood bison population estimate, 2014. Unpublished report. Environment and Natural Resources, Government of the Northwest Territories, Fort Smith, NT. 3pp.
- Armstrong, T. and J. Boulanger. 2016. Mackenzie wood bison population estimate, March 2016. Unpublished report. Environment and Natural Resources, Government of the Northwest Territories, Fort Smith, NT. 4pp.
- Armstrong, T. and J. Boulanger. 2016. Slave River Lowlands wood bison population estimate, 2016. Unpublished report. Environment and Natural Resources, Government of the Northwest Territories, Fort Smith, NT. 6pp.
- Armstrong, T. 2020. Report on 2019 Mackenzie bison population monitoring. Unpublished summary report. Letter from T. Armstrong, Bison Ecologist, Environment and Natural Resources, Government of the Northwest Territories, Fort Smith, NT. 3 pp.

- Armstrong, T. 2021. 2021 Nahanni wood bison population estimate. Unpublished summary report. Letter from T. Armstrong, Wildlife Biologist (Bison), Environment and Natural Resources, Government of the Northwest Territories. 3 pp
- Armstrong, T. 2024a. 2023 Mackenzie Bison Program. Unpublished summary report. Letter from T. Armstrong, Wildlife Biologist (Bison), Environment and Natural Resources, Government of the Northwest Territories, Fort Smith, NT. 2 pp.
- Armstrong, T. 2024b. 2024 Slave River Lowlands Bison Survey Results. Unpublished summary report. Letter from T. Armstrong, Wildlife Biologist (Bison), Environment and Natural Resources, Government of the Northwest Territories, Fort Smith, NT. 3 pp.
- Armstrong, T. 2025. 2025 Nahanni Wood Bison Population Estimate. Unpublished summary report. Letter from T. Armstrong, Wildlife Biologist (Bison), Environment and Natural Resources, Government of the Northwest Territories, Fort Smith, NT. 4 pp.
- Armstrong, T., pers. comm. 2025a. Comments on draft status report. December 2025. Wildlife Biologist (Bison), Wildlife Division, Department of Environment and Climate Change, Government of the Northwest Territories, Fort Smith, NT.
- Armstrong, T., pers. comm. 2025b. Telephone and email correspondence with T. Chowns. January 2025. Wildlife Biologist (Bison), Wildlife Division, Department of Environment and Climate Change, Government of the Northwest Territories, Fort Smith, NT.
- Armstrong, T., pers. comm. 2026. Email correspondence with J. Oosenbrug. March 2026. Wildlife Biologist (Bison), Wildlife Division, Department of Environment and Climate Change, Government of the Northwest Territories, Fort Smith, NT.
- Armstrong, T. and J. Boulanger. 2016. Slave River Lowlands 2016 Wood Bison Population Estimate. Unpublished report. Environment and Natural Resources, Fort Smith, NT. 6pp.
- Aune, K., C.C. Gates, and D. Boyd. 2010. Chapter 5: Reportable or notifiable diseases. Pp. 27-37, *in* C.C. Gates, C.H. Freese, P.J.P. Gogan, and M. Kotzman (eds.). American bison: status survey and conservation guidelines 2010. IUCN/SSC Bison Specialist Group. IUCN, Gland, Switzerland and Cambridge, United Kingdom. 134pp.
- Aune, K. and R. Wallen. 2010. Chapter 8: Legal Status, Policy Issues and Listings. Pp. 63–84, *in* C.C. Gates, C.H. Freese, P.J.P. Gogan, and M. Kotzman (eds.). American bison: status survey and conservation guidelines 2010. IUCN/SSC Bison Specialist Group. IUCN, Gland, Switzerland and Cambridge, United Kingdom. 134pp.

- Aurini, L., D. Whiteside, B.T. Elkin, and J. Thundathil. 2009. Recovery and cryopreservation of epididymal sperm of plains bison (*Bison bison bison*) as a model for salvaging the genetics of Wood Bison (*Bison bison athabasca*). *Reproduction in Domestic Animals* 44:815–822.
- B.C. Ministry of Water, Land and Resource Stewardship. 2022. Large ungulate abundance in British Columbia. Available online: https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/wildlife-wildlife-habitat/ungulates/2022_provincial_ungulate_population_estimates.pdf [accessed 14 March 2026].
- Babbage, G.W. 1969. Wood bison management, Isolation Area, Elk Island National Park. Parks Canada, unpublished report. 5pp.
- Baccus, R., N. Ryman, M.H. Smith, C. Reuterwall, and D. Cameron. 1983. Genetic variability and differentiation of large grazing mammals. *Journal of Mammalogy* 64:109-120.
- Bagamian, K.H., K.A. Alexander, T.L. Hadfield, and J.K. Blackburn. 2013. Ante-and postmortem diagnostic techniques for anthrax: rethinking pathogen exposure and the geographic extent of the disease in wildlife. *Journal of Wildlife Diseases* 49:786-801.
- Baker, K. 1974. Bison survey – Zones 3 and 5. March 12-16, 1974. Department of Environment and Natural Resources, Government of the Northwest Territories, unpublished report. 33pp.
- Bakhteeva, I. and V. Timofeev. 2022. Some peculiarities of anthrax epidemiology in herbivorous and carnivorous animals. *Life* 12(6) p.870.
- Ball, M.C., T.L. Fulton, and G.A. Wilson. 2016. Genetic analyses of wild bison in Alberta, Canada: implications for recovery and disease management. *Journal of Mammalogy* 97 (6):1525–1534.
- Baltzer, J.L., S. Haché, J. Hodson, M.R. Ahmed, S. Carrière, M. Coyle, E.J.B. McIntire, A. McLaren, E. Riordan-Short, M.R. Turetsky, J. van der Sluijs, J. Wilson, and B.K. Woodworth. 2025. Impacts of novel wildfire disturbance on landcover and wildlife in boreal North America. *Frontiers in Environmental Science*, 13:1504568.
- Banfield, A.W. and N.S. Novakowski. 1960. The survival of the wood bison (*Bison bison athabasca* Rhoads) in the Northwest Territories. National Museum of Canada. Natural History Papers No. 8. 6pp.
- Barandongo, Z. R., A. C. Dolfi, S. A. Bruce, K. Rysava, Y-H. Huang, H. Joel, A. Hassim, P. L. Kamath, H. van Heerden, and W. C. Turner. 2023. The Persistence of Time: The Lifespan of *Bacillus anthracis* Spores in Environmental Reservoirs. *Research in Microbiology*, 174 (6): 104029.

- Bednarski, J.M. 2008. Landform assemblages produced by the Laurentide Ice Sheet in northeastern British Columbia and adjacent Northwest Territories—constraints on glacial lakes and patterns of ice retreat. *Canadian Journal of Earth Sciences* 45:593-610.
- Belanger, R.J., M.A. Edwards, L.N. Carbyn, and S.E. Nielsen. 2020. Evaluating trade-offs between forage, biting flies, and footing on habitat selection by wood bison (*Bison bison athabascae*). *Canadian Journal of Zoology* 98:254-261.
- Beltaos, S., T.D. Prowse and T. Carter. 2006. Ice regime of the lower Peace River and ice-jam flooding of the Peace-Athabasca Delta. *Hydrological Processes* 20:4009–4029.
- Benedict, B.M. and P.S. Barboza. 2022. Adverse effects of Diptera flies on northern ungulates: *Rangifer*, *Alces*, and *Bison*. *Mammal Review* 52:425-437.
- Berezowski, J.A., G.D. Appleyard, T.B. Crawford, J. Haigh, H. Li, D.M. Middleton, B.P. O'Connor, K. West, and M. Woodbury. 2005. An Outbreak of Sheep-Associated Malignant Catarrhal Fever in Bison (*Bison Bison*) after Exposure to Sheep at a Public Auction Sale. *Journal of Veterinary Diagnostic Investigation*, 17(1).
- Berger, J. and C. Cunningham. 1994. Bison: Mating and conservation in small populations. *Methods and Cases in Conservation Science*. Columbia University Press, New York. 330pp.
- Bergman, C.M., J.M. Fryxell and C.C. Gates. 2000. The effect of tissue complexity and sward height on the functional response of wood bison. *Functional Ecology* 14:61–69.
- Bergman, C.M., J.M. Fryxell, C.C. Gates and D. Fortin. 2001. Ungulate foraging strategies: energy maximizing or time minimizing? *Journal of Animal Ecology* 70:289–300.
- Bergmann, G.T., J.M. Craine, M.S. Robeson and N. Fierer. 2015. Seasonal shifts in diet and gut microbiota of the American bison (*Bison bison*). *PloS one*, 10(11), p.e0142409.
- Bernard, J.M. and F.A. Bernard. 1977. Winter standing crop and nutrient contents in five central New York wetlands. *Bulletin of the Torrey Botanical Club* 104:57-59.
- Bernard, J.M. and G. Hankinson. 1979. Seasonal changes in standing crop and nutrient levels in a *Carex rostrata* wetland. *Oikos* 32:328-336.
- Bernard, J.M., D. Solander, and J. Kvet. 1988. Production and nutrient dynamics in *Carex* wetlands. *Aquatic Botany* 30:125-147.
- Bibi, F. 2007. Origin, paleoecology, and paleobiogeography of early Bovini. *Palaeogeography Palaeoclimatology and Palaeoecology* 248:60-72
- Bierer, B.W. 1974. History of animal plagues of North America: With occasional reference to other diseases and diseased conditions. U.S. Department of Agriculture, Washington, D.C.

- Bigelow, N.H., L.B. Brubaker, M.E. Edwards, S.P. Harrison, I.C. Prentice, P.M. Anderson, A.A. Andreev, P.J. Bartlein, T.R. Christensen, W. Cramer, J.O. Kaplan, A.V. Lozhkin, N.V. Matveyeva, D.F. Murray, A.D. McGuire, V.Y. Razzhivin, J.C. Ritchie, B. Smith, D.A. Walker, K. Gajewski, V. Wolf, B.H. Holmqvist, Y. Igarashi, K. Kremenetskii, A. Paus, M.F.J. Pisaric, and V.S. Volkova. 2003. Climate change and Arctic ecosystems: 1. Vegetation changes north of 55° N between the last glacial maximum, mid-Holocene, and present. *Journal of Geophysical Research*, 108(D19), 8170, doi:10.1029/2002JD002558.
- Bill, K.E., C.M. Dieleman, J.L. Baltzer, G.É. Degré-Timmons, M.C. Mack, N.J. Day, S.G. Cumming, X.J. Walker, and M.R. Turetsky. 2023. Post-fire Recovery of Soil Organic Layer Carbon in Canadian Boreal Forests. *Ecosystems*, 26(8): 1623-1639.
- Bison Integrated Genomics (BIG) Project. 2022. Website: www.bigproject.ca [accessed 11 December 2024].
- Bjorge, R.R. and J.R. Gunson. 1989. Wolf, *Canis lupus*, population characteristics and prey relationships near Simonette River, Alberta. *Canadian Field-Naturalist* 103:327-334.
- Blanchet, G.H. 1926. Great Slave Lake area Northwest Territories. Department of the Interior, Government of Canada. 58pp.
- Bonsal, B., B. Tam, X. Zhang, G. Li, L. Philips, and R. Rong. 2024. Do meteorological, agricultural, and hydrological indicators all point to an increased frequency and intensity of droughts across Canada under a changing climate? *Atmosphere-Ocean* 62:372–390.
- Boonstra, R., D. Hik, G.R. Singleton, and A. Tinnikov. 1998. The impact of predator-induced stress on the snowshoe hare cycle. *Ecological Monographs* 79(5):371-394.
- Borghans, J.A.M., J.B. Beltman, and R.J. De Boer. 2004. MHC polymorphism under host-pathogen coevolution. *Immunogenetics* 55:732–739.
- Bork, A.M., C.M. Strobeck, F.C. Yeh, R.J. Hudson, and R.K. Salmon, 1991. Genetic relationship of wood and plains bison based on restriction fragment length polymorphisms. *Canadian Journal of Zoology* 69:43-48.
- Bothwell, P.M., W.J. De Groot, D.E. Dube, T. Chowns, D.H. Carlsson, and C.N. Stefner. 2004. Fire regimes in Nahanni National Park and the Mackenzie Bison Sanctuary, Northwest Territories, Canada. Pp. 43-54, in R.T Engstrom, K.E.M. Galley, and W.J. de Groot (eds.). *Proceedings of the 22nd Tall Timbers Fire Ecology Conference: Fire in temperate, boreal and montane ecosystems*. Tallahassee, Florida: Tall Timbers Research Station. 333 pp.
- Boyd, D.P. 2003. Conservation of North American bison: status and recommendations. M.E.D. dissertation, University of Calgary, Calgary. 222 pp.

- Boyd, D.P., G.A. Wilson, J.N. Derr, and N.D. Halbert. 2010a. Chapter 4: Genetics. Pp. 19–26, in C.C. Gates, C. H. Freese, P.J.P. Gogan, and M. Kotzman (eds.). American bison: status survey and conservation guidelines 2010. IUCN/SSC Bison Specialist Group. IUCN, Gland, Switzerland and Cambridge, United Kingdom. 134 pp.
- Boyd, D.P., G.A. Wilson, and C.C. Gates. 2010b. Chapter 3: Taxonomy and nomenclature. Pp. 13–18, in C.C. Gates, C. H. Freese, P.J.P. Gogan, and M. Kotzman (eds.). American bison: status survey and conservation guidelines 2010. IUCN/SSC Bison Specialist Group. IUCN, Gland, Switzerland and Cambridge, United Kingdom. 134 pp.
- Braack, L. and V. De Vos. 1990. Feeding habits and flight range of blow-flies (*Chrysomyia* spp.) in relation to anthrax transmission in the Kruger National Park, South Africa. *Onderstepoort Journal of Veterinary Research* 57:141–142.
- Bradley, M., T. Ellsworth, and L. Kearney. 1998. Fort Providence moose census, November/December 1994. Department of Environment and Natural Resources, Government of the Northwest Territories. Manuscript Report No. 104. 15 pp.
- Bradley, M. and F. Johnson. 2000. Fort Providence Moose Census, November/December 1997. Department of Environment and Natural Resources, Government of the Northwest Territories. Manuscript Report No. 135. 16 pp.
- Bradley, M. and J. Wilmshurst. 2005. The fall and rise of bison populations in Wood Buffalo National Park: 1971 to 2003. *Canadian Journal of Zoology* 83:1195-1205.
- Brand, C.J., M.J. Pybus, W.B. Ballard, and R.O. Peterson. 1995. Infectious and parasitic diseases of the gray wolf and their potential effects on wolf populations in North America. Pp. 419–429, in L.N. Carbyn, S.H. Fritts and D.R. Seip (eds.). *Ecology and conservation of wolves in a changing world*. Occasional Publication No. 35. Canadian Circumpolar Institute, Edmonton, AB. 620 pp.
- Brett, R. and O. Melnik. 2023. 2023. Northwest Territories forest health report. Environment and Natural Resources, Government of Northwest Territories. 49 pp.
- B.C. Conservation Data Centre (BC-CDC). 2023. Conservation Status Report: *Bos bison athabascae*. B.C. Ministry of Environment. Website: <https://a100.gov.bc.ca/pub/eswp/> [accessed 2 November 2024].
- Brock, B.E., B.B. Wolfe, and T.W.D. Edwards. 2008. Spatial and temporal perspectives on spring break-up flooding in the Slave River Delta, NWT. *Hydrological Processes* 22:4058-4072.

- Broughton E. 1987. Diseases affecting bison. Pp. 34-38 in H.W. Reynolds and A.W.L. Hawley (eds.). Bison ecology in relation to agricultural development in the Slave River Lowlands, N.W.T. Occasional Paper No.63, Ottawa, On. 72 pp.
- Broughton, E. 1992. Anthrax in bison in Wood Buffalo National Park. Canadian Veterinary Journal 33:134-135.
- Brown, V.H. 2012. Ice stream dynamics and pro-glacial lake evolution along the north-western margin of the Laurentide Ice Sheet. Ph.D. dissertation, Durham University, Durham, UK.
- Bruggeman J.E., R.A. Garrott, P.J. White, D.D. Bjornlie, F.G.R. Watson, and J.J. Borkowski. 2009. Effects of snow and landscape attributes on bison winter travel patterns and habitat use. Pp. 623–647, in R.A. Garrott, P.J. White, and F.G.R. Watson (eds.). The Ecology of Large Mammals in Central Yellowstone: sixteen years of integrated field studies. San Diego, CA: Academic Press. 712pp.
- Buckland, S.T., D.R. Anderson, K.P. Burnham, J.L. Laake, D.L. Borchers, and L. Thomas. 2001. Introduction to Distance Sampling. Oxford University Press. 432pp.
- Buergelt, C.D., A.W. Layton, P.E. Ginn, M. Taylor, J.M. King, P.L. Habecker, E. Mauldin, R. Whitlock, C. Rossiter, and M.T. Collins. 2000. Paratuberculosis in the North American bison (*Bison bison*). Veterinary Pathology 37:428–38.
- Buitrago Gutierrez, S. 2024. The role of forage quantity and quality in the migration and diet of a northern ungulate during their neonatal period. M.Sc. dissertation, University of Alberta, Edmonton. 38pp.
- Buntjer, J.B., M. Otsen, I.J. Nijman, M.T.R. Kuiper, and J.A. Lenstra. 2002. Phylogeny of bovine species based on AFLP fingerprinting. Heredity 88:46-51.
- Butler, W.F. 1873. The wild north land: being the story of a winter journey, with dogs, across northern North America. London: S. Low, Marston, Low and Searle. 358pp.
- Calef, G.W. 1975. Bison census – Game Management Zones 3 and 5. March 31 – April 2, 1975. Department of Environment and Natural Resources, Government of the Northwest Territories, unpublished report. 11pp.
- Calef, G.W. 1976. Status of bison in the N.W.T. Progress report. Department of Environment and Natural Resources, Government of the Northwest Territories, unpublished report. 74pp.
- Calef, G.W., pers. comm. 1985. In-person conversation with T. Chowns. January 1980. Biologist, Fish and Wildlife Service, Department of Natural and Cultural Affairs. Government of the Northwest Territories, Yellowknife, NT.

- Calef, G.W. 1984. Population growth in an introduced herd of wood bison (*Bison bison athabasca*). Pp.183-200, in Olson, R., Hastings, R. and F. Geddes (eds.). Northern ecology and resource management. University of Alberta Press, Edmonton, AB.
- Calef, G.W. and J. Van Camp. 1987. Seasonal distribution, group size and structure, and movements of bison herds. Pp. 15-20, in Reynolds, H.W. and A.W.L. Hawley (eds.). Bison Ecology in Relation to Agricultural Development in the Slave River Lowlands, N.W.T. Occasional Paper No.63, Ottawa, ON. 72pp.
- Cameron, A.E. 1922. Post Glacial Lakes in the Mackenzie River Basin N.W.T. Canada. The Journal of Geology 30:337-353.
- Campbell, B.H. and M. Hinkes. 1983. Winter diets and habitat use of Alaska bison after wildfire. Wildlife Society Bulletin 11:16-21.
- Camsell, C. 1917. Salt and gypsum deposits in district between Peace and Slave rivers, northern Alberta. Geological survey of Canada summary report for 1916. Pp. 134–145.
- Canada Gazette. 2013. Archived – Vol. 147, No. 12 – June 5, 2013. Website: www.gazette.gc.ca/rp-pr/p2/2013/2013-06-05/html/si-tr59-eng.php [accessed 18 August 2013].
- Canada National Parks Act (S.C. 2000, c.32).
- Canadian Food Inspection Agency (CFIA). 2012. Website: www.inspection.gc.ca [accessed September 24, 2012].
- Canadian National Fire Database (CNFDB). 2023. Website: <https://cwfis.cfs.nrcan.gc.ca/ha/nfdb?type=nbac&year=9999> [accessed 9 May 2025].
- Canadian Parks and Wilderness Society (CPAWS). 2024. Bison in Alberta. Website: <https://cpawsnab.org/our-work/wildlife-species-at-risk/bison-conservation> [accessed 10 October 2024].
- Cannon, K. 2001. What the past can provide: contribution of prehistoric bison studies to modern bison management. Great Plains Research 11:145-74.
- Cannon, K.P. 2007. "They went as high as they choose:" What an isolated skull can tell us about the biogeography of high-altitude bison. Arctic, Antarctic, and Alpine Research 39:44-56.
- Carbyn, L.N. 1983. Wolf predation on elk in Riding Mountain National Park, Manitoba. Journal of Wildlife Management 47:963-976.
- Carbyn, L.N. and T. Trottier. 1987. Responses of bison on their calving grounds to predation by wolves in Wood Buffalo National Park. Canadian Journal of Zoology 65:2072-2078.

- Carbyn, L.N. and T. Trottier. 1988. Description of wolf attacks on bison calves in Wood Buffalo National Park. *Arctic* 41:297-302.
- Carbyn, L.N., N. Lunn, and K. Timoney. 1998. Trends in the distribution and abundance of bison in Wood Buffalo National Park. *Wildlife Society Bulletin* 26:463-470.
- Carbyn, L.N., S.M. Oosenbrug, and D.W. Anions. 1993. Wolves, bison and the dynamics related to the Peace-Athabasca Delta in Canada's Wood Buffalo National Park. *Circumpolar Research Series No. 4*. Canadian Circumpolar Institute, University of Alberta, Edmonton, AB.
- Carey, J.R. 1993. *Applied demography for biologists*. Oxford University Press, New York. 224pp.
- Case, L., A. McLaren, and T. Armstrong. 2025. *Bison Control Area Program Annual Report 2022/2023*. Department of Environment and Climate Change, Government of the Northwest Territories. Manuscript Report No. 334. 19 pp.
- Case, T.J. 1979. Optimal body size and an animal's diet. *Acta Biotheoretica* 28:54-69.
- Caughley, G. 1976. Wildlife management and the dynamics of ungulate populations. *Applied Biology* 1:183-246.
- Caughley, G. 1970. Eruption of ungulate populations with emphasis on Himalayan thar in New Zealand. *Ecology* 51:53-72.
- Caughley, G. 1979. What is this thing called carrying capacity? Pp. 2-8, *in* M.S. Boyce and L.D. Harden-Wing (eds.). *North American elk: ecology, behavior and management*. University of Wyoming, Laramie, Wyoming.
- CBC News. 2013. More Alberta bison to roam Russia. 23 September, 2013.
- Chen, S. and R.S. Morley. 2005. Observed herd size and animal association. *Ecological Modeling* 189:425-435.
- Chenery, E.S., N.J. Harms, H. Fenton, N.E. Mandrak, and P.K. Molnár. 2023. Revealing large-scale parasite ranges: an integrated spatiotemporal database and multisource analysis of the winter tick. *Ecosphere* 14:p.e4376.
- Choquette, L.P.E. and E. Broughton. 1981. Anthrax. Pp. 288-296, *in* J.W. Davis, L.H. Carstad and D.O. Trainer (eds.). *Infectious Diseases of Wild Mammals*. Second edition. Iowa State University Press, Ames, Iowa.
- Choquette, L.P.E., E. Broughton, A.A. Courier, J.G. Cousineau, and N.S. Novakowshi. 1972. Parasites and diseases of bison in Canada. III. Anthrax outbreaks in the last decade in northern Canada and control measures. *Canadian Field-Naturalist* 86:127-132.

- Choquette, L.P., E. Broughton, J.G. Cousineau, and N.S. Novakowski. 1978. Parasites and diseases of bison in Canada IV. Serologic survey for brucellosis in bison in northern Canada. *Journal of Wildlife Diseases* 14:329-332.
- Chowns, T. 1979. Wildlife Sighting appendix to Wildlife Officer Monthly Report (Fort Smith Region), March 1979. Department of Environment and Natural Resources, Government of the Northwest Territories, unpublished report.
- Chowns, T. 1986. Bison habitat types: Mink Lake area. Department of Environment and Natural Resources, Government of the Northwest Territories, unpublished report. 21pp.
- Chowns, T. 1987. Seasonal changes in distribution of wood bison in the Mackenzie Bison Sanctuary. Environment and Natural Resources File Report No. 67.
- Chowns, T. 1988. Wildlife Sighting appendix to Wildlife Officer Monthly Report (Fort Smith Region), July 1988. Department of Environment and Natural Resources, Government of the Northwest Territories, unpublished report.
- Chowns, T. 1990. Hudson Bay Company Fort of the Forks (Fort Simpson) Mackenzie District account books and journals 1822-1871. Unpublished data provided by T. Chowns. 1990. Department of Environment and Natural Resources, Government of the Northwest Territories.
- Chowns, T. 1992. Mackenzie bison range ten-year prescribed burn proposal. Department of Environment and Natural Resources, Government of the Northwest Territories, unpublished report. 7 pp.
- Chowns, T. 1995. Wildlife Sighting appendix to Wildlife Officer Monthly Report (Fort Smith Region), Aug. 1995. Department of Environment and Natural Resources, Government of the Northwest Territories, unpublished report.
- Chowns, T. 1996. Wildlife Sighting appendix to Wildlife Officer Monthly Report (Fort Smith Region), Feb. 1996. Department of Environment and Natural Resources, Government of the Northwest Territories, unpublished report.
- Chowns, T. 1997. Wildlife Sighting appendix to Wildlife Officer Monthly Report (Fort Smith Region), July 1997. Department of Environment and Natural Resources, Government of the Northwest Territories, unpublished report.
- Chowns, T. 2002. Fort Providence fire history study. Department of Environment and Natural Resources, Government of the Northwest Territories, unpublished report. 39 pp.
- Chowns, T., pers. comm. 2025. Telephone and email correspondence with J. Oosenbrug, NWT Species at Risk Secretariat. Consultant, Powassan, ON.

- Chowns, T. and R. Graf. 1987. Numbers and distribution of the Mackenzie wood bison herd, March 1983. Environment and Natural Resources File Report No. 68.
- Chowns, T., C.C. Gates, and F. Lepine. 1998. Large scale fire burning to improve wood bison habitat in northern Canada. Pp. 205–210, in L. Irby and J. Knight (eds.). International Symposium on Bison Ecology and Management in North America. Montana State University, Bozeman, MT.
- Christman, G.M. 1971. The mountain bison. *American West* 8:44-47.
- Christopherson, R.J., R.J., Hudson, and R.G. Richmond. 1978. Comparative winter bioenergetics of American bison, yak, Scottish highland and Hereford calves. *Acta Theriologica* 23:49-54.
- Cizauskas, C.A., S.E. Bellan, W.C. Turner, R.E. Vance, and W.M. Getz. 2014. Frequent and seasonally variable sublethal anthrax infections are accompanied by short-lived immunity in an endemic system. *Journal of Animal Ecology* 83:1078–1090.
- Clark, D.A., L. Workman, and T.S. Jung. 2016. Impacts of reintroduced bison on First Nations people in Yukon, Canada: finding common ground through participatory research and social learning. *Conservation and Society* 14:1-12.
- Coder, G.D. 1975. The national movement to preserve the American buffalo in the United States and Canada between 1880 and 1920. Ph.D. dissertation, Ohio State University, Columbus. 348pp.
- Collins, M. 2021. Paratuberculosis in ruminants (Johne's Disease). Website: www.merckvetmanual.com/digestive-system/intestinal-diseases-in-ruminants/paratuberculosis-in-ruminants. [accessed 18 October 2024].
- Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2013. COSEWIC assessment and status report on the Plains Bison *Bison bison bison* and the Wood Bison *Bison bison athabascae* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xv + 109 pp.
- Conference of Management Authorities (CMA). 2019. Recovery Strategy for Wood Bison (*Bison bison athabascae*) in the Northwest Territories. Conference of Management Authorities, Yellowknife, NT.
- Conference of Management Authorities (CMA). 2025. Progress Report on the Recovery of Wood Bison (*Bison bison athabascae*) in the Northwest Territories (2020–2024). Conference of Management Authorities, Yellowknife, NT.
- Coppedge, B.R. and J.H. Shaw. 1998. Bison grazing patterns on seasonally burned tallgrass prairie. *Journal of Range Management* 51:258–264.

- Coppoletta, M., K.E. Merriam, and B.M. Collins. 2016. Post-fire vegetation and fuel development influences fire severity patterns in reburns. *Ecological Applications* 26:686–699.
- Corbet, G.B. and J.E. Hill, 1991. A world list of mammalian species (3rd edition). Natural History Museum Publications. 243 pp.
- Cordes, L.D. 1975. Vegetation change in the Peace-Athabasca Delta, 1970-1974. Parks Canada unpublished report. 186pp.
- COSEWIC. 2002. COSEWIC assessment and update status report on the woodland caribou *Rangifer tarandus caribou* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 98pp.
- COSEWIC. 2020. Guidelines for Recognizing Designatable Units, approved by COSEWIC in November 2020. Website: <https://cosewic.ca/index.php/en/reports/preparing-status-reports/guidelines-recognizing-designatable-units.html> [accessed 28 November 2024].
- COSEWIC. 2021. COSEWIC Assessment Process, Categories and Guidelines, Approved by COSEWIC in November 2021. Committee on the Status of Endangered Wildlife in Canada (COSEWIC), Ottawa, ON. 19 pp. Website: https://cosewic.ca/images/cosewic/pdf/Assessment_process_criteria_Nov_2021_en.pdf [accessed 10 November 2024].
- Courant, S. and D. Fortin. 2012. Time allocation of bison in meadow patches driven by potential energy gains and group size dynamics. *Oikos* 121:1163-1173.
- Coyle, M. 2018. NWT Fire History (1965-2017). Website: www.geomatics.gov.nt.ca/sites/geomatics/files/resources/nwt_firehistory_2017_highres.pdf. [accessed 6 May 2025].
- Craig, B.G. 1965. Glacial Lake McConnell and the surficial geology of parts of Slave River and Redstone River map-areas, District of Mackenzie. Geological Survey of Canada, Bulletin 122.
- Creager, J.S. and D.A. McManus. 1967. Geology of the floor of Bering and Chukchi Seas - American studies. Pp. 7-31, in D.M. Hopkins (ed.). *The Bering Land Bridge*. Stanford University Press, Stanford.
- Cronin, M.A. and N. Cockett. 1993. Kappa-casein polymorphisms among cattle breeds and bison herds. *Animal Genetics* 24:135–138.
- Cronin, M.A., M.D. MacNeil, N. Vu, V. Leesburg, H.D. Blackburn, and J.N. Derr. 2013. Genetic variation and differentiation of bison (*Bison bison*) subspecies and cattle (*Bos taurus*) breeds and subspecies. *Journal of Heredity* 104:500-509.

- Crosbie, M.L. 1978. The nature and origin of the deposits in canyons of the Ram Plateau, Northwest Territories, Canada. Ph.D. dissertation, McMaster University, Hamilton. 167pp.
- Currie, D.C. 2014. Black flies (Diptera: Simuliidae) of the prairie grasslands of Canada. Pp.371-387, *in* H.A. Cárcamo and D.J. Giberson (eds.). *Arthropods of Canadian Grasslands*. Vol 3: Biodiversity and Systematics Part 1. Biological Survey of Canada.
- Cwynar, L.C. and R.W. Spear. 1995. Paleovegetation and paleoclimatic changes in the Yukon at 6 ka BP. *Géographie Physique et Quaternaire* 49:29–35.
- Dahl-Jensen, D., K. Mosegaard, N. Gundestrup, G.D. Clow, S.J. Johnsen, A.W. Hansen, and N. Balling. 1998. Past temperatures directly from the Greenland ice sheet. *Science* 282:268-271.
- Damman, A.W.H. 1979. Geographic patterns in peatland development in eastern North America. pp. 42-57, *in* E. Kivinen, L. Heikurainen, and P. Pakarinen (eds.). *Classification of peat and peatlands*. Proceedings of the International Peat Society Symposium, Hyytiala, Finland, 1979. International Peat Society, Helsinki.
- Dancose, K., D. Fortin, and X. Guo. 2011. Mechanisms of functional connectivity: the case of free-ranging bison in a forest landscape. *Ecological Applications* 21:1871-1885.
- Dary, D. 1989. *The Buffalo Book*. The full saga of the American Animal. Swallow Press/Ohio University Press. 434pp.
- Dawe, D.A., M.A. Parisien, A. Van Dongen, and E. Whitman. 2022. Initial succession after wildfire in dry boreal forests of northwestern North America. *Plant Ecology* 223:789-809.
- Dawson, G.M. 1881. Report of an exploration from Port Simpson on the Pacific Coast, to Edmonton on the Saskatchewan. Report of Progress for Geological Survey of Canada 1879-80. 177pp.
- Day, J.H. 1966. Reconnaissance soils survey of the Liard River Valley, Northwest Territories. Canada Department of Agriculture, Research Branch.
- Day, J.H. 1968. Soils of the upper Mackenzie River area, Northwest Territories. Canada Department of Agriculture, Research Branch.
- Day, J.H. 1972. Soils of the Slave River Lowland in the Northwest Territories. Canada Department of Agriculture, Research Branch.
- Day, N.J., J.F. Johnstone, K.A. Reid, S.G. Cumming, M.C. Mack, M.R. Turetsky, X.J. Walker, and J.L. Baltzer. 2023. Material legacies and environmental constraints underlie fire resilience of a dominant boreal forest type. *Ecosystems* 26:473-490.

- Delgiudice, G.D., F.J. Singer, U.S. Seal, and G. Bowser. 1994. Physiological responses of Yellowstone bison to winter nutritional deprivation. *Journal of Wildlife Management* 58:24-34.
- DeMars, C.A., S.E. Nielsen, and M.A. Edwards. 2020. Effects of linear features on resource selection and movement rates of wood bison (*Bison bison athabascae*). *Canadian Journal of Zoology* 98:21-31.
- Department of Environment and Climate Change (ECC). 2024a. NWT wood bison population sizes estimated from aerial surveys. Unpublished data provided by T. Armstrong. Environment and Climate Change, Government of the Northwest Territories, Fort Smith, NT.
- Department of Environment and Climate Change (ECC). 2024b. Vehicle-bison collisions. Unpublished data provided by T. Armstrong. Environment and Climate Change, Government of the Northwest Territories, Fort Smith, NT.
- Department of Infrastructure (INF), unpubl. data. 2026. Annual number of vehicles travelling on Highway #3 at or near Fort Providence during nighttime (2001-2025). Unpublished data provided by R. Thom. Email to J. Oosenbrug, 9 March 2026. Government of the Northwest Territories, Yellowknife, NT.
- Derksen, C., D., Burgess, C., Duguay, S., Howell, L., Mudryk, S., Smith, C. Thackeray, and M. Kirchmeier-Young. 2019. Chapter 5: Changes in snow, ice, and permafrost across Canada. Pp. 194–260, in E. Bush and D.S. Lemmen (eds.). *Canada's Changing Climate Report*, Government of Canada, Ottawa.
- Derr, J.N., P.W. Hedrick, N.D. Halbert, L. Plough, L.K. Dobson, J. King, C. Duncan, D.L. Hunter, N.D. Cohen, and D. Hedgecock. 2012. Phenotypic effects of cattle mitochondrial DNA in American Bison. *Conservation Biology*. doi: 10.1111/j.1523-1739.2012.01905.x
- Dewart, L. 2023. Window of opportunity: examining gray wolf (*Canis lupus*) diets and seasonal patterns of predation on wood bison (*Bison bison athabascae*). M.Sc. dissertation, University of Alberta, Edmonton. 46pp.
- De Vos, V. The Isolation of Viable and Pathogenic *Bacillus anthracis* Organisms from 200-Year-Old Bone Fragments from the Kruger National Park in Proceedings of the ARC-Onderstepoort OIE International Congress with WHO-Cosponsorship on Anthrax, Brucellosis, CBPP, Clostridial and Mycobacterial Diseases, 9–15 August, Berg-en-Dal, Kruger National Park, 22–24. Pretoria: Sigma Press, 1998.

- Dirschl, H., D.C. Dabbs, and G. Gentle. 1974. Landscape classification and plant successional trends: Peace-Athabasca Delta. Canadian Wildlife Service Report Series No. 30. 34pp.
- Dobson, A. and M. Meagher. 1996. The population dynamics of brucellosis in the Yellowstone National Park. *Ecology* 77:1026–1036.
- Doughty, C.E., A. Wolf, and C.B. Field. 2010. Biophysical feedbacks between the Pleistocene megafauna extinction and climate: The first human induced global warming? *Geophysical Research Letters* 37: L15703. doi:10.1029/2010GL043985.
- Douglas, K.C. 2006. Comparing the genetic diversity of late Pleistocene Bison with Modern *Bison bison* using ancient DNA techniques and the mitochondrial DNA control region. M.S. dissertation, Baylor University, Waco, Texas.
- Douglas, K.C., N.D. Halbert, C. Kolenda, C. Childers, D.L. Hunter, and J.N. Derr. 2011. Complete mitochondrial DNA sequence analysis of *Bison bison* and bison–cattle hybrids: Function and phylogeny. *Mitochondrion* 11:166-175.
- Dragon, D.C., B.T. Elkin, J.S. Nishi, and T.R. Ellsworth. 1999. A review of anthrax in Canada and implications for research on the disease in northern bison. *Journal of Applied Microbiology* 87:208-213.
- Dragon, D.C. and B.T. Elkin. 2001. An overview of early anthrax outbreaks in northern Canada: field reports of the Health of Animals Branch, Agriculture Canada, 1962–71. *Arctic* 54:32-40.
- Dragon, D.C. and R.P. Rennie. 1995. The ecology of anthrax spores: tough but not invincible. *Canadian Veterinary Journal*. 36:295-301.
- Dratch, P.A. and P.J.P. Gogan. 2010. Bison Conservation Initiative: Bison Conservation Genetics Workshop: report and recommendations. Natural Resource Report NPS/NRPC/BRMD/NRR—2010/257. National Park Service, Fort Collins, Colorado.
- Drummond, A.J., A. Rambaut, B. Shapiro, and O.G. Pybus. 2005. Bayesian coalescent inference of past population dynamics from molecular sequences. *Molecular Biology and Evolution*, 22:1185-1192.
- Dyke, A.S. 2004. An outline of North American deglaciation with emphasis on central and northern Canada. *Developments in Quaternary Sciences* 2:373-424.
- Dyke, A.S. 2005. Late Quaternary vegetation history of northern North America based on pollen, macrofossil, and faunal remains. *Géographie Physique et Quaternaire* 59:211–262.

- Eastham, L.C. and R.S. Feranec. 2024. Assessing the influence of body size on patterns of dietary niche segregation among the ungulate community in Yellowstone National Park, USA. *Mammalian Biology* 104:431-445.
- Ecosystem Classification Group. 2007. Ecological regions of the Northwest Territories – Taiga Plains. Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT, Canada. vii + 209pp.
- Ecosystem Classification Group. 2010. Ecological regions of the Northwest Territories – Cordillera. Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT, Canada. x + 245pp.
- Egerton J. M. B. 1962. The cow-calf relationship and rutting behaviour in the American Bison. M.Sc. dissertation, University of Alberta, Edmonton. 155pp.
- Elkin, B., T. Armstrong, and T. Ellsworth. 2020. Anthrax Response Plan, Version 10 – Updated July 2020. Department of Environment and Climate Change, Government of the Northwest Territories, Yellowknife, NT. File Report No. 155a. 97pp.
- Elkin, B.T., J. Nishi, and G. Appleyard. 2006. Current status of MAP infection in Canadian bison populations. Pp. 7–8, in M. Woodbury, E. Garde, H. Schwantje, J. Nishi and B.T. Elkin (eds.) Workshop on *Mycobacterium avium* subsp. *paratuberculosis* in North American bison (*Bison bison*) – proceedings and workshop report. Department of Environment and Natural Resources, Government of the Northwest Territories. Manuscript Report No. 170. 93 pp.
- Environment and Climate Change (ECC), unpubl. data. 2024a. Anthrax mortalities detected in NWT wood bison populations. Unpublished data provided by T. Armstrong (June 2024). Government of the Northwest Territories, Fort Smith, NT.
- Environment and Climate Change (ECC), unpubl. data. 2024b. Population estimates for NWT wood bison populations. Unpublished data provided by T. Armstrong (June 2024). Government of the Northwest Territories, Fort Smith, NT.
- Environment and Climate Change (ECC), unpubl. data. 2024c. Vehicle collisions with wood bison reported to GNWT-ECC, including number of bison mortalities. Unpublished data provided by T. Armstrong (July 2024). Government of the Northwest Territories, Fort Smith, NT.
- Environment and Climate Change (ECC), unpubl. data. 2025a. Classification survey results for NWT bison populations. Unpublished data provided by T. Armstrong (January 2025 and March 2026) and N. Larter (October 2025). Government of the Northwest Territories.
- Environment and Climate Change (ECC), unpubl. data. 2026a. Number of bison harvested annually by Resident Hunters in the Slave River Lowlands, 2013-2026. Unpublished data

provided by T. Armstrong (March 2026). Government of the Northwest Territories, Fort Smith, NT.

Environment and Climate Change (ECC), unpubl. data. 2026b. Approximate wildfire extent within bison range in the NWT. Unpublished data from M. Coyle provided by E. McHugh (April 2026). Government of the Northwest Territories, Yellowknife, NT.

Environment and Climate Change Canada (ECCC). 2018. Recovery Strategy for the Wood Bison (*Bison bison athabasca*) in Canada. *Species at Risk Act Recovery Strategy Series*. Environment and Climate Change Canada. Ottawa. 59 pp.

Environment and Climate Change Canada (ECCC). 2021. Imminent threat assessment for Wood Bison (*Bison bison athabasca*), 2020. Environment and Climate Change Canada, Gatineau, QC. 50 pp. Website: https://publications.gc.ca/collections/collection_2021/eccc/cw66/CW66-605-2020-eng.pdf [accessed 14 March 2026].

Environment and Climate Change Canada (ECCC). 2022. Edézhíe National Wildlife Area and Dehcho Protected Area. Website: www.canada.ca/en/environment-climate-change/services/national-wildlife-areas/locations/edehzhie.html [accessed 21 December 2024].

Environment and Climate Change Canada (ECCC) (Draft). 2025. Progress Towards the Implementation of the Recovery Strategy for Wood Bison (*Bison bison athabasca*): Draft for Jurisdictional Review. *Species at Risk Act Recovery Strategy Series*. Environment and Climate Change Canada, Ottawa.

Environment and Natural Resources (ENR). 2010. Wood Bison Management Strategy for the Northwest Territories 2010-2020. Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT. 32pp.

Environment Canada. 2011. Scientific Assessment to Inform the Identification of Critical Habitat for Woodland Caribou (*Rangifer tarandus caribou*), Boreal Population, in Canada: 2011 Update. Ottawa, On., Canada. 102 pp. plus appendices.

Environment Canada. 2012. Recovery Strategy for the Woodland Caribou (*Rangifer tarandus caribou*), Boreal population, in Canada. *Species at Risk Act Recovery Strategy Series*. Environment Canada, Ottawa. xi + 138pp.

Falk, D.A., P.J. van Mantgem, J.E. Keeley, R.M. Gregg, C.H. Guiterman, A.J. Tepley, D.J. Young, and L.A. Marshall. 2022. Mechanisms of forest resilience. *Forest Ecology and Management* 512: p.120129.

- Federal Environmental Assessment and Review Office (FEARO). 1990. Northern diseased bison: Report of the Environmental Assessment Panel. Environment Canada, Federal Environmental Assessment and Review Office Report 35. Minister of Supply Services Canada, Ottawa, ON. 47 pp. + ix.
- Ferguson, T.A. 1993. Wood bison and the early fur trade. Pp. 63-79, in P.A. McCormack, and R.G. Ironside (eds.). The uncovered past: roots of northern Alberta Societies. Circumpolar Research Series No. 3. Canadian Circumpolar Institute Press, University of Alberta. 186p.
- Ferguson, T.A. and F. Lavolette 1992. A note on historical mortality in a northern bison population. *Arctic* 45:47-50.
- Fidler, P. 1792. Journal of a journey with the Chepawyans or Northern Indians, to the Slave Lake, & to the east & west of the Slave river, in 1791 & 2. Pp. 495-555, in J.B. Tyrrell (ed.). Journals of Samuel Hearne and Philip Turnor between the Years 1774 and 1792. Originally published in 1934 as Champlain Society Publication XXI. A facsimile edition in 1968 by New York: Greenwood Press Publishers. 611pp.
- Fischer, L. and C.C. Gates. 2005. Competition potential between sympatric woodland caribou and wood bison. *Canadian Journal of Zoology* 83:1162-1173.
- Flannigan, M.D., B.M. Wotton, G.A. Marshall, W.J. De Groot, J. Johnston, N. Jurko, and A.S. Cantin. 2016. Fuel moisture sensitivity to temperature and precipitation: climate change implications. *Climatic Change* 134:59-71.
- Flerov, K.K. 1979. Systematics and evolution. Pp. 9-127, in E.V. Sokolov (ed.). European bison. Morphology, systematics, evolution, ecology. Nauka Publisher, Moscow.
- Ford, D.C. 1976. Evidences of multiple glaciation in South Nahanni National Park, Mackenzie Mountains, Northwest Territories. *Canadian Journal of Earth Sciences* 13:1433-1445.
- Ford, D.C. 2017. The many landscapes of South Nahanni National Park. Pp.205-225, in O. Slaymaker (ed.). Landscapes and Landforms of Western Canada. 454pp.
- Ford, E.B. 1931. Mendelism and Evolution. Methuen, London. 116pp.
- Forde, T., J. De Buck, B. Elkin, S. Kutz, F. van der Meer, and K. Orsel. 2013. Contrasting results of culture-dependent and molecular analyses of *Mycobacterium avium* subsp. *paratuberculosis* from wood bison. *Applied and Environmental Microbiology*, 79:4448-4454.
- Fortelius M. 1985. Ungulate cheek teeth: developmental, functional, and evolutionary interrelations. *Acta Zoologica Fennica*, 180:1-76.

- Fortin, D. 2002. Optimal searching behaviour: the value of sampling information. *Ecological Modelling* 153:279–290.
- Fortin, D. and M.E. Fortin. 2009. Group-size-dependent association between food profitability, predation risk and distribution of free-ranging bison. *Animal Behaviour* 78:887–892.
- Fortin, D., J.M. Fryxell, and R. Pilote. 2002. The temporal scale of foraging decisions in bison. *Ecology* 83:970–982.
- Fortin, D., J.M. Fryxell, L.O. O’Brodivich, and D. Frandsen. 2003. Foraging ecology of bison at the landscape and plant community levels: the applicability of energy maximization principles. *Oecologia* 134:219–227.
- Fortin, D., M.E. Fortin, H.L. Beyer, T. Duchesne, S. Courant, and K. Dancose. 2009. Group-size-mediated habitat selection and group fusion-fission dynamics of bison under predation risk. *Ecology* 90:2480–2490.
- Forney, R.R. and M.M. Peacock. 2024. The effects of fire on large-and medium-sized mammal communities: what do we know? A review. *Mammal Review*, 54(4), pp.357–372.
- Foster, J. 1998. Working for wildlife: The beginning of preservation in Canada. University of Toronto Press, Toronto. 297pp.
- Frankham, R., J.D. Ballou, M.D. Eldridge, R.C. Lacy, K. Ralls, M.R. Dudash, and C.B. Fenster. 2011. Predicting the probability of outbreeding depression. *Conservation Biology* 25:465–475.
- Franklin, J. 1823. Narrative of a journey to the shores of the Polar Sea in the years 1819–20–21–22. London: John Murray. 768pp.
- Froese, D., M. Stiller, P.D. Heintzman, A.V. Reyes, G.D. Zazula, A.E. Soares, M. Meyer, E. Hall, B.J. Jensen, L.J. Arnold, and R.D. MacPhee. 2017. Fossil and genomic evidence constrains the timing of bison arrival in North America. *Proceedings of the National Academy of Sciences* 114:3457–3462.
- Fryxell, J.M. 1991. Forage quality and aggregation by large herbivores. *American Naturalist* 138:478–498.
- Fuhlendorf, S.D. and D.M. Engle. 2001. Restoring heterogeneity on rangelands: ecosystem management based on evolutionary grazing patterns: we propose a paradigm that enhances heterogeneity instead of homogeneity to promote biological diversity and wildlife habitat on rangelands grazed by livestock. *BioScience* 51:625–632.

- Fuhlendorf, S.D., D.M. Engle, J.A.Y. Kerby, and R. Hamilton. 2009. Pyric herbivory: rewilding landscapes through the recoupling of fire and grazing. *Conservation Biology* 23:588-598.
- Fuller, J.A., R.A. Garrott, P.J. White, K.E. Aune, T.J. Roffe, and J.C. Rhyan. 2007. Reproduction and survival of Yellowstone bison. *Journal of Wildlife Management* 10:2365-2372.
- Fuller, W.A. 1950. Aerial census of northern bison in Wood Buffalo Park and vicinity. *Journal of Wildlife Management* 14:445-451.
- Fuller, W.A. 1951. Second aerial census of northern bison, January 20-31. Canadian Wildlife Service, Environment Canada, unpublished report.
- Fuller, W.A. 1957. The biology and management of the bison of Wood Buffalo National Park. Ph.D. dissertation, University of Wisconsin, Madison. 130 pp.
- Fuller, W.A. 1959. The horns and teeth as indicators of age in bison. *Journal of Wildlife Management* 23:342-345.
- Fuller, W.A. 1960. Behavior and social organization of the wild bison of Wood Buffalo National Park, Canada. *Arctic* 13:3-19.
- Fuller, W.A. 1961. The ecology and management of the American bison. *La Terre et la Vie* 108:286-304.
- Fuller, W.A. 1966. The biology and management of the bison of Wood Buffalo National Park. Canadian Wildlife Service Wildlife Management Bulletin Series 1, No.16. 52pp.
- Fuller, W.A. 2002. Canada and the "buffalo", *Bison bison*: a tale of two herds. *Canadian Field-Naturalist*, 116:141-159.
- Fuller, W.A. and N.S. Novakowski. 1955. Wolf control operations, Wood Buffalo National Park, 1951-52. *Wildlife Management Bulletin, Series 1, No. 11*. Canadian Wildlife Service, Environment Canada. 20pp.
- Gaboriau, D.M., É. Chaste, M.P. Girardin, H. Asselin, A.A. Ali, Y. Bergeron, and C. Hély. 2023. Interactions within the climate-vegetation-fire nexus may transform 21st century boreal forests in northwestern Canada. *Iscience* 26(6).
- Gaillard, J.M., M. Festa-Bianchet, and N.G. Yoccoz. 1998. Population dynamics of large herbivores: variable recruitment with constant adult survival. *Trends in Ecology and Evolution* 13:58-63.
- Gainer, R.S. and J.R. Saunders. 1989. Aspects of the epidemiology of anthrax in Wood Buffalo National Park and environs. *Canadian Veterinary Journal* 30:953-956.

- Gairdner, A.G. 1909. Appendix Y. Constable A. G. Gairdner, Fort Chipewyan to Buffalo Country, March, 1909. Pp. 191-192, *in* Report of the Northwest Mounted Police, 1909. Sessional Paper No. 28 263pp.
- Game Declared in Danger of Becoming Extinct, C.R.C., c1236 (Northwest Territories Act)*
- Garde, E., S. Kutz, H. Schwantje, A. Veitch, E. Jenkins, and B. Elkin. 2009. Examining the risk of disease transmission between wild Dall's sheep and mountain goats, and introduced domestic sheep, goats, and llamas in the Northwest Territories. Environment and Natural Resources, Government of the Northwest Territories. Manuscript Report No. 186. 209 pp. + xvi.
- Gardner, C.L. and A.R. DeGange. 2003. A review of information on wood bison in Alaska and adjacent Canada, with particular reference to the Yukon Flats. Alaska Department of Fish and Game, Fairbanks, Alaska. 29pp.
- Garretson, M.S. 1923. Wood bison. Report of the American Bison Society 1922-23:29-33.
- Garretson, M.S. 1938. American Bison: the story of its extermination as a wild species and its restoration under federal protection. New York: New York Zoological Society. 254pp.
- Garrott, R.A., J.E. Bruggeman, M.S. Becker, S.T. Kalinowski, and P.J. White. 2007. Evaluating prey switching in wolf-ungulate systems. *Ecological Applications* 17:1588-1597.
- Gast, M., pers. comm. 2026. Email correspondence with J. Oosenbrug. March 2026. Manager, Wildlife Research and Monitoring, Wildlife Division, Department of Environment and Climate Change, Government of the Northwest Territories, Fort Simpson, NT.
- Gates, C.C. 1988. Status of bison in northern Canada. Pg. 9, *in* J. Malcomb (ed.). North American Bison Workshop. U.S. Fish and Wildlife Service and Glacier National Historic Association, Missoula, Montana.
- Gates, C.C. 1993. Biopolitics and pathobiology: Diseased bison in northern Canada. Pp. 271-288, *in* R.E. Walker (ed.). Proceedings of the Northern Public Bison Herds Symposium, 27-29 July 1993, Lacrosse, Wisconsin, Custer State Park, Custer, South Dakota.
- Gates, C.C., T. Chowns, and H.W. Reynolds. 1992a. Wood buffalo at the crossroads. Pg. 139-165, *in* J. Foster, D. Harrison and I.S. MacLaren (eds.). Alberta: Studies in the Arts and Sciences, Special Issue on the Buffalo. University of Alberta Press, Edmonton, AB. 244pp.
- Gates, C.C., B.T. Elkin, and D. Dragon. 1995. Investigation, control and epizootiology of anthrax in an isolated, free-roaming bison population in northern Canada. *Canadian Journal of Veterinary Research* 59:256-264.

- Gates, C.C., B.T. Elkin, L. Keary, and T. Chowns. 1992b. Surveillance of the Bison Free Management Area, January - June 1992. Environment and Natural Resources, Government of the Northwest Territories. Manuscript Report No. 65. 26 pp.
- Gates, C.C. and S. Gray. 1992. Surveillance of the bison free management area, Northwest Territories. Environment and Natural Resources, Government of the Northwest Territories. Manuscript Report No. 50. 29 pp.
- Gates, C.C. and N.C. Larter. 1990. Growth and dispersal of an erupting large herbivore population in northern Canada: The Mackenzie wood bison (*Bison bison athabascae*). *Arctic* 43:231-238.
- Gates, C.C., B. Stelfox, T. Muhly, T. Chowns, and R.J. Hudson. 2005. The ecology of bison movements and distribution in and beyond Yellowstone National Park: A critical review with implications for winter use and transboundary population management. Report commissioned by the United States National Park Service, Yellowstone Center for Resources. Faculty of Environmental Design, University of Calgary, AB. 313pp.
- Gates, C.C., C.H. Freese, P.J.P. Gogan, and M. Kotzman. (eds.). 2010. American Bison: Status Survey and Conservation Guidelines 2010. Gland, Switzerland: International Union for the Conservation of Nature (IUCN). 134 pp.
- Gates, C.C., N.C. Larter, and P.K. Komers. 1991. Size and composition of the Mackenzie Bison population in 1989. Environment and Natural Resources File Report No. 93. 29pp.
- Gates, C.C., J. Mitchell, J. Wierzchowski, and L. Giles. 2001a. A landscape evaluation of bison movements and distribution in northern Canada. AXYS Environmental Consulting Ltd., Calgary, AB.
- Gates, C.C., R.O. Stephenson, H.W. Reynolds, C.G. Van Zyll de Jong, H. Schwantje, M. Hoefs, J. Nishi, N. Cool, J. Chishom, A. James, and B. Koonz. 2001b. National recovery plan for the Wood Bison (*Bison bison athabascae*). National Recovery Plan No. 21. Recovery of Nationally Endangered Wildlife Committee (RENEW). Ottawa, ON. 50 pp.
- Geist, V. 1971. The relation of social evolution and dispersal in ungulates during the Pleistocene, with emphasis on the old world deer and the genus *Bison*. *Quaternary Research* 1:285-315.
- Geist, V. 1991. Phantom subspecies: The wood bison *Bison bison* "athabascae" Rhoads 1897 is not a valid taxon, but an ecotype. *Arctic* 44:283-300.
- Geist, V. and P. Karsten. 1977. The wood bison (*Bison bison athabascae* Rhoads) in relation to hypotheses on the origin of the American bison (*Bison bison* Linnaeus). *Zeitschrift Fuer Säugetierkunde* Bd. 42:119-127.

- Ghassemi-Khademi, T., S.M. Madjzadeh, R. Khosravi, and A. Asadi. 2021. The phylogenetic relationships within the Tribe Bovini (Bovidae: Bovinae) using mitochondrial genome. *Journal of Genetic Resources* 7:15-28.
- Gignac, L.D. and D.H. Vitt. 1994. Responses of northern peatlands to climate change: effects on bryophytes. *Journal of the Hattori Botanical Laboratory* 75:119-132.
- Gilpin, M.E. and M.E. Soulé. 1986. Minimum viable populations: processes of species extinction. Pp. 19-34, *in* Conservation biology: the science of scarcity and diversity. Sinauer Associates, Sunderland, Massachusetts.
- Gladu, P. 1910. Appendix S. Pierre Gladu, Buffalo Guardian, on patrol from Chipewyan to the Caribou and Salt Mountains. Pp. 195-196, *in* Report of the Royal Northwest Mounted Police 1910. Sessional Paper No. 28. 276pp.
- Gogan, P.J.P., N.C. Larter, J.H. Shaw, and J.E. Gross. 2010. General biology, ecology and demographics. pp. 39-54
- Gorham, E. 1974. The relationship between standing crop in sedge meadows and summer temperature. *Journal of Ecology* 62:487-491.
- Gorini, L., J.D.C. Linnell, R. May, M. Panzacchi, L. Boitani, M. Odden, and E.B. Nilsen. 2012. Habitat heterogeneity and mammalian predator-prey interactions. *Mammal Review* 42:55-77.
- Government of Alberta. 2013. Managing disease risk in northern Alberta wood bison outside of Wood Buffalo National Park: 2012-2013 progress report. Government of Alberta. 15 pp.
- Government of Alberta. 2021. Wood bison status changes in Alberta. Government of Alberta. 3 pp.
- Government of Alberta. 2025a. Aerial Wildlife Survey Report: Hay-Zama Wood Bison Aerial Survey (2025). Environment and Protected Areas, Government of Alberta, Edmonton, AB. 2 pp.
- Government of Alberta. 2025b. Wood Bison Hunt - Disease Surveillance, Changes in Bison Status and New Bison Protection Areas. My Wild Alberta, Environment and Protected Areas, Government of Alberta, Edmonton, AB. Website: <https://mywildalberta.ca/hunting/game-species/wood-bison-hunt-disease-surveillance.aspx> [accessed 24 March 2026].
- Government of British Columbia. 2024. Peace Region Bison File. Presentation by Chris Lewis, Species at Risk Biologist. Ministry of Water, Land and Resource Stewardship, Government of British Columbia, Victoria, B.C. 22 pp. Website:

<https://nestakeholderroundtable.ca/app/uploads/sites/573/2024/06/June-5-Bison.pdf>
[accessed 24 March 2026].

Government of Canada. 2022. Report on the State of Conservation of Wood Buffalo National Park World Heritage Site (Canada), Property ID 256. In response to: World Heritage Committee Decision 44 Com 7B.190. 65 pp.

Government of the Northwest Territories (GNWT). 2005. 53.04 - Forest Fire Management Policy. Government of the Northwest Territories. Yellowknife, NT. 10 pp.

Government of the Northwest Territories (GNWT). 2017. A Field Guide to Common Wildlife Diseases and Parasites in the Northwest Territories. Government of the Northwest Territories. Yellowknife, NT. 88 pp.

Government of the Northwest Territories (GNWT). 2019. Domestic Animal Permit: Frequently Asked Questions. Government of the Northwest Territories. Yellowknife, NT. 3 pp. Website: www.gov.nt.ca/ecc/sites/ecc/files/resources/faq_domestic_animal_permit.pdf [accessed 16 March 2026].

Government of the Northwest Territories (GNWT). 2023. *Forest Act*. Bill 74. Second Session, Nineteenth Legislative Assembly of the Northwest Territories. 70 pp.

Government of the Northwest Territories (GNWT). 2025. Tłı̨ch̨ Highway Project, Department of Infrastructure, Government of the Northwest Territories. Website: www.inf.gov.nt.ca/en/Tlı̨choHighway [accessed 16 March 2026].

Government of the Northwest Territories (GNWT). 2026. Agriculture Sector Profile. Website: www.iti.gov.nt.ca/en/agriculture-sector-profile [accessed 13 April 2026].

Government of the Northwest Territories and Tłı̨ch̨ Government. 2025. Government of the Northwest Territories and Tłı̨ch̨ Government Joint Proposal on Increased Harvest of Mackenzie Wood Bison. Submitted to the Wek'èezhìı Renewable Resources Board. Website: www.wrrb.ca/sites/default/files/FINAL%20WRRB%20Management%20Proposal%20MackBisonHarvest_2025v.2.pdf

Government of Yukon. 2012. Management plan for the Aishihik wood bison (*Bison bison athabascae*) herd in southwestern Yukon. Environment Yukon, Whitehorse, Yukon, Canada.

Government of Yukon. 2026. Wood Bison. Government of Yukon, Whitehorse, Yukon. Website: www.yukon.ca/en/outdoor-recreation-and-wildlife/yukon-wildlife/wood-bison [accessed 14 March 2026].

- Graf, R., T. Chowns, and J. Beaulieu. 1990. Distribution and abundance of the Mackenzie wood bison herd, July 1983. Environment and Natural Resources, Government of the Northwest Territories. Manuscript Report No. 27. 11pp.
- Graham, M. 1923. Canada's wild buffalo: observations in Wood Buffalo Park. F.A. Ackland. 17pp.
- Graham, M. 1924. Finding range for Canada's buffalo. Canadian Field-Naturalist 38:189.
- Grant, P.R., B.R. Grant, and K. Petren. 2005. Hybridization in the recent past. The American Naturalist 166:56-67.
- Green, W.C.H. 1990. Reproductive effort and associated costs in bison (*Bison bison*): do older mothers try harder? Behavioral Ecology 1:148-160.
- Green, W.C.H. 1992. The development of independence in bison: pre-weaning spatial relations between mothers and calves. Animal behaviour 43:759-773.
- Green, W.C.H., J.G. Griswold, and A. Rothstein. 1989. Post-weaning associations among bison mothers and daughters. Animal Behaviour 38:847-858.
- Green, W.C.H. and A. Rothstein. 1991. Trade-offs between growth and reproduction in female bison. Oecologia 86:521-527.
- Greig, R. and K. Cox. 2012. Bison Control Area Program Annual Report December 2010 - April 2011. Environment and Natural Resources, Government of the Northwest Territories. Manuscript Report No. 215. 34pp.
- Griffith, E. *et al.* 1827. The Animal Kingdom: Arranged in Conformity with Its Organization. G. B. Whittaker, London, England. pp. 87-89.
- Gross, J.E. and G. Wang. 2005. Effects of Population Control Strategies on Retention of Genetic Diversity in National Park Service Bison (*Bison bison*) Herds. USGS-Biological Resources Division, Bozeman, Montana.
- Gross, J.E., G. Wang, N.D. Halbert, P.A. Gogan, J.N. Derr, and J.W. Templeton. 2006. Effects of population control strategies on retention of genetic diversity in National Park Service Bison (*Bison bison*) herds. Revised Final Report Submitted to Yellowstone Research Group USGS-BRD Department of Biology, Montana State University, Bozeman, Montana.
- Groves, C.P. 1981. Systematic relationships in the bovini (Artiodactyla, Bovidae). Journal of Zoological Systematics and Evolutionary Research 19:264-278.
- Gunn, A., J. Antoine, J. Boulanger, J. Bartlett, B. Croft, and A. D'Hont. 2004. Boreal caribou habitat and land use planning in the Deh Cho Region, Northwest Territories. Environment

- and Natural Resources, Government of the Northwest Territories. Manuscript Report No. 153. 48pp.
- Guthrie, R.D. 1970. Bison evolution and zoogeography in North America during the Pleistocene. *Quarterly Review of Biology* 45:1-15.
- Guthrie, R.D. 1980. Bison and man in North America. *Canadian Journal of Anthropology* 1:55-73.
- Guthrie, R.D. 2001. Origin and causes of the mammoth steppe: a story of cloud cover, woolly mammal tooth pits, buckles, and inside-out Beringia. *Quaternary Science Reviews* 20:549-574.
- Haigh, J.C., C. Mackintosh, and F. Griffin. 2002. Viral, parasitic and prion diseases of farmed deer and bison. *Revue Scientifique et Technique-Office International des Épizooties* 21:219-248.
- Halbert, N.D. 2003. The utilization of genetic markers to resolve modern management issues in historic bison populations: implications for species conservation Ph.D. dissertation, Texas A&M University, Houston. 199pp.
- Halbert, N.D. and J.N. Derr. 2008. Patterns of genetic variation in US federal bison herds. *Molecular Ecology* 17:4963-4977.
- Hall, R.B. 1968. Bison inventory, N.W.T. Environment and Natural Resources, Government of the Northwest Territories, unpublished report. 1pp.
- Hall, R.B. 1973. Wood bison observation, Mackenzie Bison Sanctuary. Environment and Natural Resources, Government of the Northwest Territories, unpublished report. 4pp.
- Hanks, C. and S. Irving. 1987. Implications of the Desnoyers site (JePw-1). Prince of Wales Northern Heritage Centre, Government of the Northwest Territories, unpublished report. 30pp.
- Hanley, T.A. 1982. The nutritional basis for food selection by ungulates. *Journal of Range Management* 35:146-151.
- Harkin, J.B. 1923. Letter from J. B. Harkin, Commissioner of Parks, Ottawa, Canada, dated November 27, 1923, addressed to Edmund Seymour, President of the American Bison Society. 1pp.
- Harington, C.R. 1981. Pleistocene saiga antelopes in North America and their paleoenvironmental implications. Pp. 193-225, *in* W.C. Mahaney (ed.). *Quaternary Paleoclimate*. Norwich, University of East Anglia, Geo Books.
- Harington, C.R. 1990. Arctic bison. *Biome* 10:4.

- Harrington, C.R. and J. Cinq-Mars 1995. Radiocarbon dates on saiga antelope (*Saiga tatarica*) fossils from Yukon and the Northwest Territories. *Arctic*, 48:1-7.
- Harper, F. 1932. Mammals of the Athabaska and Great Slave Lakes region. *Journal of Mammalogy*. 13:19-36.
- Harper, W.L. and C.C. Gates. 2000. Recovery of wood bison in British Columbia. Pp. 915-923, in L.M. Darling (ed.). *Proceedings of a Conference on the Biology and Management of Species and Habitats at Risk, Kamloops, B.C., 15-19 Feb., 1999*. Volume II. B.C. Ministry of Environment, Lands and Parks, Victoria, B.C. and University College of the Cariboo, Kamloops, BC. 520pp.
- Harper, W.L., J.P. Elliott, I. Hatter, and H. Schwantje. 2000. Management Plan for Wood Bison in British Columbia. B.C. Ministry of the Environment, Lands and Parks, Victoria, BC. 43pp
- Harris, S.W. and W.H. Marshall 1963. Ecology of water level manipulation on a northern marsh. *Ecology* 44:331-343.
- Harvey, L. and D. Fortin. 2013. Spatial heterogeneity in the strength of plant-herbivore interactions under predation risk: the tale of bison foraging in wolf country. *PLoS One*, 8(9), p.e73324.
- Haufe, W.O. 1980. Control of black flies in the Athabasca River: evaluation and recommendations for chemical control of *Simulium arcticum* Malloch. Alberta Black Fly Coordinating Committee for the Pollution Control Division of Alberta Environment. 38pp.
- Haugen, A.O. 1974. Reproduction in the plains bison. *Iowa State Journal of Research* 41:1-8.
- Hawley, A.W.L. 1987. Bison and cattle use of forages. Pp. 13-14, in H.W. Reynolds and A.W.L. Hawley (eds.). *Bison Ecology in Relation to Agricultural Development in the Slave River Lowlands, N.W.T. Occasional Paper No.63*, Ottawa, ON. 72pp.
- Hawley, A.W.L., D.G. Peden, H.W. Reynolds, and W.R. Stricklin. 1981b. Bison and cattle digestion of forages from the Slave River Lowlands, Northwest Territories, Canada. *Journal of Range Management* 34:126-130.
- Hawley, A.W.L., D.G. Peden, and W.R. Stricklin. 1981a. Bison and Hereford steer digestion of sedge hay. *Canadian Journal of Animal Science* 61:165-174.
- Hawley, V.D. 1980. Mackenzie Bison Sanctuary Survey – March 1980. Environment and Natural Resources, Government of the Northwest Territories, unpublished report. 14pp.
- Haynes, G. 1984. Tooth wear rate in northern bison. *Journal of mammalogy* 65:487-491.

- Hearne, S. 1795. A journey from Prince of Wales Fort in Hudson's Bay to the Northern Ocean, in the years 1769, 1770, 1771 and 1772. London: Strahan and Cadill. 458pp.
- Hebda, R.J. 1995. British Columbia vegetation and climate history with focus on 6 ka BP. *Géographie Physique et Quaternaire*, 49:55-79.
- Hecker, L. 2022. Influence of nutrition on the habitat selection of the Ronald Lake wood bison (*Bison bison athabascae*) herd. PhD Thesis, University of Alberta. Website: <https://ualberta.scholaris.ca/items/97590deo-012b-45af-ab2b-e36805abd9c9> [accessed 14 March 2026].
- Hecker, L.J., S.C. Coogan, S.E. Nielsen, and M.A. Edwards. 2021a. Latitudinal and seasonal plasticity in American bison *Bison bison* diets. *Mammal Review* 51:193-206.
- Hecker, L.J., M.A. Edwards, and S.E. Nielsen. 2021b. Assessing the nutritional consequences of switching foraging behavior in wood bison. *Ecology and Evolution* 11:16165-16176.
- Hecker, L.J., M.A. Edwards, and S.E. Nielsen. 2023. Behavioral habitat selection of wood bison (*Bison bison athabascae*) in boreal forests. *Mammal Research* 68:341-353.
- Hedrick, P.W. 2009. Conservation Genetics and North American Bison (*Bison bison*). *Journal of Heredity* 100:411-420.
- Hedrick, P.W. 2010. Cattle ancestry in bison: explanations for higher mtDNA than autosomal ancestry. *Molecular ecology* 19:3328-3335.
- Hedrick, P.W., K.M. Parker, E.L. Miller, and P.S. Miller. 1999. Major histocompatibility complex variation in the endangered Przewalski's horse. *Genetics* 152:1701-1710.
- Heinselman, M.L. 1963. Forest sites, bog processes and peatland types in the glacial Lake Agassiz region, Minnesota. *Ecological Monographs* 33:327-374.
- Heintzman, P.D., D. Froese, J.W. Ives, A.E.R. Soares, G.D. Zazula, B. Letts, T.D. Andrews, J.C. Driver, E. Hall, P.G. Hare, and C.N. Jass. 2016. Bison phylogeography constrains dispersal and viability of the Ice Free Corridor in western Canada. *Proceedings of the National Academy of Sciences* 113:8057-8063.
- Herchmer, L.W. 1898. Annual Report of the Royal North West Mounted Police, 1898. Pp. 156.
- Heuschele, W.P. and H.W. Reid. 2001. Malignant catarrhal fever. Pp.157-163 in E.S. Williams and I.K. Barker (eds.). *Infectious Diseases of Wild Mammals*, Third edition. Iowa State Press, Ames, Iowa.
- Hewitt, C.G. 1921. The buffalo or bison: Its present, past, and future. Pp.113-142, in C.G. Hewitt, (ed.). *The Conservation of the Wildlife of Canada*. Charles Scribner's Sons, New York. 344pp.

- Hilbert, D.W., D.M. Swift, J.K. Detling, and M.I. Dyer. 1981. Relative growth rates and the grazing optimization hypothesis. *Oecologia* 51:14-18.
- Hill, M.E., M.G. Hill, and C.C. Widga 2008. Late Quaternary *Bison* diminution on the Great Plains of North America: evaluating the role of human hunting versus climate change. *Quaternary Science Reviews* 27:1752-1771.
- Himsworth, C.G., B.T. Elkin, J.S. Nishi, A.S. Neimanis, G.A. Wobeser, C. Turcotte, and F.A. Leighton. 2010. An outbreak of bovine tuberculosis in an intensively managed conservation herd of wild bison in the Northwest Territories. *Canadian Veterinary Journal* 51:593-597.
- Hind, H.Y. 1860. Narrative of the Canadian Red River exploring expedition of 1857 (Vol. 2). Cambridge University Press, Cambridge, United Kingdom.
- Hofmann, R.R. 1989. Evolutionary steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system. *Oecologia*, 78:443-457.
- Hogenbirk, J.C. and R.W. Wein. 1991. Fire and drought experiments in northern wetlands: a climate change analogue. *Canadian Journal of Botany* 69:1991-1997.
- Holman, H.L. 1944. Report on forest fire protection in the Mackenzie District (Vol. 464, File 50050). National Archives of Canada, RG, 39. 26pp.
- Holworth, W.N. 1960. Buffalo range and food habits of buffalo in Wood Buffalo Park. Canadian Wildlife Service, Environment Canada, unpublished report. No. 24-60. 19pp.
- Holt, R.A. and J.H. Lawton. 1994. The ecological consequences of shared natural enemies. *Annual Review of Ecology and Systematics* 25:495-520.
- Holt, R.D. 1977. Predation, apparent competition, and the structure of prey communities. *Theoretical Population Biology* 12:197-229.
- Hornaday, W.T. 1889. The extermination of the American bison, with a sketch of its discovery and life history. Pp. 369-548, in the Annual Report (1887) of the Smithsonian Institution, Washington, D.C.
- Hsieh, H-Y., and G. C. Stewart. Does environmental replication contribute to *Bacillus anthracis* spore persistence and infectivity in soil? *Research in Microbiology* 174 (5): 104052.
- Hu, F.S., B.Y. Lee, D.S. Kaufman, S. Yoneji, D.M. Nelson, and P.D. Henne. 2002. Response of tundra ecosystem in southwestern Alaska to Younger-Dryas climatic oscillation. *Global Change Biology* 8:1156-1163.
- Huberman, Y., J. Beckers, R. Brett, G. Castilla, R. Errington, E.C. Fraser-Reid, D. Goodsman, E.H. Hogg, J. Metsaranta, E. Neilson, J. Olesinski, M.-A. Parisien, D. Price, T. Ramsfield, C. Shaw,

- D. Thompson, M.F. Voicu, E. Whitman, and J. Edwards. 2022. The state of Northwest Territories forests in the wake of climate change: baseline conditions and observed changes to forest ecosystems. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre. Information Report NOR-X-430. 136pp.
- Hudson, R.J. and S. Frank. 1987. Foraging ecology of bison in aspen boreal habitats. *Journal of Range Management* 40:71-75.
- Hudson, R.J. and R.G. White. 1985. *Bioenergetics of Wild Herbivores*. Boca Raton: CRC Press Inc.
- Huggard, D.J. 1993. Prey selectivity of wolves in Banff National Park. I. Prey species. *Canadian Journal of Zoology* 71:130–139.
- Hugh-Jones, M. and J. Blackburn. 2009. The ecology of *Bacillus anthracis*. *Molecular Aspects of Medicine*. 30:356–367.
- Hugh-Jones, M.E. and V. de Vos. 2002. Anthrax and wildlife. *Revue Scientifique et Technique de l'Office International des Epizooties* 21:359-383.
- Husseman, J.S., D.L. Murray, G. Power, C. Mack, C.R. Wenger, and H. Quigley. 2003. Assessing differential prey selection patterns between two sympatric large carnivores. *Oikos* 101:591-601.
- Independent Environmental Consultants. 2018. Volume 1: Milestone 3 – Final SEA Report: Strategic Environmental Assessment of Wood Buffalo National Park World Heritage Site. Prepared for Parks Canada. 247 pp.
- International Code of Zoological Nomenclature. 1999. (4th edition). Ride, W.D.L., H.G. Cogger, C. Dupuis, O. Kraus, A. Minelli, F.C. Thompson, and P.K. Tubbs (eds.). The International Trust for Zoological Nomenclature, Natural History Museum, London, UK.
- Isenberg, A.C. 2000. *The Destruction of the Bison: an environmental history 1750 - 1920*. Cambridge University Press, Cambridge, United Kingdom. 220pp.
- IUCN Red List of Threatened Species (IUCN). 2026. Criterion A tool: population reduction calculator. Website: www.iucnredlist.org/resources/criterion-a [accessed 6 March 2026].
- IUCN Standards and Petitions Committee. 2024. Guidelines for Using the IUCN Red List Categories and Criteria. Version 16. Prepared by the Standards and Petitions Committee. Website: www.iucnredlist.org/documents/RedListGuidelines.pdf [accessed 2 November 2024].
- Jacobson, R. 1974. Wood bison (*Bison bison*) survey: Mackenzie Bison Sanctuary, N.W.T. Canadian Wildlife Service, Environment Canada, unpublished report. 7pp.

- Jacobson, R. 1976. Preliminary habitat assessment: Mackenzie Bison Sanctuary, N.W.T. Canadian Wildlife Service, Environment Canada, unpublished report. 58pp.
- Jalkotzy, M. 1979. Wolf – bison project Slave River Lowlands N.W.T. completion report. Department of Environment and Natural Resources, Government of the Northwest Territories, unpublished report. 19pp.
- Jalkotzy, M. and J. Van Camp. 1977. Fire in a boreal prairie – Hook Lake area, NWT. Department of Environment and Natural Resources, Government of the Northwest Territories, unpublished report. 14pp.
- Janecek, L.L., R.L. Honeycutt, R.M. Adkins, and S.K. Davis 1996. Mitochondrial gene sequences and the molecular systematics of the artiodactyl subfamily bovinæ. *Molecular Phylogenetics and Evolution* 6:107-119.
- Janis, C.M. 1990. Correlation of cranial and dental variables with dietary preferences in mammals: a comparison of macropodoids and ungulates. Pp. 255-300, *in* J. Damuth and B. J. MacFadden (eds.). *Body Size in Mammalian Paleobiology*. Cambridge: University of Cambridge Press. 397pp.
- Janzen, D.H. 1986. The eternal external threat. Pp. 286-303, *in* M.E. Soule (ed.). *Conservation Biology: the science of scarcity and diversity*. Sinauer, Sunderland, MA.
- Janzen, S.S. 1990. The Burning north: A history of fire and fire protection in the Northwest Territories. M.A. dissertation, University of Alberta, Edmonton.
- Jarman, P. 1983. Mating system and sexual dimorphism in large, terrestrial, mammalian herbivores. *Biological Reviews* 58:485-520.
- Jarvis, A.M. 1897. Annual report of the Royal Northwest Mounted Police, 1897. Printer to the King, Ottawa, ON. Pp. 158-169.
- Jarvis, A.M. 1907. Annual report of the Royal Northwest Mounted Police, 1907. Printer to the King, Ottawa, ON. Pp. 122-129.
- Jeffrey, W.W. 1961. Notes on plant occurrence along lower Liard River, N.W.T. National Museum of Canada Bulletin No. 171, Contributions to Botany, 1959. Pp. 32-115.
- Jeglum, J.K. 1971. Plant indicators of pH and water level in peatlands at Candle Lake, Saskatchewan. *Canadian Journal of Botany* 49:1661-1676.
- Jensen, O., J. Nishi, N.L. Cool, D. Poll, and H.W. Reynolds. 2003. Assessing suitable and critical habitat for Wood Bison (*Bison bison athabasca*) using Geographic Information Systems

(GIS) and remote sensing: Preliminary Results. Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton.

- Jiranantasak, T., J.S. Benn, M.C. Metrailler, S.J. Sawyer, M.Q. Burns, A.P. Bluhm, J.K. Blackburn, and M.H. Norris, 2022. Characterization of *Bacillus anthracis* replication and persistence on environmental substrates associated with wildlife anthrax outbreaks. *Plos one*, 17(9) p.e0274645.
- Johnson, E.A., K., Miyanishi, and J.M.H. Weir. 1998. Wildfires in the western Canadian boreal forest: landscape patterns and ecosystem management. *Journal of Vegetation Science* 9: 603-610.
- Johnson, W.A. 1909. Appendix X. Constable W. A. Johnson, Smith's Landing to buffalo country, March, 1909. Pp. 189-190, *in* Report of the Northwest Mounted Police, 1909. Sessional Paper No. 28. 263pp.
- Johnstone, J. F. 2006. Response of boreal plant communities to variations in previous fire-free interval. *International Journal of Wildland Fire* 15:497–508.
- Johnstone, J.F., F.S. Chapin III, J. Foote, S. Kemmett, K. Price, and L. Viereck. 2004. Decadal observations of tree regeneration following fire in boreal forests. *Canadian Journal of Forest Research* 34:267-273.
- Joly, D.O. 2001. Brucellosis and tuberculosis as factors limiting population growth of northern bison. Ph.D. dissertation, University of Saskatchewan, Saskatoon.
- Joly, D.O. and F. Messier. 2000. A numerical response of wolves to bison abundance in Wood Buffalo National Park, Canada. *Can. J. Zool.* 78:1101–1104.
- Joly, D.O. and F. Messier. 2001. Limiting effects of bovine brucellosis and tuberculosis on wood bison within Wood Buffalo National Park: Final Report, submitted to Parks Canada, March 2001.
- Joly, D.O. and F. Messier. 2004a. Factors affecting apparent prevalence of tuberculosis and brucellosis in wood bison. *Journal of Animal Ecology* 73:623–631.
- Joly, D.O. and F. Messier. 2004b. Testing hypotheses of bison population decline (1970–1999) in Wood Buffalo National Park: synergism between exotic disease and predation. *Canadian Journal of Zoology* 82:1165–1176.
- Joly, D.O. and F. Messier. 2005. The effect of bovine tuberculosis and brucellosis on reproduction and survival of wood bison in Wood Buffalo National Park. *Journal of Animal Ecology* 74:543-551.

- Jorgensen, A.G., R. Alfaro-Sánchez, S.G. Cumming, A.L. White, G.É. Degré-Timmons, N. Day, M. Turetsky, J.F. Johnstone, X.J. Walker, and J.L. Baltzer. 2023. The influence of postfire recovery and environmental conditions on boreal vegetation. *Ecosphere* 14(7), p.e4605. Website: <https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/ecs2.4605#ecs24605-bib-0055>.
- Jung, T.S. 2015. Winter diets of reintroduced bison (*Bison bison*) in northwestern Canada. *Mammal Research* 60:385-391.
- Jung, T.S. 2020. Investigating Local Concerns Regarding Large Mammal Restoration: Group Size in a Growing Population of Reintroduced Bison (*Bison bison*). *Global Ecology and Conservation*. Volume 24, December 2020, e01303. DOI: 10.1016/j.gecco.2020.e01303.
- Jung, T.S. 2021. Longevity in a hunted population of reintroduced American bison (*Bison bison*). *Mammal Research*, 66(1), pp.237-243.
- Jung, T.S., L. Workman, and K. Clyde. 2012. Management plan for the Aishihik wood bison (*Bison bison athabascae*) herd in southwestern Yukon. *Environment Yukon*. 28pp.
- Jung, T.S., M.J.L. Peers, P.D. Edwards, F.K.A. Schmiegelow, and R. Boonstra. 2026. Under pressure: assessing the influence of hunting on stress and diet quality of boreal bison (*Bison bison*). *Global Ecology and Conservation*, 66:e04080.
- Jung T.S., R. Drummond, S.D. Taylor, K. Kuba, R. Osborne, C. Pinard, and T.J. Grantham. 2023. Results of the 2022 mark-resight survey of the Aishihik bison (*Bison bison*) population. Yukon Fish and Wildlife Branch Report SR-23-01. 14pp.
- Jung, T.S., S.A. Stotyn, and N.C. Larter. 2019. Freezer meals: comparative value of muskrat (*Ondatra zibethicus*) push-ups as late-winter forage for a northern ungulate. *European Journal of Wildlife Research*. DOI: <https://doi.org/10.1007/s10344-019-1301-7>.
- Jutha, N. pers. comm. 2026. Comments on draft wood bison status report provided to J. Oosenbrug. January 2026. Wildlife Veterinarian, Government of the Northwest Territories, Yellowknife, NT.
- Karasov, W.H. 1992. Daily energy expenditure and the cost of activity in mammals. *American Zoologist* 32:238-248.
- Kaufman, D.S., T.A. Ager, N.J. Anderson, P.M. Anderson, J.T. Andrews, P.J. Bartlein, L.B. Brubaker, L.L. Coats, L.C. Cwynar, M.L. Duvall, A.S. Dyke, M.E. Edwards, W.R. Eisner, K. Gajewski, A.F. Geirsdottir, S. Hu, A.E. Jennings, M.R. Kaplan, M.W. Kerwin, A.V. Lozhkin, G.M. MacDonald, G.H. Miller, C.J. Mock, W.W. Oswald, B.L. Otto-Bliesner, D.F. Porinchu,

- K. Ruhland, J.P. Smol, E.J. Steig, and B.B. Wolfe. 2004. Holocene thermal maximum in the western Arctic (0–180 W). *Quaternary Science Reviews* 23:529-560.
- Khan, M.A. 1980. Protection of cattle from black flies. Pp. 217-232, in W.O. Haufe, and G.C.R. Croome (eds.). *Control of Black Flies in the Athabasca River: Technical Report*. Alberta Black Fly Coordinating Committee for the Pollution Control Division of Alberta Environment. 242pp.
- Keller, L.F. and D.M. Waller. 2002. Inbreeding effects in wild populations. *Trends in Ecology and Evolution* 17:230-235.
- Kemper, B., D. Poll, and G. Trottier. 1975. Investigations of potential waterfowl-agricultural conflicts in the Mills Lake area, N.W.T. Canadian Wildlife Service, Environment Canada, unpublished report. 95pp.
- Kenefic, L.J., T. Pearson, R.T. Okinaka, J.M. Schupp, D.M. Wagner, J. Ravel, A.R. Hoffmaster, C.P. Trim, W.-K. Chung, J.A. Beaudry, J.T. Foster, J.I. Mead, and P. Keim. 2009. Pre-Columbian origins for North American anthrax. *PLoS ONE* 4(3): e4813. doi:10.1371/journal.pone.0004813.
- Kienast, F., P. Tarasov, L. Schirmermeister, G. Grosse, and A.A. Andreev. 2008. Continental climate in the east Siberian Arctic during the last interglacial: implications from palaeobotanical records. *Global and Planetary Change* 60:535-562.
- King, R. 1836. *Narrative of a Journey to the Shores of the Arctic Ocean, in 1833, 1834, and 1835; Under the Command of Capt. Back, RN (Vol. 1)*. London: Richard Bentley. 347pp.
- Kirkpatrick, J.F., J.C. McCarthy, D.F. Gudermuth, S.E. Shideler, and B.L. Lasley. 1996. An assessment of the reproductive biology of Yellowstone bison (*Bison bison*) subpopulations using noncapture methods. *Canadian Journal of Zoology* 74:8-14.
- Kitto, F.H. 1924. The survival of the American bison in Canada. *Geographical Journal* 63:431-437.
- Kitto, F.H. 1930. *The North West Territories 1930*. Department of the Interior. North West Territories and Yukon. Ottawa: F.A. Ackland, Printer to the King's Most Excellent Majesty. 137pp.
- Knight, C. 1849. *Sketches in natural history: History of the mammalia*. C. Cox, London.
- Kochtubajda, B., R.E. Stewart, M.D. Flannigan, B.R. Bonsal, C. Cuell, and C.J. Mooney. 2019. An assessment of surface and atmospheric conditions associated with the extreme 2014 wildfire season in Canada's Northwest Territories. *Atmosphere-Ocean* 57:73-90.

- Köhler, M. 1993. Skeleton and habitat of recent and fossil ruminants. *Münchner Geowissenschaftliche Abhandlungen* 25:1-88.
- Komers, P.E. 1992. Mating strategies of male wood bison. Ph.D. dissertation, University of Saskatchewan, Saskatoon.
- Komers, P.E., F. Messier, and C.C. Gates. 1992. Search or relax: the case of bachelor wood bison. *Behavioral Ecology and Sociobiology* 31:192-203.
- Komers, P.E., F. Messier, and C.C. Gates. 1993. Group structure in wood bison: nutritional and reproductive determinants. *Canadian Journal of Zoology* 71:1367-1371.
- Komers, P.E., F. Messier, and C.C. Gates. 1994a. Plasticity of reproductive behaviour in wood bison bulls: when subadults are given a chance. *Ethology Ecology and Evolution* 6:313-330.
- Komers, P.E., F. Messier, and C.C. Gates. 1994b. Plasticity of reproductive behaviour in wood bison bulls: on risks and opportunities. *Ethology Ecology and Evolution* 6:481-495.
- Korec, E., M. Hančl, O. Kott, L. Škorpíková, A. Srbová, O. Chalupa, A. Grieblová, P. Šplíchalová, and J. Korcová. 2019. Genus *Bison* has the biggest sex-related difference in longevity among mammals. *Approaches in Poultry, Dairy & Veterinary Sciences*, 5(4), pp.1-4.
- Korosi, J.B., J.R. Thienpont, M.F. Pisaric, P. Demontigny, J.T. Perreault, J. McDonald, M.J. Simpson, T. Armstrong, S.V. Kokelj, J.P. Smol, and J.M. Blais. 2017. Broad-scale lake expansion and flooding inundates essential wood bison habitat. *Nature Communications*, 8(6): p.14510.
- Krumbiegel, I. and G.G. Sehm. 1989. The geographic variability of the plains bison. A reconstruction using the earliest European illustrations of both subspecies. *Archives of Natural History* 16:169-190.
- Krutko, M., pers. comm. 2026. Email correspondence with J. Oosenbrug. March 2026. Renewable Resource Officer, Environment and Climate Change, Government of the Northwest Territories, Fort Providence, NT.
- Kuyt, E. 1972. Food habits and ecology of wolves on barren-ground caribou range in the Northwest Territories. *Canadian Wildlife Service Report Series No. 21*. 36pp.
- Lacy, R.C. 1987. Loss of genetic diversity from managed populations: interacting effects of drift, mutation, immigration, selection, and population subdivision. *Conservation Biology* 1:143-158.
- Lafferty, I., pers. comm. 1980. In-person conversation with T. Chowns. November 1980. Retired trapper, Hay River, NWT.

- Land Withdrawal Order (Dinaga Wek'ehoki (North Arm of Great Slave Lake)), NWT R-054-2014 (*Northwest Territories Lands Act*).
- Larter, N.C. 1988. Diet and habitat selection of an erupting wood bison population. M.Sc. dissertation, University of British Columbia, Vancouver, B.C. 109 pp.
- Larter, N.C. 1997. How do plant communities respond to an erupting bison *Bison bison athabasca* population? *Wildlife Biology* 3:107-116.
- Larter, N.C. 2017. 2017 Nahanni Wood Bison Population Estimate. Unpublished summary report. Letter from N. Larter, Manager, Wildlife Research and Monitoring, Environment and Natural Resources, Government of the Northwest Territories, Fort Simpson, NT. 4 pp.
- Larter, N.C. 2021. Surveys of the Nahanni wood bison population 2002-2018. Environment and Natural Resources Manuscript Report No. 294. 25pp.
- Larter, N.C. pers. comm. 2025. Comments on draft wood bison status report provided to J. Oosenbrug. March and October 2025. *Wildlife Biologist* (ret.), Grande Prairie, AB.
- Larter, N.C. and D.G. Allaire. 2007. History and current status of the Nahanni wood bison population. Environment and Natural Resources File Report No. 136. 37pp.
- Larter, N.C. and D.G. Allaire. 2013. Population survey of the Nahanni wood bison population, March 2011. Environment and Natural Resources Manuscript Report No. 229. 24pp.
- Larter, N.C., D.G. Allaire, and T.S. Jung. 2007. Population survey of the Nahanni wood bison population, March 2004. Environment and Natural Resources Manuscript Report No. 176. 30pp.
- Larter, N.C. and C.C. Gates. 1990. Home ranges of wood bison in an expanding population. *Journal of Mammalogy* 71:604-607.
- Larter, N.C. and C.C. Gates. 1991. Diet and habitat selection of wood bison in relation to seasonal changes in forage quantity and quality. *Canadian Journal of Zoology* 69:2677-2685.
- Larter, N.C., A.R.E. Sinclair, T. Ellsworth, J. Nishi, and C.C. Gates. 2000. Dynamics of reintroduction in an indigenous large ungulate: the wood bison of northern Canada. *Animal Conservation* 4:299-309.
- Larter, N.C., A.R.E. Sinclair, and C.C. Gates. 1994. The response of predators to an erupting bison, *Bison bison athabasca*, population. *Canadian Field-Naturalist* 108:318-327.
- Larter, N.C., J.S. Nishi, T. Ellsworth, D. Johnson, G. More, and D.G. Allaire. 2003. Observations of wood bison swimming across the Liard River, Northwest Territories, Canada. *Arctic* 56:408-412.

- Lemmen, D.S. 1998. Surficial geology, Buffalo Lake, District of Mackenzie, Northwest Territories. Geological Survey of Canada, "A" Series Map, 1906A, Natural Resources Canada.
- Lemmen, D.S., A. Duk-Rodkin, and J.M. Bednarski. 1994. Late glacial drainage systems along the northwest margin of the Laurentide ice sheet. *Quaternary Science Reviews* 13:75-9
- Leonard, J.L., L.B. Perkins, D.J. Lammers, and J.A. Jenks. 2017. Are bison intermediate feeders? Unveiling summer diet selection at the northern fringe of historical distribution. *Rangeland Ecology and Management* 70:405-410.
- Leverkus, S. 2011. Wood bison in northeast British Columbia. Prepared for: C.D. Thiessen, Ministry of Natural Resource Operations Government of British Columbia. 56pp.
- Lewis, C. J. 2024. Pink Mountain Plains Bison Aerial Survey Results – Minimum Count 2024 Technical Report. British Columbia Ministry of Water, Land and Resource Stewardship. Northeast Region, BC. 19pp.
- Lewis, C.J. and S. Das Gupta. 2021. Wood Bison - Etthithun Herd minimum population survey results: February 22-25th, 2021. Technical Report. British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development. Peace Region, BC. 30 pp.
- Lewis, H.T. 1977. Maskuta: the ecology of Indian fires in northern Alberta. *Western Canadian Journal of Anthropology* 8:15-52.
- Lewis, H.T. 1982. A time of burning. Boreal Institute for Northern Studies, University of Alberta, Edmonton. Occasional Publication 17.
- Lewis, H.T. and T.A. Ferguson. 1988. Yards, corridors, and mosaics: how to burn a boreal forest. *Human Ecology* 16:57-77.
- Llamas B., M.L. Holland, K. Chen, J.E. Cropley, A. Cooper, and C.M. Suter. 2012. High-resolution analysis of cytosine methylation in ancient DNA. *PLoS ONE* 7(1): e30226. doi:10.1371/journal.pone.0030226.
- Look, A. pers. comm. 1985. In-person conversation with T. Chowns. November 1985. Trapper and retired Game Management Officer, Fort Providence, NT.
- Looman, J. 1979. The vegetation of the Canadian prairie provinces. 1. An overview. *Phytocoenologia* 5:347-366.
- Lotenberg, G. 1996. History of wood bison in the Yukon - a re-evaluation based on traditional knowledge and written records. Unpublished report prepared by Boreal Research Associates for Yukon Department of Renewable Resources.

- Lott, D.F. 1974. Sexual and aggressive behavior of adult male American bison (*Bison bison*). Pp. 382-394, in V. Geist and F. Walther (eds.). *The Behaviour of Ungulates and its Relation to Management*. IUCN Publications New Series No. 24. Morges, Switzerland. 437pp.
- Lott, D.F. 1979. Dominance relations and breeding rate in mature male American bison. *Zeitschrift für Tierpsychologie* 49:418-432.
- Lott, D.F. 1981. Sexual behavior and intersexual strategies in American bison. *Zeitschrift für Tierpsychologie* 56:97-114.
- Lott, D.F. 2002. *American Bison. A Natural History*. University of California Press, Berkeley and Los Angeles. 245pp.
- Lott, D.F. and J.C. Galland. 1987. Body mass as a factor influencing dominance status in American bison cows. *Journal of Mammalogy* 68:683-685.
- Lucas, F.A. 1899. The fossil bison of North America. *Proceedings of the U.S. National Museum* 21:755-771.
- MacBeth, M. 1913. The Radford-Street expedition. *Canada Monthly* 15:12-13, 65-67.
- MacDonald, G.M. 1987. Postglacial vegetation history of the Mackenzie River Basin. *Quaternary Research*, 28:245-262.
- MacDonald, G.M. 1995. Vegetation of the continental Northwest Territories at 6 ka BP. *Géographie Physique et Quaternaire* 49:37-43.
- MacDonald, G.M. and J.C. Ritchie. 1986. Modern pollen spectra from the western interior of Canada and the interpretation of late Quaternary vegetation development. *New Phytologist* 103:245-268.
- MacDonald, G.M. and T.K. McLeod 1996. The Holocene closing of the 'ice-free' corridor: A biogeographical perspective. *Quaternary International* 32:87-95.
- MacEachern, S., J. McEwan, and M. Goddard. 2009. Phylogenetic reconstruction and the identification of ancient polymorphism in the Bovini tribe (Bovidae, Bovinae). *BMC Genomics* 10:17pp.
- MacFarlane, R.R. 1908. Notes on mammals collected and observed in the northern Mackenzie River District, North-West Territories of Canada with remarks on explorers and explorations of the far north. Pp. 673-764, in *Proceedings of the United States National Museum*, 28(1045).
- MacGregor, J. G. 1952. *The land of twelve foot Davis: a history of the Peace River Country*. Institute of Applied Art, Edmonton, AB. 394pp.

- Mackenzie, A. 1801. Voyages from Montreal, on the River St. Lawrence, through the continent of North America to the Frozen and Pacific Oceans: in the years 1789 and 1793. London. 412pp.
- Mackenzie Bison Working Group (MBWG). 2018. Mackenzie Bison Management Plan. Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT.
- MacNulty, D.R. 2002. The predatory sequence and the influence of injury risk on hunting behavior in the wolf. Ph.D. Dissertation, University of Minnesota, St. Paul, Minnesota.
- MacNulty, D.R., N. Varley, and D.W. Smith. 2001. Grizzly Bear, *Ursus arctos*, usurps bison calf, *Bison bison*, captured by wolves, *Canis lupus*, in Yellowstone National Park, Wyoming. *Canadian Field-Naturalist* 115:495-498.
- Macrae, J.A. 1901. Notes taken in the Peace River, Athabasca, and adjacent country. *Ottawa Naturalist* 14:226-230.
- Mainguy, J., K. Worley, S.D. Cote, and D.W. Coltman. 2007. Low MHC DRB class II diversity in the mountain goat: past bottlenecks and possible role of pathogens and parasites. *Conservation Genetics* 8:885-891.
- Mair, W.W. 1954. The wolf and predator control in the Canadian Arctic. *The Arctic Circular* 7:40-50.
- Margolis, E.Q., C.H. Guiterman, R.D. Chavardès, J.D. Coop, K. Copes-Gerbitz, D.A. Dawe, D.A. Falk, J.D. Johnston, E. Larson, H. Li, J.M. Marschall, C.E. Naficy, A.T. Naito, M.-A. Parisien, S.A. Parks, J. Portier, H.M. Poulos, K.M. Robertson, J.H. Speer, M. Stambaugh, T.W. Swetnam, A.J. Tepley, I. Thapa, C.D. Allen, Y. Bergeron, L.D. Daniels, P.Z. Fulé, D. Gervais, M.P. Girardin, G.L. Harley, J.E. Harvey, K.M. Hoffman, J.M. Huffman, M.D. Hurteau, L.B. Johnson, C.W. Lafon, M.K. Lopez, R.S. Maxwell, J. Meunier, M. North, M.T. Rother, M.R. Schmidt, R.L. Sherriff, L.A. Stachowiak, A. Taylor, E.J. Taylor, V. Trouet, M.L. Villarreal, L.L. Yocom, K.B. Arabas, A.H. Arizpe, D. Arseneault, A. Azpeleta Tarancon, C. Baisan, E. Bigio, F. Biondi, G.D. Cahalan, A. Caprio, J. Cerano-Paredes, B.M. Collins, D.C. Dey, I. Drobyshev, C. Farris, M. A. Fenwick, W. Flatley, M.L. Floyd, Z. Gedalof, A. Holz, L.F. Howard, D.W. Huffman, J. Iniguez, K.F. Kipfmüller, S.G. Kitchen, K. Lombardo, D. McKenzie, A.G. Merschel, K.L. Metlen, J. Minor, C.D. O'Connor, L. Platt, W.J. Platt, T. Saladyga, A.B. Stan, S. Stephens, C. Sutheimer, R. Touchan, and P.J. Weisberg. 2022. The North American tree-ring fire-scar network. *Ecosphere* 13(7): p.e4159.
- Martin, J.M., J.I. Mead, and P.S. Barboza. 2018. Bison body size and climate change. *Ecology and Evolution* 8:4564-4574.

- Martin, J.M., R.A. Short, G.E. Plumb, L. Markewicz, D.H. Van Vuren, B. Wehus-Tow, E. Otarola-Castillo, and M.E. Hill Jr. 2023. Integrated evidence-based extent of occurrence for North American bison (*Bison Bison*) since 1500 CE and before. *Ecology* 104(1): e3864.
- Matson, G.M. 1981. Workbook for cementum analysis. Milltown, MO. 30pp.
- Matthews, S.B. 1991. An assessment of bison habitat in the Mills/Mink Lakes area, Northwest Territories, using LANDSAT thematic mapper data. *Arctic* 44:75-80.
- Mayr, E. 1969. Principles of systematic zoology. McGraw-Hill, New York. 428pp.
- McConnell, R.G. 1891. Report on an exploration in the Yukon and Mackenzie basins, N.W.T. Pp. 45-163, in Geological Survey of Canada, Annual Report, New Series, Vol. 4 Part D.
- McCormack, P.A. 1992. The political economy of bison management in Wood Buffalo National Park. *Arctic* 45:367-380.
- McDonald, J.N. 1981. North American bison: their classification and evolution. Berkeley: University of California Press. 350pp.
- McFarland, H., T. Seaton, M. Taras, D. Bruning, K. Romanoff, K. Miller, N. Weber, and J. Roach. 2018. Wood Bison News (Issue No. 10, Spring - 2018). Department of Fish and Game, Division of Wildlife Conservation. Available online: https://alaskawildlife.org/wp-content/uploads/2022/01/woodbison_news_10_spring_2018.pdf [accessed 21 April 2026].
- McFarlane (Zittlau), K., G.A. Wilson, and J.S. Nishi. 2006. Management strategies for conservation of genetic diversity in wood bison (*Bison bison athabascae*). Environment and Natural Resources File Report No. 135.
- McGillivray, S. 1829-30. Journal of Simon McGillivray, Hudson's Bay Company chief trader, Fort Resolution retrieved from a trash can in Fort Resolution in 1924. Obtained by D. Harrison and read by T. Chowns.
- McHugh, T. 1958. Social behavior of the American buffalo (*Bison bison bison*). *Zoologica* 43:1-40.
- McLeod, R.W. 1908. Letter from Sergeant R. W. McLeod addressed to Officer Commanding, R. N. W. M. Police, Lesser Slave Lake. 1908. Pg. 139, in Appendix J. Annual Report of Superintendent W. H. Routledge, commanding 'N' Division. Pp. 115-139, in Annual Report of the Royal North West Mounted Police, 1908. Sessional Paper No. 28. 272pp.
- McLeod, R.W. 1909. Appendix T. Patrol report, Sergeant R. W. MacLeod, Fort Vermilion to Hay River, January, 1909. Pp. 178-180, in Report of the Royal Northwest Mounted Police, 1909. Sessional Paper No. 28. 263pp.

- McLeod, R.W. 1911. Appendix U. Sergeant R. W. McLeod's patrol, Fort Vermilion to Great Slave Lake. Pp. 180-181, *in* Annual Report of the Royal Northwest Mounted Police, 1911. Sessional Paper No. 28. 319pp.
- McLeod, S.R. 1997. Is the concept of carrying capacity useful in variable environments? *Oikos* 79: 529-542.
- McMillan, B.R., M.R. Cottam, and D.W. Kaufman. 2000. Wallowing behavior of American bison (*Bos bison*) in tallgrass prairie: an examination of alternate explanations. *American Midland Naturalist* 144:159-167.
- McNaughton, S.J. 1979. Grassland-herbivore dynamics. Pp. 46-81, *in* A.R.E. Sinclair and M. Norton-Griffiths (eds.). *Serengeti: Dynamics of an Ecosystem*. Chicago: University of Chicago Press. 389pp.
- Meagher, M.M. 1971. Snow as a factor influencing bison distribution and numbers in Pelican Valley, Yellowstone National Park. Pp. 63-67, *in* Proceedings of Snow and Ice in Relation to Wildlife and Recreation Symposium. Iowa State University, Ames, Iowa.
- Meagher, M.M. 1973. The Bison of Yellowstone National Park. *Scientific Monographs* 1:1-161. National Park Service, Government Printing Office, Washington, DC.
- Mech, L.D. 1970. The wolf: the ecology and behaviour of an endangered species. The Natural History Press, New York. 384pp.
- Mech, L. D. and L. Boitani. 2003. Wolf social ecology. Pp. 1-34, *in* Mech, L.D. and L. Boitani (eds.). *Wolves: behavior, ecology, and conservation* University of Chicago Press. 472pp.
- Mech, L.D. and L.D. Frenzel. 1971. Ecological studies of the timber wolf in northeastern Minnesota. U.S. Department of Agriculture and Forest Services Research Paper NC-148.
- Mech, L.D. and R.O. Peterson. 2003. Wolf-prey relations. Pp. 131-157, *in* Mech, L.D. and L. Boitani (eds.). *Wolves: behavior, ecology, and conservation* University of Chicago Press. 472pp.
- Mellor, A.H.L. 1909. Appendix W. Corporal H. L. Mellor, Smith's Landing to Buffalo Country, September, 1909. Pp. 187-188, *in* Report of the Northwest Mounted Police, 1909. Sessional Paper No. 28. 263pp.
- Mellor, A.H.L. 1910. Appendix T. Report of Sergeant A. H. L. Mellor, on patrol along the southern shore of Great Slave Lake, in connection with location of wood buffalo. Pp. 197-200, *in* Annual Report of the Royal Northwest Mounted Police, 1910. 276pp.

- Melton, D.A., N.C. Larter, C.C. Gates, and J.A. Virgl. 1989. The influence of rut and environmental factors on the behaviour of wood bison. *Acta Theriologica* 34:179-193.
- Meyer, D., A.B. Beaudoin, and L.J. Amundson. 2011. Chapter 1. Human ecology of the Canadian prairie ecozone ca. 9000 BP: the Paleo-Indian period. Pp. 5-54, in B.A. Nicholson (ed.). *Human Ecology of the Canadian Prairie Ecozone 11,000 to 300 BP* Canadian Plains Research Center. 190pp.
- Miller, H.A., R.W. Drummond, and T.S. Jung. 2024. Results of a 2024 Population Survey of Reintroduced Bison (*Bison bison*) in the Yukon. Yukon Fish and Wildlife Branch Report SR24-09, Whitehorse, YT. 14 pp.
- Mikko, S., K. Roed, S. Schmutz, and L. Andersson. 1999. Monomorphism and polymorphism at the Mhc *DRB* loci in domestic and wild ruminants. *Immunological Reviews* 167:169-178.
- Mikko, S., M. Spencer, B. Morris, S. Stabile, T. Basu, C. Stormont and L. Andersson. 1997. A comparative analysis of Mhc *DRB3* polymorphism in the American bison (*Bison bison*). *Journal of Heredity* 8:499-503.
- Millar, J.B. 1973. Vegetation changes in shallow marsh wetlands under improving moisture regime. *Canadian Journal of Botany* 51:1443-1457.
- Miller, C. and D.L. Urban. 2000. Connectivity of forest fuels and surface fire regimes. *Landscape Ecology* 15:145-154.
- Miller H.A., R. Drummond, and T.S. Jung. 2023. Results of a 2023 population survey of reintroduced bison (*Bison bison*) in the Yukon. Yukon Fish and Wildlife Branch Report SR23-16, Whitehorse, Yukon, Canada. 9pp.
- Millette, F.J. and A.N. Sturko. 1977. A proposal to review and revise the anthrax control program in Wood Buffalo National Park. Parks Canada, unpublished report. 17pp.
- Minett, F.C. 1950. Sporulation and viability of *B. anthracis* in relation to environmental temperature and humidity. *Journal of Comparative Pathology and Therapeutics* 60:161-176.
- Mitchell, J.A. and C.C. Gates. 2002. Status of the Wood Bison (*Bison bison athabascae*) in Alberta. Alberta Sustainable Resource Development, Fish and Wildlife Division and Alberta Conservation Association, Wildlife Status Report No. 38. 32pp.
- Miyamoto, M.M., S.M. Tanhauser, and P.J. Laipis. 1989. Systematic relationships in the artiodactyl tribe Bovini (family Bovidae), as determined from mitochondrial DNA sequences. *Systematic Zoology* 38:342-349.

- Modi, W.S., D.S. Gallagher, and J.E. Womack. 1996. Evolutionary histories of highly repeated DNA families among the Artiodactyla (Mammalia). *Journal of Molecular Evolution* 42:337-349.
- Moen, A.N. 1973. *Wildlife ecology*. San Francisco: Freeman. 458pp.
- Mooring, M.S. 2024. Programmed grooming after 30 years of study: a review of evidence and future prospects. *Animals* 14:p.1266.
- Mooring, M.S. and W.M. Samuel. 1998a. The biological basis of grooming in moose: programmed versus stimulus-driven grooming. *Animal Behaviour* 56:1561-1570.
- Mooring, M.S. and W.M. Samuel. 1998b. Tick-removal grooming by elk (*Cervus elaphus*): testing the principles of the programmed-grooming hypothesis. *Canadian Journal of Zoology* 76:740-750.
- Mooring, M.S. and W.M. Samuel. 1998c. Tick defense strategies in bison: the role of grooming and hair coat. *Behaviour* 135:693-718.
- Morgan, S.B. 1987. The effects of Tabanidae (Diptera) on the behavior of wood bison at Waterhen, Manitoba. M.Sc. dissertation, University of Manitoba, Winnipeg.
- Moss, E.H. 1953. Marsh and bog vegetation in northwestern Alberta. *Canadian Journal of Botany* 31:448-470.
- Mulloy, G.A. 1912. Report No. 30-34 of George A. Mulloy. Pp. 145-158, *in* Report to the Director of Forestry for 1912. Department of the Interior, Government of Canada.
- Murie, A. 1944. The wolves of Mount McKinley. *Fauna of the National Parks of the United States*. Fauna Series No. 5. United States Government Printing Office, Washington, D.C. 238pp.
- Mychasiw, L. 1987. Primary range survey of the Mackenzie Bison Sanctuary. Department of Environment and Natural Resources, Government of the Northwest Territories, unpublished report. 113pp.
- Myers, M. 2012. Endangered and threatened wildlife and plants; reclassifying the wood bison under the Endangered Species Act as Threatened throughout its range. U.S. Fish and Wildlife Service. Department of the Interior. *Federal Register* 77 (86):26191-26212.
- Nahanni Bison Working Group (NBWG). 2019. Nahanni Bison Management Plan. Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT. File Report No. 153.

- National Wetlands Working Group. 1997. The Canadian Wetland Classification System. Second edition. Warner, B.G. and C.D.A. Rubec (eds). Wetlands Research Center, Waterloo, Ontario, Canada. 68pp.
- Nei, M., T. Maruyama, and R. Chakraborty. 1975. The bottleneck effect and genetic variability in populations. *Evolution* 29:1-10.
- Nevai, A.L. and R.A. Van Gorder. 2012. Effect of resource subsidies on predator-prey population dynamics: a mathematical model. *Journal of Biological Dynamics* 6:891-922.
- New, D., B. Elkin, T. Armstrong, and T. Epp. 2017. Anthrax in the Mackenzie wood bison (*Bison bison athabascae*) population: 2012 anthrax outbreak and historical exposure in nonoutbreak years. *Journal of Wildlife Diseases*, 53:769-780.
- Nijman, I.J., D.C. Van Boxtel, L.M. Van Cann, Y. Marnoch, E. Cuppen, and J.A. Lenstra. 2008. Phylogeny of Y chromosomes from bovine species. *Cladistics* 24:723-726.
- Niroula, N., P. Ghodasara, N. Marreros, B. Fuller, H. Sanderson, S. Zriba, S. Walker, T.K. Shury, and J.M. Chen. 2025. Orally administered live BCG and heat-inactivated *Mycobacterium bovis* protect bison against experimental bovine tuberculosis. *Scientific Reports* 15: 3764.
- Nishi, J.S. 2017. Status of the American Bison (*Bison bison*) in Alberta: Update 2017. Alberta Wildlife Status Report No. 38. Prepared for Alberta Environment and Parks, and Alberta Conservation Association. 135pp.
- Nishi, J.S., T.R. Ellsworth, N. Lee, D. Dewar, B.T. Elkin, and D.C. Dragon. 2007. Northwest Territories: An outbreak of anthrax (*Bacillus anthracis*) in free-roaming bison in the Northwest Territories, June-July 2006. *Can Vet J.* Jan;48(1):37-8. PMID: 17310621; PMCID: PMC1716754.
- Northwest Territories Nuisance Bison Control Regulations. 1992. R-070-92 (N.W.T. Reg. 070-92).
- Novakowski, N.S. 1957a. Aerial resurvey of bison in Wood Buffalo National Park and surrounding areas, 1957. Canadian Wildlife Service, Environment Canada, unpublished report. 12pp.
- Novakowski, N.S. 1957b. Report on tagging, testing and slaughtering of bison in the Lake Claire area Wood Buffalo National Park, October, November 1957. Canadian Wildlife Service, Environment Canada, unpublished report. 14pp.
- Novakowski, N.S. 1959. Report on the investigation of probable wood bison in the Nyarling River area and an investigation of historical wood bison range in the Fort Providence area. Canadian Wildlife Service, Environment Canada, unpublished report. 18pp.

- Novakowski, N.S. 1961. Estimates of the bison population in Wood Buffalo National Park and the Northwest Territories based on transects and total counts. Canadian Wildlife Service, Environment Canada, unpublished report. 8pp.
- Novakowski, N.S. 1963a. Report on the transfer of wood bison, 1963. Canadian Wildlife Service, Environment Canada, unpublished report. 4pp.
- Novakowski, N.S. 1963b. Wood bison transfer – completion report. Canadian Wildlife Service, Environment Canada, unpublished report. 5pp.
- Novakowski, N.S. 1965a. Population dynamics of a beaver population in northern latitudes. Ph.D. Dissertation, University of Saskatchewan, Saskatoon. 154pp.
- Novakowski, N.S. 1965b. Slaughter report – Grand Detour 1964-1965. Canadian Wildlife Service, Environment Canada, unpublished report. 4pp.
- Novakowski, N.S., J.G. Cousineau, G.B. Kolenosky, G.S. Wilton, and L.P.E. Choquette. 1963. Parasites and diseases of bison in Canada. II. Anthrax epizooty in the Northwest Territories. Transactions of the North American Wildlife and Natural Resources Conference 28:233–239.
- Novakowski, N.S. and W.E. Stevens. 1965. Survival of the wood bison *Bison bison athabascae* Rhoads in Canada. Paper presented to the 45th Meeting of the American Society of Mammalogists, Winnipeg, MB, June 21, 1965. 5pp.
- Nudds, T.D. 1993. How many bison, *Bison bison*, should be in Wood Buffalo National Park? Canadian Field-Naturalist 107:117-119.
- O'Brien, M.P., A. Beja-Pereira, N. Anderson, R.M. Ceballos, W.H. Edwards, B. Harris, R.L. Wallen, V. Costa, and G. Luikart. 2017. Brucellosis transmission between wildlife and livestock in the Greater Yellowstone Ecosystem: Inferences from DNA genotyping. Journal of Wildlife Diseases, 53(2):339-343.
- O'Brien, S.J. and J.F. Evermann. 1988. Interactive influence of infective disease and genetic diversity in natural populations. Trends in Ecology and Evolution 3:254-259.
- O'Donnell, J.A., J.W. Harden, A.D. McGuire, and V.E. Romanovsky. 2011. Exploring the sensitivity of soil carbon dynamics to climate change, fire disturbance and permafrost thaw in a black spruce ecosystem. Biogeosciences 8:1367-1382.
- Ogilvie, S.C. 1979. The Park Buffalo. Calgary-Banff Chapter, National and Provincial Parks Association of Canada, Calgary, Alberta.
- Ogilvie, W. 1893. Report on the Peace River and tributaries in 1891. Pp. 1-44, part 7 in Annual Report of the Department of the Interior, Government of Canada for 1892.

- Oldham, E.G. 1947. Report on the buffalo count Wood Buffalo National Park. Parks Canada, unpublished report.
- Olech, W. 1987. Analysis of inbreeding in European bison. *Acta Theriologica* 32:373-387.
- Olesinski and R. Brett. 2016. 2016 Northwest Territories forest health report. Environment and Natural Resources, Government of Northwest Territories. 24pp.
- Olson, W.E. 2002. Plains and wood bison weight and population dynamics in Elk Island National Park for 2001-2002. Elk Island National Park, unpublished annual report. Fort Saskatchewan, AB.
- Olson, W.E. 2006. A photographic guide to ontogenetic and seasonal variation in phenotypic expression of plains and wood bison. Parks Canada, unpublished report. 120 pp.
- O'Toole, D., H. Li, and T.B. Crawford. 2000. Malignant catarrhal fever in bison. University of Wyoming, Washington State University and United States Department of Agriculture, unpublished report.
- Owen-Smith, N. 1993. Comparative mortality rates of male and female kudus: the costs of sexual size dimorphism. *Journal of Animal Ecology*, 62:428–440.
- Palmer, T.S. 1916. Our national herds of buffalo. *Annual Report of the American Bison Society* 10:40-62.
- Parks Canada. Wood Buffalo National Park of Canada. Web site: <https://parks.canada.ca/pn-np/nt/woodbuffalo/info/action> [accessed 27 March 2026].
- Parks Canada. 2019. Wood Buffalo National Park World Heritage Site Action Plan. Government of Canada, Parks Canada. Web site: <https://parks.canada.ca/pn-np/nt/woodbuffalo> [accessed 2 March 2026].
- Parks Canada. 2024. Bison Project Update, Wood Buffalo National Park (2024). Published November 12, 2024. Resource Conservation Team, Wood Buffalo National Park, Parks Canada. Website: https://parks.canada.ca/pn-np/nt/woodbuffalo/nature/science_nature/bison/revision-2024-update [accessed 14 March 2026].
- Parks Canada, unpubl. data. 2024. Anthrax outbreaks and number of wood bison mortalities in Wood Buffalo National Park. Unpublished data provided by J. Rabley. Email to J. Oosenbrug, 9 September 2024. Parks Canada, Fort Smith, NT.
- Parks, S.A., C.H. Guiterman, E.Q. Margolis, M. Lonergan, E. Whitman, J.T. Abatzoglou, D.A. Falk, J.D. Johnston, L.D. Daniels, C.W. Lafon, and R.A. Loehman. 2025. A fire deficit persists

across diverse North American forests despite recent increases in area burned. *Nature Communications* 16(1): p.1493.

- Parks, S.A., M.A. Parisien, C. Miller, L.M. Holsinger, and L.S. Baggett. 2018. Fine-scale spatial climate variation and drought mediate the likelihood of reburning. *Ecological Applications* 28:573-586.
- Pavelsky, T.M. and L.C. Smith. 2008. Remote sensing of hydrologic recharge in the Peace-Athabasca Delta, Canada. *Geophysical Research Letters* 35: L08403, doi:10.1029/2008GL033268.
- Peach, K. 2002. Analysis of bison skulls from Banff National Park: determination of sex, subspecies, and age. Parks Canada, unpublished report. 9 pp.
- Peacock, D. 1997. Yellowstone bison slaughter. *Wild Earth*. 7(2): 6-11.
- Peden, D.G. and G.J. Kraay. 1979. Comparison of blood characteristics in plains bison, wood bison, and their hybrids. *Canadian Journal of Zoology* 57:1778-1784.
- Peden, D.G. and H.W. Reynolds. 1981. Estimates of annual herbage production in the Falaise Lake area of the Mackenzie Bison Sanctuary, Northwest Territories, 1979. Canadian Wildlife Service, Environment Canada, unpublished report. 123 pp.
- Peden, D.G., G.M. Van Dyne, R.W. Rice, and R.M. Hansen. 1974. The trophic ecology of *Bison bison* L. on shortgrass prairie. *Journal of Applied Ecology* 11:489-498.
- Penner, D.F. 1978. Some relationships between moose and willow in the Fort Providence, NWT area. M.Sc. dissertation, University of Alberta, Edmonton. 183pp.
- Perry, A.B. 1909. Royal Northwest Mounted Police report, sessional papers 1909.
- Perry, A.B. 1910. Commissioner's report. Pp. 7-29, in Report of the Royal Northwest Mounted Police 1910. Sessional Paper No. 28. 276pp.
- Pertoldi, C., M. Tokarska, J.M. Wójcik, D. Demontis, V. Loeschcke, V.R. Gregersen, D. Coltman, G.A. Wilson, E. Randi, M.M. Hansen, and C. Bendixen. 2009. Depauperate genetic variability detected in the American and European bison using genomic techniques. *Biology Direct* 4:48 doi:10.1186/1745-6150-4-48.
- Peters, D.L. and T.D. Prowse. 2001. Regulation effects on the lower Peace River, Canada. *Hydrological Processes* 15:3181-3194.
- Peters, D.L., T.D. Prowse, A. Pietroniro, and R. Leconte. 2006. Flood hydrology of the Peace-Athabasca Delta, northern Canada. *Hydrological Processes* 20:4073-4096.

- Peters, H.F. and S.B. Slen. 1964. Hair coat characteristics of bison, domestic × bison hybrids, cattalo, and certain domestic breeds of beef cattle. *Canadian Journal of Animal Science* 44:48-57.
- Peters, R.H. and J.V. Raelson. 1984. Relations between individual size and mammalian population density. *American Naturalist* 124:498-517.
- Peters, H.F. and S.B. Slen. 1964. Hair coat characteristics of bison, domestic × bison hybrids, cattalo, and certain domestic breeds of beef cattle. *Canadian Journal of Animal Science* 44:48-57.
- Petitot, E. 1891. *Autour Du Grand Lac Des Esclaves*. Nouvelle Librairie Parisienne, 368pp.
- Piertney, S.B. and M.K. Oliver. 2006. The evolutionary ecology of the major histocompatibility complex. *Heredity* 96:7-21.
- Piet, L.J.M. 1992. Paleogeography and sedimentology of fluvial point bars, chute-fills and oxbow-fills in the lower Liard River NWT. M.Sc. dissertation, University of Calgary, Calgary. 107pp.
- Pike, W. 1892. *The barren ground of northern Canada*. New York: E.P. Dutton and Company 300pp.
- Pilo, P. and J. Frey. 2018. Pathogenicity, population genetics and dissemination of *Bacillus anthracis*. *Infection, Genetics and Evolution* 64:115-125.
- Plumb, G.E., D.H. Ranglack, and K. Perzanowski. 2024. 2023 Report of the Bison Specialist Group. IUCN SSC and Secretariat. 2023 Report of the IUCN Species Survival Commission and Secretariat. Gland, Switzerland: IUCN. 4pp.
- Plumb, G.E., P.J. White, M.B. Coughenour, and R.L. Wallen, 2009. Carrying capacity, migration, and dispersal in Yellowstone bison. *Biological Conservation* 142:2377-2387.
- Polziehn, R.O., R. Beech, J. Sheraton, and C. Strobeck. 1996. Genetic relationships among North American bison populations. *Canadian Journal of Zoology* 74:738-749.
- Porsild, A.E. and W.J. Cody. 1980. *Vascular plants of continental Northwest Territories, Canada*. National Museums of Canada. 667pp.
- Post, D.M., T.S. Armbrust, E.A. Horne, and J.R. Goheen. 2001. Sexual segregation results in differences in content of quality of bison (*Bos bison*) diets. *Journal of Mammalogy* 82:407-413.
- Preble, E.A. 1908. *A biological investigation of the Athabaska-Mackenzie region*. North American Fauna, No. 27. 574pp.

- Preisser, E.L., D.I. Bolnick, and M.F. Benard. 2005. Scared to death? The effects of intimidation and consumption in predator-prey interactions. *Ecology* 86:501-509.
- Price, D.T., R.I. Alfaro, K.J. Brown, M.D. Flannigan, R.A. Fleming, E.H. Hogg, M.P. Girardin, T. Lakusta, M. Johnston, D.W. McKenney, and J.H. Pedlar. 2013. Anticipating the consequences of climate change for Canada's boreal forest ecosystems. *Environmental Reviews* 21:322-365.
- Pringle, W.L. 1987. Forage potential for livestock production. Pp. 39-44, in Reynolds, H.W. and A.W.L. Hawley (eds.). *Bison Ecology in Relation to Agricultural Development in the Slave River Lowlands, N.W.T. Occasional Paper No.63, Ottawa, ON. 72pp.*
- Pringle, W.L., A. Hennig, R. Cairns, and B. Siemens. 1975. Salt status of some soils of the Slave River Lowlands in Canada's Northwest Territories. *Canadian Journal of Soil Science* 55:399-406.
- Prowse, T.D., S. Beltaos, B. Bonsal, T. Carter, M.C. English, T. Gardner, J.J. Gibson, D.L. Peters, and L. Romolo. 2004. Hydro-climatic impacts affecting the Peace-Athabasca-Slave catchments and deltas, in Environment Canada, Northern Rivers Ecosystem Initiative: Collective Findings.
- Prowse, T.D., S. Beltaos, J.T. Gardner, J.J. Gibson, R.J. Granger, R. Leconte, D.L. Peters, A. Pietroniro, L.A. Romolo, and B. Toth. 2006. Climate change, flow regulation and land-use effects on the hydrology of the Peace-Athabasca-Slave system; findings from the Northern Rivers Ecosystem Initiative. *Environmental Monitoring and Assessment* 113:167-197.
- Prowse, T.D. and F.M. Conly. 1996. Impact of flow regulation on the aquatic ecosystem of the Peace and Slave Rivers, Northern Rivers Basin Study, Synthesis Report No. 1. 168pp.
- Prowse, T.D. and F.M. Conly. 2002. A review of hydroecological results of the northern river basins study, Canada. Part 2. Peace-Athabasca Delta. *River Research and Applications*, 18:447-460.
- Prowse, T. D., D., Peters, S., Beltaos, A., Pietroniro, L., Romolo, J.Töyrä, and R. Leconte. 2002. Restoring ice-jam floodwater to a drying delta ecosystem. *Water International* 27: 58- 69.
- Prusak, B., G. Grzybowski, and G. Ziêba, 2004. Taxonomic position of *Bison bison* (Linnaeus 1758) and *Bison bonasus* (Linnaeus 1758) as determined by means of cytb gene sequence. *Animal Science Papers and Reports* 22:27-35.
- Pyne, S.J. 1997. *Fire in America: a cultural history of wildland and rural fire.* University of Washington Press. 68opp.

- Quinlan, A., M.A. Dale, and C.C. Gates. 2003. Effects of prescribed burning on herbaceous and woody vegetation in northern lowland meadows. *Restoration Ecology* 11:343-350.
- Rabley, J., pers. comm. 2025. Telephone and email correspondence with T. Chowns. January 2025. Ecologist Team Lead, Wood Buffalo National Park, Parks Canada, Government of Canada, Fort Smith, NT.
- Radford, H.V. 1911. Preliminary report on the condition of the wild wood bison of Northwestern Canada. American Bison Society unpublished notes. 17pp.
- Radwan, J., A. Kawalko, J.M. Wojcik, and W. Babik. 2007. MHC-DRB₃ variation in a free-living population of the European bison, *Bison bonasus*. *Molecular Ecology* 16:531-540.
- Raup, H.M. 1933. Range conditions in the Wood Buffalo Park of Western Canada with notes on the history of wood bison. Special Publication of the American Committee for International Wildlife Protection. Vol. I, No. 2. 52pp.
- Raup, H.M. 1935. Botanical investigations in Wood Buffalo National Park. National Museum of Canada Bulletin 74 Biological Series No. 20. 174pp.
- Rawleigh, G.J., M.A. Edwards, D. Epperson, and S.E. Nielsen. 2024. Trade-offs between forage availability, accessibility, and predation risk on winter foraging strategies of wood bison (*Bison bison athabascae*). *Ecology and Evolution* 14(10), p.e70385.
- Redburn, M.J., W.L. Strong, and C.C. Gates. 2008. Suitability of boreal mixedwood clearcuts as wood bison (*Bison bison athabascae*) foraging habitat in north-central Alberta, Canada. *Forest Ecology and Management* 255:2225-2235.
- Redford, K.H. and E. Fern. 2006. The ecological future of the North American bison. Wildlife Conservation Society, Bronx, New York.
- Reid, K.A., N.J. Day, R. Alfaro-Sánchez, J.F. Johnstone, S.G. Cumming, M.C. Mack, M.R. Turetsky, X.J. Walker, and J.L. Baltzer, 2023. Black spruce (*Picea mariana*) seed availability and viability in boreal forests after large wildfires. *Annals of Forest Science* 80(1), p.4.
- Reinhardt, V. 1985. Social behaviour in a confined bison herd. *Behaviour* 92:209-226.
- Reynolds, H.W. 1976. Bison diets of Slave River Lowlands, Canada. Ph.D. Dissertation, Colorado State University.
- Reynolds, H.W. 1979. The wood bison rehabilitation program. Paper presented to the Bison Management Workshop, Salina, Kansas, April 10-12, 1979. 23pp.
- Reynolds, H.W. 1982. An endangered species program brings wood bison to Nahanni. *Zoonoos* 55:4-8.

- Reynolds, H.W. 1987. Description of the Slave River Lowlands. Pp. 13-14 in H.W. Reynolds and A.W.L. Hawley (eds.). Bison ecology in relation to agricultural development in the Slave River Lowlands, N.W.T. Occasional Paper No.63, Ottawa, On. 72pp.
- Reynolds, H.W. 1987. The Canadian Wildlife Service program to restore wood bison. Pp. 323-328, in G.L. Holroyd, W.B. McGillivray, P.H.R. Stepney, D.M. Ealey, G.C. Trottier, and K.E. Eberhart (eds.). Proceedings of the Workshop on Endangered Species in the Prairie Provinces. Edmonton: Alberta Culture, Historical Resources Division. Provincial Museum of Alberta, Occasional Paper No. 9.
- Reynolds, H.W. and C.C. Gates. 1991. Managing wood bison: A once endangered species. Pp. 363-371, in L.A. Renecker and R.J. Hudson (eds.). Wildlife Production: Conservation and Sustainable Development. AFES misc. pub. 91-6. University of Alaska Fairbanks, Fairbanks, Alaska.
- Reynolds, H.W., C.C. Gates, and R.D. Glaholt. 2003. Bison (*Bison bison*). Pp.1009-1060, in Feldhamer, G.A., B.C. Thompson, and J.A. Chapman (eds.). Wild Mammals of North America: Biology, Management and Conservation. Johns Hopkins University Press, Maryland.
- Reynolds, H.W., J.R. McGillis, and R.D. Glaholt. 1980. Range assessment of the Liard-South Nahanni rivers region, N.W.T. as habitat suitable for wood bison. Canadian Wildlife Service, Environment Canada, unpublished report. 39pp.
- Reynolds, H.W., R.M. Hansen, and D.G. Peden. 1978. Diets of the Slave River lowland bison herd, Northwest Territories, Canada. Journal of Wildlife Management 42:581-590.
- Reynolds, H.W. and A.W.L. Hawley. 1987. Introduction. Pp. 10-12, in Reynolds, H.W. and A.W.L. Hawley (eds.). Bison Ecology in Relation to Agricultural Development in the Slave River Lowlands, N.W.T. Occasional Paper No.63, Ottawa, ON. 72pp.
- Reynolds, H.W. and D.G. Peden. 1987. Vegetation, bison diets, and snow cover. Pp. 39-44, in Reynolds, H.W. and A.W.L. Hawley (eds.). Bison Ecology in Relation to Agricultural Development in the Slave River Lowlands, N.W.T. Occasional Paper No.63, Ottawa, Ontario. 72pp.
- Rhoads, S.N. 1897. Notes on living and extinct species of American bovidae. Proceedings of the Academy of Natural Sciences of Philadelphia 49:483-502.
- Rhyan, J.C., K. Aune, T. Roffe, D. Ewalt, S. Hennager, T. Gidlewski, S. Olsen, and R. Clarke. 2009. Pathogenesis and epidemiology of brucellosis in Yellowstone bison: serologic and culture results from adult females and their progeny. Journal of Wildlife Diseases, 45:729-739.

- Richards, C.L., O. Bossdorf, and M. Pigliucci. 2010. What role does heritable epigenetic variation play in phenotypic evolution? *Integrative Biology Faculty Publications* 60:232-237.
- Richardson, J. 1829. *Fauna Boreali-Americana. Part First, Quadrupeds*. John Murray, London. 300pp.
- Richardson, J. 1851. *Arctic searching expedition: a journal of a boat-voyage through Rupert's Land and the Arctic Sea, in search of the discovery ships under the command of Sir John Franklin, 1847-1850*. London. 426pp.
- Richmond, R.J., R.J. Hudson, and R.J. Christopherson. 1977. Comparison of forage intake and digestibility by American bison, yak, and cattle. *Acta Theriologica* 22:225-230.
- Riney, T. 1964. The impact of introductions of large herbivores on the tropical environment. *IUCN Publication, New Series*. 4:261-273.
- Rippin, B. 1971. *Aerial buffalo survey, Fort Smith, N.W.T.* Department of Environment and Natural Resources, Government of the Northwest Territories, unpublished report. 13pp.
- Rippin, B. 1972. *Wood bison survey – Zone 7. March 6, 1972.* Department of Environment and Natural Resources, Government of the Northwest Territories, unpublished report. 6pp.
- Ritchie, J.C. 1976. The late-Quaternary vegetational history of the western interior of Canada. *Canadian Journal of Botany* 54:1793-1818.
- Ritchie, J.C. and G.M. MacDonald. 1986. The patterns of post-glacial spread of white spruce. *Journal of Biogeography* 13:527-540.
- Rivals, F. and G.M. Semprebon. 2011. Dietary plasticity in ungulates: insight from tooth microwear analysis. *Quaternary International* 245:279-284.
- Robinson, M.J. and J.L. Robinson. 1946. *Fur production in the Northwest Territories*. Bureau of Northwest Territories and Yukon Affairs, Department of Mines and Resources, Ottawa. *Reprinted from Canadian Geographical Journal*. 16pp.
- Robison, C.D., D.S. Davis, J.W. Templeton, M. Westhusin, W.B. Foxworth, M.J. Gilsdorf, and L.G. Adams. 1998. Conservation of germ plasm from bison infected with *Brucella abortus*. *Journal of Wildlife Diseases* 34:582-589.
- Roe, E.F. 1970. *The North American buffalo*. University of Toronto Press. 991pp.
- Rokaya, P. A. Das and K.E. Lindenschmidt. 2017. Exploring flow operation schemes for sustainable ice-jam flood management along the Peace River in western Canada. *in Proceedings of the 19th Workshop on the Hydraulics of Ice Covered Rivers*. Whitehorse, YT.

- Rostad, H.P.W., R.A. White, and D.F. Acton. 1976. Soil Survey and Land Evaluation of the Liard and Mackenzie River Area Northwest Territories. Saskatchewan Institute of Pedology, University of Saskatchewan.
- Routledge, W.A. 1908. Appendix J. Annual Report of Superintendent W. H. Routledge, commanding 'N' Division. Pp. 115-135, *in* Annual Report of the Royal North West Mounted Police, 1908. 272pp.
- Rowe, J.S. and G.W. Scotter. 1973. Fire in the boreal forest. *Quaternary Research* 3:444-464.
- Rowe, M. 2007. 2007 Nordquist Wood Bison Inventory. Peace Region Technical Report. Ministry of Environment, British Columbia, Fort St. John, B.C., 9pp.
- Rowe, M. and R. Backmeyer. 2006. Etthithun wood bison inventory: March 2006. BC Ministry of Environment, Fort St. John, BC. 6 pp.
- Russell, F. 1898. Explorations in the far north. University of Iowa. Iowa City. 290pp.
- Rutberg, A.T. 1984. Birth synchrony in American bison (*Bison bison*): Response to predation or season? *Journal of Mammalogy* 65:418-423.
- Rutberg, A.T. 1986. Lactation and fetal sex ratios in American bison. *American Naturalist* 127:89-94.
- Rutter, N.W. and A.N. Boydell. 1981. Surficial geology and geomorphology, Sibbeston Lake, District of Mackenzie. Geological Survey of Canada, Preliminary Map, 10-1979.
- Sabine, J. 1823. No. V. Zoological Appendix. Pp. 647-703, *in* Franklin, J. 1823. Narrative of a journey to the shores of the Polar Sea in the years 1819-20-21-22. London: John Murray. 768pp.
- Safronov, V.M., R.N. Smetanin, and V.V. Stepanova. 2012. Introduction of the wood bison (*Bison bison athabasca* Rhoads, 1897) in Central Yakutia. *Russian journal of biological invasions*, 3(1), pp.34-48.
- Salb, A., C. Stephen, C. Ribble, and B. Elkin. 2014. Descriptive epidemiology of detected anthrax outbreaks in wild wood bison (*Bison bison athabasca*) in northern Canada, 1962-2008. *Journal of Wildlife Diseases* 50, no. 3: 459-468.
- Sanderson, E.W., K.H. Redford, B. Weber, K. Aune, D. Baldes, J. Berger, D. Carter, C. Curtin, J. Derr, S. Dobrott, E. Fearn, C. Fleener, S. Forrest, S.C. Gerlach, C.C. Gates, J. Gross, P.H. Gogan, S. Grassel, J.A. Hilty, M. Jensen, K. Kunkel, D. Lammers, R. List, K. Minkowski, T. Olson, C. Pague, P.B. Robertson, and B. Stephenson. 2008. The ecological future of the

- North American Bison: Conceiving long-term, large-scale conservation of wildlife. *Conservation Biology* 22:252-266.
- Sarmiento, S. and A. Palanisami 2011. Coherence between atmospheric teleconnections and Mackenzie River Basin lake levels. *Journal of Great Lakes Research* 37:642-649.
- Scholten, R.C., R. Jandt, E.A. Miller, B. M. Rogers and S. Veraverbeke. 2021. Overwintering fires in boreal forests. *Nature* 593: 399-404.
- Schultz, C.B. and J.M. Hillerud, 1977. The antiquity of *Bison latifrons* (Harlan) in the Great Plains of North America. *Transactions of the Nebraska Academy of Science* 4:103-116.
- Schwarz, A.G., J.P. Thorpe, and R.E. Redmann. 1986. Isolated grasslands in the boreal forest region of western Canada. Pp. 22-26, in *Proceedings of the Tenth North American Prairie Conference*, Texas Woman's University, Denton, Texas.
- Schwarz, A.G. and R.W. Wein. 1997. Threatened dry grasslands in the continental boreal forests of Wood Buffalo National Park. *Canadian Journal of Botany* 75:1363- 1370.
- Schwartz, C.C., and A.W. Franzmann. 1991. Interrelationships of black bears to moose and forest succession in the northern coniferous forest. *Wildlife Monographs* 113:1-58.
- Seibert, F.V. 1923. A reconnaissance in the home of the wood buffalo. Pp. 13- 17 in appendix to M. Graham. 1923. *Canada's wild buffalo*. F.A. Ackland. 17pp.
- Seibert, F.V. 1925. Some notes on Canada's so-called wood buffalo. *Canadian Field-Naturalist* 39:204-206.
- Seton, E.T. 1886. The ruminants of the north-west. Pp. 113-117, in *Proceedings of the Canadian Institute: 1884-1885*. Toronto: Copp Clark Co. 123pp.
- Seton, E.T. 1911. *The arctic prairies*. London, New York. 416pp.
- Seton, E.T. 1927. *Lives of game animals, Vol. III. The Country Life Press, Garden City, New York.* 870 pp.
- Shadrina, E.G., Y.L. Volpert, and I.M. Okhlopkov. 2022. Introduction of mammals in Yakutia: analysis of effectiveness, prospects, and negative impacts. *Russian Journal of Biological Invasions*, 13:105-122.
- Shapiro, B., A.J. Drummond, A. Rambaut, M.C. Wilson, P.E. Matheus, A.V. Sher, O.G. Pybus, M.T. Gilbert, I. Barnes, J. Binladen, E. Willerslev, A.J. Hansen, G.F. Baryshnikov, J.A. Burns, S. Davydov, J.C. Driver, D.G. Froese, C.R. Harington, G. Keddie, P. Kosintsev, M.L. Kunz, L.D. Martin, R.O. Stephenson, J. Storer, R. Telford, S. Zimov, and A. Cooper. 2004. Rise and fall of the steppe bison. *Science* 306:1561-1565.

- Shachak, M. and S. Brand. 1988. Relationship among settling, demography and habitat selection: an approach and a case study. *Oecologia* 76:620-626.
- Shaw, J.H. 1995. How many bison originally populated western rangelands? *Rangelands* 17:148-150.
- Shaw, J.H. and T.S. Carter. 1989. Calving patterns among American bison. *Journal of Wildlife Management* 53:896-898.
- Sheppard, A.H.C., L.J. Hecker, M.A. Edwards, and S.E. Nielsen. 2021. Determining the influence of snow and temperature on the movement rates of wood bison (*Bison bison athabascae*). *Canadian Journal of Zoology* 99:489-496.
- Shrestha, R.R., K.E. Bennett, D.L. Peters, and D. Yang. 2021. Hydrologic extremes in Arctic rivers and regions: Historical variability and future perspectives. Pp.187-218, in D. Yang and D.L. Kane (eds.). *Arctic Hydrology, Permafrost and Ecosystems*. Springer Nature. 914pp.
- Shury, T.K., pers. comm. 2025. Telephone and email correspondence with T. Chowns. January 2025. Manager, Wildlife Health and Management, Parks Canada, Government of Canada, Saskatoon, SK.
- Shury, T.K., J.S. Nishi, B.T. Elkin, and G.A. Wobeser. 2015. Tuberculosis and brucellosis in wood bison (*Bison bison athabascae*) in northern Canada: a renewed need to develop options for future management. *Journal of Wildlife Diseases* 51:543–554.
- Silva, M. and J.A. Downing. 1995. The allometric scaling of density and body mass: a nonlinear relationship for terrestrial mammals. *American Naturalist* 145:704-727.
- Simon, R.N., S.G. Cherry, and D. Fortin. 2019. Complex tactics in a dynamic large herbivore–carnivore spatiotemporal game. *Oikos* 128:1318-1328.
- Simpson, G. 1821. *Journal of Occurrences in the Athabasca Department by George Simpson, 1820 and 1821, and Report*. edited by E.E. Rich in 1939. Toronto: The Champlain Society. 498pp.
- Simpson, T. 1843. *Narrative of the discoveries on the north coast of America effected by the officers of the Hudson's Bay Company during the years 1836-39*. London: R. Bentley. 455pp.
- Sinclair, A.R.E. 1979. Dynamics of the Serengeti ecosystem. Pp. 1-30, in Sinclair A.R.E. and M. Norton-Griffiths (eds.). *Serengeti: dynamics of an ecosystem*. University of Chicago Press, Chicago. 397pp.

- Sinclair, A.R.E. 2003. Mammal population regulation, keystone processes and ecosystem dynamics. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences* 358(1438):1729-1740.
- Skinner, M.F. and O.C. Kaisen. 1947. The fossil bison of Alaska and preliminary revision of the genus. *Bulletin of the American Museum of Natural History* 89:123-256.
- Slave River Lowlands Bison Working Group (SRLBWG), unpublished meeting notes. 2023. Slave River Lowlands Bison Working Group meeting. Fort Smith, NT, November 29, 2023. Environment and Climate Change, Government of the Northwest Territories, Fort Smith, NT. 6 pp.
- Slave River Lowlands Bison Working Group (SRLBWG), unpublished meeting notes. 2024. Slave River Lowlands Bison Working Group meeting. Fort Smith, NT, November 15, 2024. Environment and Climate Change, Government of the Northwest Territories, Fort Smith, NT. 8 pp.
- Slave River Lowlands Bison Working Group (SRLBWG), unpublished meeting notes. 2025. Slave River Lowlands Bison Working Group meeting. Fort Smith, NT, December 3, 2025. Environment and Climate Change, Government of the Northwest Territories, Fort Smith, NT. 38 pp.
- Smith, D.G. 1992. Glacial Lake Mackenzie, Mackenzie Valley, Northwest Territories, Canada. *Canadian Journal of Earth Sciences* 29:1756-1766.
- Smith, D.G. 1994. Glacial Lake McConnell: Paleogeography, age, duration, and associated river deltas, Mackenzie River basin, western Canada. *Quaternary Science Reviews* 13:829-843.
- Smith, D.L. 1990. The impacts of wood bison (*Bison bison athabascae*) grazing on a sub-hygric shrub meadow plant community type, Mackenzie Bison Sanctuary, Northwest Territories. M.Sc. Dissertation, University of Alberta, Edmonton. 164pp.
- Smith, D.L. and G. H. La Roi. 2005. The response of subhumid mid-boreal graminoids to grazing by wood bison. *Community Ecology* 6:39-47.
- Smith, D.W, T.D. Drummer, K.M. Murphy, D.S. Guernsey, and S.B. Evans. 2004. Winter prey selection and estimation of wolf kill rates in Yellowstone National Park, 1995–2000. *Journal of Wildlife Management* 68:153–66.
- Smith, D.W., L.D. Mech, M. Meagher, W.E. Clark, R. Jaffe, M.K. Phillips, and J.A. Mack. 2000. Wolf-bison interactions in Yellowstone National Park. *Journal of Mammalogy* 81:1128-1135.

- Smith, S.L., M.M. Burgess, D. Riseborough, and F. Mark Nixon 2005. Recent trends from Canadian permafrost thermal monitoring network sites. *Permafrost and Periglacial Processes* 16:19-30.
- Songchang, G., L. Jianquan, Q. Delin, Y. Jie, and Z. Xinquan. 2006. Taxonomic placement and origin of yaks: implications from analyses of mtDNA D-loop fragment sequences. *Acta Theriologica Sinica* 26:325-330.
- Soper, J.D. 1941. History, range, and home life of the northern bison. *Ecological Monographs* 11:347-412.
- Soper, J.D. 1942. The mammals of Wood Buffalo Park, northern Alberta and District of Mackenzie. *Journal of Mammalogy* 23:119-145.
- Solounias, N., S.M.C. Moelleken, and J.M. Plavcan. 1995. Predicting the diet of extinct bovids using masseteric morphology. *Journal of Vertebrate Paleontology* 15:795-805.
- Species at Risk Act*. 2002. S.C. 2002, c. 29.
- Species at Risk Committee (SARC). 2016. Species Status Report for Wood Bison (*Bison bison athabascae*) in the Northwest Territories. Species at Risk Committee, Yellowknife, NT. 234pp.
- Species at Risk Committee (SARC). 2022. Species Assessment Process. Species at Risk Committee, Yellowknife, NT. 33pp.
- Species at Risk (NWT) Act. 2009. S.N.W.T. 2009, c. 16.
- Squires, L. and A.G. Van der Valk. 1992. Water-depth tolerances of the dominant emergent macrophytes of the Delta Marsh, Manitoba. *Canadian Journal of Botany* 70:1860-1867.
- Stahler, D.R., D.W. Smith, and D.S. Guernsey. 2006. Foraging and feeding ecology of the gray wolf (*Canis lupus*): lessons from Yellowstone National Park, Wyoming, USA. *The Journal of Nutrition* 136:1923S-1926S.
- Stephenson, R.O., S.C. Gerlach, R.D. Guthrie, C.R. Harington, R.O. Mills, and G. Hare. 2001. Wood bison in late Holocene Alaska and adjacent Canada: Paleontological, archaeological and historical records. Pp.124-158, in S.C. Gerlach and M.S. Murray (eds.). *People and wildlife in northern North America: Essays in honor of R. Dale Guthrie*, BAR International Series 944. British Archaeological Reports, Oxford.
- Sterne, M. 1959. Anthrax. Pp. 16-51, in A.W. Stableforth and I.A. Galloway (eds.). *Infectious diseases of animals. Diseases due to bacteria. Vol. 1*. Butterworths Scientific Publications, London.

- Stevens-Rumann, C.S., S.J. Prichard, E. Whitman, M.A. Parisien, and A.J. Meddens. 2022. Considering regeneration failure in the context of changing climate and disturbance regimes in western North America. *Canadian Journal of Forest Research* 52:1281-1302.
- Stock, K.S. 2005. The Skownan First Nation Model for sustainable development and Aboriginal stewardship. Ph.D. dissertation, University of Manitoba, Winnipeg. 320 pp.
- Stormont, C.J. 1993. An update on bison genetics. pp. 15–37, *in* R. Walker (ed.). *Proceedings of the North American Public Bison Herds Symposium, Lacrosse, Wisconsin*. Custer State Park Press, South Dakota. 444pp.
- Strong, W.L. and C.C. Gates. 2009. Wood bison population recovery and forage availability in northwestern Canada. *Journal of Environmental Management* 90:434-440.
- Swanson, D.K. 2006. Biogeographical evidence for the grass (Poaceae) species of Pleistocene Beringian lowlands. *Arctic* 59:191-200.
- Swihart, R.K., N.A. Slade, and B.J. Bergstrom. 1988. Relating body size to the rate of home range use in mammals. *Ecology* 69:393-399.
- Szeicz, J.M., G.M. MacDonald, and A. Duk-Rodkin. 1995. Late Quaternary vegetation history of the central Mackenzie Mountains, Northwest Territories, Canada. *Palaeogeography, Palaeoclimatology, Palaeoecology* 113:351-371.
- Telfer, E.S. and J.P. Kelsall. 1979. Studies of morphological parameters affecting ungulate locomotion in snow. *Canadian Journal of Zoology* 57:2153-2159.
- Telfer, E.S. and J.P. Kelsall. 1984. Adaptation of some large North American mammals for survival in snow. *Ecology* 65:1828-1834.
- Tempany, I. and S.C. Cooper. 1975. Total bison count. Wood Buffalo National Park. Parks Canada, unpublished report.
- Templeton, J.W., D.M. Estes, R.E. Price, R. Smith III, and L.G. Adams. 1990. Immunogenetics of natural resistance to bovine brucellosis. Pp. 396-399, *in* *Proceedings of the 4th World Congress on Genetics applied to Livestock Production, Edinburgh 23-27 July 1990*. XVI.
- Tepley, A.J., E. Thomann, T.T. Veblen, G.L. Perry, A. Holz, J. Paritsis, T. Kitzberger, and K.J. Anderson-Teixeira. 2018. Influences of fire–vegetation feedbacks and post-fire recovery rates on forest landscape vulnerability to altered fire regimes. *Journal of Ecology* 106:1925-1940.
- Tessaro, S.V. 1987. A descriptive and epidemiologic study of brucellosis and tuberculosis in bison in northern Canada. Ph.D. dissertation, University of Saskatchewan, Saskatoon. 320 pp.

- Tessaro, S.V. 1989. Review of the diseases, parasites and miscellaneous pathological conditions of North American bison. *Canadian Veterinary Journal* 30:416-422.
- Tessaro, S.V. 1992. Bovine tuberculosis and brucellosis in animals, including man. Pg. 207-224, *in* J. Foster, D. Harrison and I.S. MacLaren (eds.). Alberta: Studies in the Arts and Sciences, Special issue on the buffalo. University of Alberta Press, Edmonton, AB. 244pp.
- Tessaro, S.V., L.B. Forbes, and C. Turcotte. 1990. A survey of brucellosis and tuberculosis in bison in and around Wood Buffalo National Park, Canada. *Canadian Veterinary Journal* 31:174-180.
- Tessaro, S.V., C.C. Gates, and L.B. Forbes. 1992. The brucellosis and tuberculosis status of wood bison in the Mackenzie Bison Sanctuary, Northwest Territories, Canada. *Canadian Journal of Veterinary Research* 57:231-235.
- Thieret, J.W. 1959. Grassland vegetation near Fort Providence, Northwest Territories. *Canadian Field-Naturalist* 73:161-167.
- Thiessen, C. 2010. Peace wood bison project: annual report 2009/2010. Ministry of Environment, Government of British Columbia. Peace Region Technical Report. 22pp.
- Thomas, J.P., N.C. Larter, and T.S. Jung. 2021. Individual-based seasonal habitat selection in a forest-dwelling population of reintroduced bison *Bison bison*. *Wildlife Biology*, (3): wlb.00852. 14 pp.
- Thomas, J.P., N.C. Larter, and T.S. Jung. 2022a. Identifying hotspots of Liard River crossings by Nahanni wood bison. Environment and Natural Resources, Government of the Northwest Territories. Manuscript Report No. 300. 15pp.
- Thomas, J.P., N.C. Larter, and T.S. Jung. 2022b. Enabling safe passage: predicting river crossing hotspots for a threatened boreal ungulate susceptible to drowning. *Journal of Mammalogy* 103:932-944.
- Thompson, A.J., J. Zhu, C.J. Poulsen, J.E. Tierney, and C.B. Skinner. 2022. Northern Hemisphere vegetation change drives a Holocene thermal maximum. *Science Advances* 8: p.eabj6535.
- Thompson, D.K., M.A. Parisien, J. Morin, K. Millard, C.P. Larsen, and B.N. Simpson, 2017. Fuel accumulation in a high-frequency boreal wildfire regime: from wetland to upland. *Canadian Journal of Forest Research* 47:957-964.
- Thompson, D.K., B.N. Simpson, E. Whitman, Q.E. Barber, and M.A. Parisien. 2019. Peatland hydrological dynamics as a driver of landscape connectivity and fire activity in the boreal plain of Canada. *Forests* 10(7) p.534.

- Thomson, J. 1801. Journal of John Thomson Esq. (McKenzie River), winter 1800-1801. in L.R. Masson (ed.). Acquired by McGill University in 1904 and re-edited in 2001. An electronic transcription. MFTP #0021. Rare Books and Special Collections Division, MS 472, McGill University Libraries. 28pp.
- Thundathil, J., D. Whiteside, B. Shea, D. Ludbrook, B.T. Elkin, and J. Nishi. 2007. Preliminary assessment of reproductive technologies in wood bison (*Bison bison athabascae*): implications for preserving genetic diversity. *Theriogenology* 68:93-99.
- Timoney, K.P. and G. Argus. 2006. Willows, water regime, and recent cover change in the Peace-Athabasca Delta. *Ecoscience* 13:308-317.
- Timoney, K.P. 2021. Flooding in the Peace-Athabasca Delta: climatic and hydrologic change and variation over the past 120 years. *Climatic Change* 169 Article 34.
- Timoney, K.P. 2024. Has river regulation damaged the Peace-Athabasca Delta? *Ecoscience* 31:118-148.
- Titball, R.W. and R.J. Manchee. 1987. Factors affecting the germination of spores of *Bacillus anthracis*. *Journal of Applied Bacteriology* 62:269-273.
- Tłı̨chǫ Government and Firelight Research Inc. (TG and Firelight). 2025a. Tłı̨chǫ Highway Wildlife Monitoring Report, Final Report: December 2021—February 2025. Tłı̨chǫ Government, unpublished report. 37 pp.
- Tłı̨chǫ Government and Firelight Research Inc. (TG and Firelight). 2025b. Tłı̨chǫ Highway Wildlife Monitoring Report, Harvester Interviews. Tłı̨chǫ Government, unpublished report. 68 pp.
- Townsend, G. 1972. Simulation of habitat succession and wildlife populations on the Peace-Athabasca Delta. Canadian Wildlife Service, Environment Canada, unpublished report. 123pp.
- Travers-Smith, H., T.C. Lantz, R.H. Fraser, and S.V. Kokelj. 2022. Changes in surface water dynamics across northwestern Canada are influenced by wildfire and permafrost thaw. *Environmental Research Letters* 17(11):p.114021.
- Treanor, J.J., C. Geremia, P.H. Crowley, J.J. Cox, P.J. White, R.L. Wallen, and D.W. Blanton. 2011. Estimating probabilities of active brucellosis infection in Yellowstone bison through quantitative serology and tissue culture. *Journal of Applied Ecology* 48:1324–1332.
- Treseder, L. and R.P. Graf. 1985. Moose in the Northwest Territories: a discussion paper. Department of Environment and Natural Resources, Government of the Northwest Territories. Manuscript Report No. 13. 47pp.

- Truett, J. 1996. Bison and elk in the American Southwest: in search of the pristine. *Environmental Management* 20:195-206.
- Turcotte, B. 2023. Flooding processes and recent trends in ice-induced high-water levels along rivers of Northwestern Canada. *In* 21st Workshop on the Hydraulics of Ice Covered Rivers, Saskatoon, SK. Online virtual meeting August 29 to September 1, 2021. CGU HS Committee on River Ice Processes and the Environment.
- Turnbull P.C.B. 1996. Stubborn contamination with anthrax spores. *Environmental Health* 106:171-173.
- Turnbull, P.C., J. Rijks, I. Thompson, M., Hugh-Jones and B.T. Elkin. 2001. Seroconversion in bison (*Bison bison*) in northwest Canada experiencing sporadic and epizootic anthrax. Pp. 18, *in* L. Feinman (ed.). Abstracts of the 4th International Conference on Anthrax. 50pp.
- Turnbull, P.C., M. Diekmann, J.W. Killian, W. Versfeld, V. de Vos, L. Arntzen, K. Wolter, P. Bartels, and A. Kotze. 2008a. Naturally acquired antibodies to *Bacillus anthracis* protective antigen in vultures of southern Africa. *Onderstepoort Journal of Veterinary Research* 75:95–102.
- Turnbull P.C.B., O. Cosivi, D. Ashford, W. Beyer, B. Cherkasskiy, M. Doğanay, D. Dragon, M. Hugh-Jones, A. Kaufmann, R. Leuenberger, A. Turner, and W. Wilson. 2008b. *Anthrax in Humans and Animals*, fourth edition. WHO, Geneva. 208pp.
- Turnbull, P.C.B., P.M. Lindeque, J. Le Roux, A.M. Bennet, and S.R. Parks. 1998. Airborne movement of anthrax spores from carcass sites in the Etosha National Park, Namibia. *Journal of Applied Microbiology* 84:667–676.
- Turner, W.C., K.L. Kausrud, Y.S. Krishnappa, J.P. Cromsigt, H.H. Ganz, I. Mapaure, C.C. Cloete, Z. Havarua, M. Küsters, W.M. Getz, and N.C. Stenseth. 2014. Fatal attraction: vegetation responses to nutrient inputs attract herbivores to infectious anthrax carcass sites. *Proceedings of the Royal Society B: Biological Sciences* 281(1795) p.20141785.
- Turnor, P. 1792. Journal of a journey from Cumberland House North America in Latitude 53° 56^{3/4} North and Longitude 102° 13' West of Greenwich towards the Athapiscow country and back to York Factory. Pp. 327-491, *in* J.B. Tyrrell (ed.). *Journals of Samuel Hearne and Philip Turnor between the Years 1774 and 1792*. Originally published in 1934 as Champlain Society Publication XXI. A facsimile edition in 1968 by New York: Greenwood Press Publishers. 611pp.
- Tyrrell, J.B. 1934. Introduction. Pp. 3-94, *in* J.B. Tyrrell (ed.). *Journals of Samuel Hearne and Philip Turnor between the Years 1774 and 1792*. Originally published in 1934

- as Champlain Society Publication XXI. A facsimile edition in 1968 by New York: Greenwood Press Publishers. 611pp.
- Van Camp, J. 1975. Snow conditions and the winter feeding of *Bison bison* in Elk Island National Park. Canadian Wildlife Service, Environment Canada, unpublished report. 91pp.
- Van Camp, J. 1978. Wood bison population census Mackenzie Bison Sanctuary July 12, 1976 – March 18, 1978. Department of Environment and Natural Resources, Government of the Northwest Territories, unpublished report. 9pp.
- Van Camp, J. 1987. Predation on bison. Pp. 25-33, in H.W. Reynolds and A.W.L. Hawley (eds.). Bison ecology in relation to agricultural development in the Slave River Lowlands, N.W.T. Occasional Paper No.63, Ottawa, ON. 72pp.
- Van Camp, J. 1989. A surviving herd of endangered wood bison at Hook Lake, N.W.T.? Arctic 42:314-322.
- Van Camp, J. and G.W. Calef. 1987. Population dynamics of bison. Pp. 21-24, in H.W. Reynolds and A.W.L. Hawley (eds.). Bison Ecology in Relation to Agricultural Development in the Slave River Lowlands, N.W.T. Occasional Paper No.63, Ottawa, ON. 72pp.
- Vance, R.E., A.B. Bedouine, and B.H. Luckman. 1995. The paleoecological of 6 K.A. BP. climate in the Canadian prairie provinces. Geographie Physique et Quaternaire 49:81-98.
- Vanderburgh, S. and D.G. Smith. 1988. Slave River Delta: geomorphology, sedimentology, and Holocene reconstruction, Canadian Journal of Earth Sciences 25:1990-2004.
- Van der Valk, A.G. and C.B. Davis. 1978. The role of seed banks in the vegetation dynamics of prairie glacial marshes. Ecology 59:322-35.
- Van Gelder, R.G. 1977. Mammalian Hybrids and Generic Limits. American Museum Novitates No. 2635. American Museum of Natural History. 25pp.
- Van Ness, G.B. 1971. Ecology of anthrax. Science 172:1303-1307.
- Van Vuren, D. 1987. Bison west of the Rocky Mountains: an alternative explanation. Northwest Science 61:65-69.
- Van Vuren, D. and M.P. Bray. 1986. Population dynamics of bison in the Henry Mountains, Utah. Journal of Mammalogy 67:503-511.
- van Zyll de Jong, C.G. 1986. A systematic study of recent bison, with particular consideration of the wood bison (*Bison bison athabascae* Rhoads 1898). Publications in Natural Sciences No. 6. National Museums of Canada, Ottawa, ON. 69pp.

- van Zyll de Jong, C.G. 1993. Origin and geographic variation of recent North American bison. *Alberta: Studies in the Arts and Sciences* 3(2):21-35.
- van Zyll de Jong, C.G., C.C. Gates, H. Reynolds, and W. Olson. 1995. Phenotypic variation in remnant populations of North American bison. *Journal of Mammalogy* 76:391-405.
- Vassal, M. and R. Kindopp. 2010. Wood Buffalo National Park bison survey, February 2009. Parks Canada, unpublished report. 34pp.
- Vergnaud, G., G. Girault, S. Thierry, C. Pourcel, N. Madani, and Y. Blouin. 2016. Comparison of French and worldwide *Bacillus anthracis* strains favors a recent, post-Columbian origin of the predominant North-American clade. *PLoS One*, 11(2): p.e0146216.
- Verkaar, E.L., I.J. Nijman, M. Beeke, E. Hanekamp, and J.A. Lenstra. 2004. Maternal and paternal lineages in cross-breeding bovine species. Has wisent a hybrid origin? *Molecular Biology and Evolution* 21:1165-1170.
- Vucetich, J.A. and R.O. Peterson. 2004. The influence of prey consumption and demographic stochasticity on population growth rate of Isle Royale wolves *Canis lupus*. *Oikos* 107:309–320.
- Waddington, J.M., P.J. Morris, N. Kettridge, G. Granath, D.K. Thompson, and P.A. Moore. 2015. Hydrological feedbacks in northern peatlands. *Ecohydrology* 8:113-127.
- Waggoner, V. and M. Hinkes. 1986. Summer and fall browse utilization by an Alaskan bison herd. *Journal of Wildlife Management* 50:322-324.
- Walker, D.A., J.G. Bockheim, F.S. Chapin III, W. Eugster, F.E. Nelson, and C.L. Ping. 2001. Calcium-rich tundra, wildlife, and the 'mammoth steppe'. *Quaternary Science Reviews* 20:149–163.
- Walker, M., M.H. Head, M. Berklehammer, S. Bjorck, H. Cheng, L. Cwynar, D. Fisher, V. Gkinis, A. Long, J. Lowe, and R. Newnham. 2018a. Formal ratification of the subdivision of the Holocene Series/Epoch (Quaternary System/Period): two new Global Boundary Stratotype Sections and Points (GSSPs) and three new stages/subseries. *Episodes* 41:213–223.
- Walker, X.J., J.L. Baltzer, S.G. Cumming, N.J. Day, J.F. Johnstone, B.M. Rogers, K. Solvik, M.R. Turetsky, and M.C. Mack. 2018b. Soil organic layer combustion in boreal black spruce and jack pine stands of the Northwest Territories, Canada. *International Journal of Wildland Fire* 27:125-134.
- Wall, D.A., S.K. Davis, and B.M. Read. 1992. Phylogenetic relationships in the subfamily Bovinae (Mammalia: Artiodactyla) based on ribosomal DNA. *Journal of Mammalogy* 73:262-275.

- Wang, J. 2004. Application of the one-migrant-per-generation rule to conservation and management. *Conservation Biology* 18:332-343.
- Wang, X., J. Pei, L. Xiong, P. Bao, M. Chu, X. Ma, Y. La, C. Liang, P. Yan, and X. Guo. 2024. Genetic diversity, phylogeography, and maternal origin of yak (*Bos grunniens*). *BMC Genomics* 25:p481.
- Wang, Y., E.H. Hogg, D.T. Price, J. Edwards, and T. Williamson. 2014. Past and projected future changes in moisture conditions in the Canadian boreal forest. *The Forestry Chronicle*, 90:678-691.
- Wek'èezhìi Renewable Resources Board (WRRB). 2021. Board Meeting Minutes – 10-11 February 2021. Wek'èezhìi Renewable Resources Board, Yellowknife, NT. 14 pp. Website: <https://wrrb.ca/sites/default/files/1.2%20Minutes%20-10-11feb2021%20FINAL.pdf> [accessed 21 April 2026].
- Welling, C.H., R.L. Pederson, and A.G. Van der Valk. 1988. Recruitment from the seed bank and the development of zonation of emergent vegetation during a drawdown in a prairie wetland. *Journal of Ecology* 483-496.
- Wendt IV, J.A.F. 2023. Reconstructing large herbivore abundance and environmental interactions in postglacial North America. Ph.D. dissertation, Montana State University, Bozeman. 198pp.
- Wentzel, R.G. 1975. *Limnology*. W. B. Saunders Co., Philadelphia. 743 pp.
- Wentzel, W.F. 1807. Letter to Roderick Mackenzie dated March 27, 1807, from Fort of the Forks, Mackenzie River. Pp. 1-32, in L.R. Masson (ed.). Acquired by McGill University in 1904 and re-edited in 2001. Fifteen letters from Wentzel at Mackenzie River to Roderick Mackenzie, 1807-1824. An electronic transcription. MFTP #0012. Rare Books and Special Collections Division, MS 472, McGill University Libraries. 92pp.
- Wentzel, W.F. 1811. Letter to Roderick Mackenzie dated April 30, 1811, from Fort of the Forks, Mackenzie River. Pp. 41-43, in L.R. Masson (ed.). Acquired by McGill University in 1904 and re-edited in 2001. Fifteen letters from Wentzel at Mackenzie River to Roderick Mackenzie, 1807-1824. An electronic transcription. MFTP #0012. Rare Books and Special Collections Division, MS 472, McGill University Libraries. 92pp.
- Wentzel, W.F. 1821. Mackenzie River with a map. Sent to Hon. Simon McGillivray. Copied from photostat copy of original in Dominion Archives by R. Douglas, Secretary, Geographic Board and typed in Geographic Board office, March, 1925. 12pp.

- Wentzel, W.F. 1822. Notice regarding the map of Mackenzie's River by Mr. W.F. Wentzel, of the North-West Fur Company. *Memoirs of the Wernerian Natural History Society* 4:562-563.
- Westhusin, M.E., T. Shin, J.W. Templeton, R.C. Burghardt, and L.G. Adams. 2007. Rescuing valuable genomes by animal cloning: a case for natural disease resistance in cattle. *Journal of Animal Science* 85:138-42.
- Westoby, M. 1974. An analysis of diet selection by large generalist herbivores. *The American Naturalist* 108:290-304.
- Whitman, E., Q.E. Barber, P. Jain, S.A. Parks, L. Guindon, D.K. Thompson, and M.A. Parisien. 2024. A modest increase in fire weather overcomes resistance to fire spread in recently burned boreal forests. *Global Change Biology* 30(6), p.e17363.
- Whitman, E., M.A. Parisien, D.K. Thompson, and M.D. Flannigan. 2018. Topoedaphic and forest controls on post-fire vegetation assemblies are modified by fire history and burn severity in the northwestern Canadian boreal forest. *Forests* 9(3) p.151.
- Whitman, E., M.A. Parisien, D.K. Thompson, and M.D. Flannigan. 2019. Short-interval wildfire and drought overwhelm boreal forest resilience. *Scientific Reports* 9(1):p.18796.
- Whitney, C. 1898. On snowshoes to the barren grounds, twenty eight hundred miles after musk-oxen and wood-bison. Osgood and McIlvaine and Company, London. x + 325pp.
- Wild, M.A., N. Thompson Hobbs, M.S. Graham, and M.W. Miller. 2011. The role of predation in disease control; a comparison of selective and nonselective removal on prion disease in deer. *Journal of Wildlife Diseases* 47:78–93.
- Wildlife Act*, S.N.W.T. 2013, c. 30
- Wildlife Licences and Permits Regulations, NWT Reg 027-92 (*Wildlife Act*).
- Williams, E.S. 2001. "Paratuberculosis." In *Infectious Diseases of Wild Mammals*, edited by E. S. Williams, I. K. Barker, and E. T. Thorne, 3rd ed., 361–71. Ames: Iowa State University Press.
- Williams, J.W., B.N. Shuman, T. Webb III, P.J. Bartlein, and P.L. Leduc. 2004. Late-Quaternary vegetation dynamics in North America: scaling from taxa to biomes. *Ecological Monographs* 74:309-334.
- Williams, R.W. 1966. Buffalo Survey, Slave River – Hook Lake area, N.W.T. Department of Environment and Natural Resources, Government of the Northwest Territories, unpublished report. 1pp.
- Wilson, G.A. 2001. Population genetic studies of wood and plains bison populations. Ph.D. dissertation, University of Alberta, Edmonton. 156pp.

- Wilson G.A., W. Olson, and C.M. Strobeck. 2002. Reproductive success in wood bison (*Bison bison athabascae*) established using molecular techniques. *Canadian Journal of Zoology* 80:1537–1548.
- Wilson, G.A. and C.M. Strobeck. 1999. Genetic variation within and relatedness among wood and plains bison populations. *Genome* 42:483-496.
- Wilson, J.M. and C.A. Haas. 2012. Important wildlife areas in the western Northwest Territories. Department of Environment and Natural Resources, Government of the Northwest Territories. Manuscript Report No. 221. 347pp.
- Wilson, M.C., L.V. Hills, and B. Shapiro. 2008. Late Pleistocene northward-dispersing *Bison antiquus* from the Bighill Creek formation, Gallelli gravel pit, Alberta, Canada, and the fate of *Bison occidentalis*. *Canadian Journal of Earth Sciences* 45:827-859.
- Wilson, W. 1969. Problems in the speciation of American fossil bison. Pp. 178-199, in R.G. Forbis, L.B. Davis, O.A. Christensen and G. Fedirchuk (eds.). *Post-Pleistocene man and his environment on the Northern Plains*. Proceeding of the First Annual Paleo-environmental Workshop. Students' Press, University of Calgary, Calgary.
- Winnipeg Free Press. 2026. Transfer program adds to Manitoba First Nation's bison population. Article by Crystal Greene, 9 March 2026. Website: www.winnipegfreepress.com/local/2026/03/09/transfer-program-adds-to-manitoba-first-nations-bison-population [accessed 14 March 2026].
- Wobeser, G. 2009. Bovine tuberculosis in Canadian wildlife: An updated history. *Canadian Veterinary Journal*, 50(11):1169-1176.
- Wolff, J.O. 1998. Breeding strategies, mate choice, and reproductive success in American bison. *Oikos* 83:29-544.
- Woo, M. K. and R. Thorne. 2003. Streamflow in the Mackenzie basin, Canada. *Arctic* 56:328-340.
- World Heritage Centre (WHC)/IUCN Reactive Monitoring Mission. 2022. Report on the Joint World Heritage Centre/IUCN Reactive Monitoring Mission to the World Heritage Property Wood Buffalo National Park (Canada). From 18 to 26 August, 2022. Submitted to World Heritage Centre/IUCN. 102 pp.
- Wotton, B.M. and M.D. Flannigan. 1993. Length of the fire season in a changing climate. *Forestry Chronicle* 69:187–192.
- Wu, Y. 2023. Development of high-resolution climate projections over Canada in the 21st century. Ph.D. dissertation, University of Regina, Regina. 175pp.

- Wyman, T. 2002. Grizzly bear predation on a bull bison in Yellowstone National Park. *Ursus* 13:375-377.
- Ying, K.L. and D.G. Peden. 1977. Chromosomal homology of wood bison and plains bison. *Canadian Journal of Zoology* 55:1759-1762.
- Yukon Department of Renewable Resources. 1998. Yukon bison management plan. Yukon Department of Environment, Whitehorse, Yukon.
- Yukon Wood Bison Technical Team. 2010. Management Plan for the Aishihik Wood Bison (*Bison bison athabascae*) Herd in Southwestern Yukon. Yukon Department of the Environment, Whitehorse, YK. 36pp.
- Zazula, G.D., G. MacKay, T.D. Andrews, B. Shapiro, B. Letts, and F. Brock. 2009. A late Pleistocene steppe bison (*Bison priscus*) partial carcass from Tsiigehtchic, Northwest Territories, Canada. *Quaternary Science Reviews* 28:2734-2742.
- Zimov, S.A., V.I. Chuprynin, A.P. Oreshko, F.S. Chapin III, J.F. Reynolds, and M.C. Chapin 1995. Steppe-tundra transition: a herbivore-driven biome shift at the end of the Pleistocene. *American Naturalist* 146:765-794.
- Zoltai, S.C. 1975. Southern limit of coniferous trees on the Canadian prairies. Northern Forest Research Centre, Environment Canada Information Report (NOR-X-128).11pp.
- Zoltai, S.C. 1995. Permafrost distribution in peatlands of west-central Canada during the Holocene warm period 6000 years BP. *Géographie Physique et Quaternaire* 49:45-54.
- Zoltai S.C. and C. Tarnocai 1975. Perennially frozen peatlands in the western Arctic and Subarctic of Canada. *Canadian Journal of Earth Sciences* 12:28-43.
- Zoltai, S.C. and D.H. Vitt, 1990. Holocene climatic change and the distribution of peatlands in western interior Canada. *Quaternary Research* 33:231-240.

APPENDICES

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* (Lydecker 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). 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 (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 Columbia, 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 population 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 population 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 numbers 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 populations 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 populations 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 subpopulations 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 populations 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 these bison 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). An isolation area at Elk Island National Park, 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 Elk Island National Park, 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 populations. 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 Elk Island National Park 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 Elk Island National Park. 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, non-genetic 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 groups 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 – POPULATION TRENDS AND FLUCTUATIONS

IUCN Criterion A Calculator

The percent decline in the NWT bison population calculated over three (bison) generations is provided in Figure A2. The IUCN Criterion A calculator uses an exponential assumption and two years of data for each bison subpopulation. The same calculator was used to estimate the decline over two bison generations.

The average generation time for wood bison is estimated to be between seven years (Gross *et al.* 2006) and eight years (Hedrick 2009). An overall decline of 49.1% is estimated for NWT bison assuming a 7-year generation time (2005-2026; Figure A2 (a)) and a decline of 7.9% is estimated for an 8-year generation time (2002-2026; Figure A2 (b)).

Over two generations, using the same calculator, the decline was estimated at 20.0% for a 7-year generation time (2012-2026; Figure A2 (c)) and 22.4% for an 8-year generation time (2010-2026; Figure A2 (d)).

(a) Three generation decline; bison generation time of seven years (2005-2026)

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=	2026	3 generations ago=	2005										
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	2025	563	-1	-3	100.46%	100%	99%	513	555	8.2%	(increase)
Grand Detour	2009	888	2024	49	4	2	82.44%	46%	68%	1,923	33	-98.3%	(reduction)
Hook Lake	2009	902	2024	207	4	2	90.65%	68%	82%	1,336	170	-87.3%	(reduction)
Mackenzie	2008	1,555	2023	1,945	3	-1	101.50%	105%	99%	1,487	1,916	28.9%	(increase)
Total:										5,259	2,675	-49.1%	(reduction)

(b) Three generation decline; bison generation time of eight years (2002-2026)

Calculating 3 generation decline with exponential assumption and only 2 years of data for each subpopulation

Generation time (years)=	8	Assessment period=	24	years									
Assessment year=	2026	3 generations ago=	2002										
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	2025	563	2	-3	100.46%	101%	99%	506	555	9.7%	(increase)
Grand Detour	2000	235	2024	49	-2	2	93.68%	114%	88%	206	43	-79.1%	(reduction)
Hook Lake	2000	283	2024	207	-2	2	98.71%	103%	97%	276	202	-26.9%	(reduction)
Mackenzie	2000	1,998	2023	1,945	-2	-1	99.88%	100%	100%	1,993	1,947	-2.3%	(reduction)
Total:										2,982	2,747	-7.9%	(reduction)

(c) Two generation decline; bison generation time of seven years (2012-2026)

Calculating 2 generation decline with exponential assumption and only 2 years of data for each subpopulation

Generation time (years)=	7	Assessment period=	14	years									
Assessment year=	2026	2 generations ago=	2012										
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	2011	408	2025	563	-1	-3	102.33%	98%	93%	417	525	25.9%	(increase)
Grand Detour	2014	368	2024	101	2	2	87.87%	77%	77%	477	78	-83.6%	(reduction)
Hook Lake	2014	715	2024	207	2	2	88.34%	78%	78%	916	162	-82.4%	(reduction)
Mackenzie	2012	1,525	2023	1,945	0	-1	102.24%	100%	98%	1,525	1,902	24.8%	(increase)
Total:										3,335	2,667	-20.0%	(reduction)

(d) Two generation decline; bison generation time of eight years (2010-2026)

Calculating 2 generation decline with exponential assumption and only 2 years of data for each subpopulation

Generation time (years)=	8	Assessment period=	16	years									
Assessment year=	2026	2 generations ago=	2010										
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	2011	408	2025	563	1	-3	102.33%	102%	93%	399	525	31.8%	(increase)
Grand Detour	2009	888	2024	101	-1	2	86.51%	116%	75%	768	76	-90.2%	(reduction)
Hook Lake	2009	902	2024	207	-1	2	90.65%	110%	82%	818	170	-79.2%	(reduction)
Mackenzie	2012	1,525	2023	1,945	2	-1	102.24%	105%	98%	1,459	1,902	30.4%	(increase)
Total:										3,444	2,674	-22.4%	(reduction)

Figure A2. NWT bison population/subpopulation trends calculated using IUCN Criterion A, exponential assumption, two data point calculator. Trends are calculated for three generations [(a) and (b)] and two generations [(c) and (d)].

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 Elk Island National Park 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 8).

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 bison have been considered a separate subpopulation. By 1968, the Hook Lake subpopulation 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 for the Delta subpopulation. 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.

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). The Greater Wood Buffalo metapopulation subpopulations occurring within the NWT (Nyarling, Grand Detour/Little Buffalo, and Hook Lake) showed great fluctuations between the 1980s to 2024 (CMA 2025; see also Figure 23c), 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, Figure 23c shows numbers have generally been in decline from 2009 to 2024.

After the Mackenzie anthrax outbreak in 2012 and subsequent population crash, Figure 23a indicates the Mackenzie bison have been steadily rebounding in numbers to 2023.

APPENDIX A₃ – HABITAT TRENDS

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. 2025b). Extensive fires returned to the Slave River Lowlands in 2023 (Figure 22), 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. 2025b).

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 km²) in area, only had three small permanent wet areas remaining. Boulogne Lake formerly occupied approximately 12 square miles (31 km²) 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 km² in 1986 to 43.4 km² in 1992, contracted to 21.1 km² in 1997, then recharged from 1997, increasing its surface area to 56.4 km² 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; Fuhendorf 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 wheat sedge (*C. atherodes*) and bluejoint grass (*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 inexplansa*), 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 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 newly 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 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.

The 1994 fire north of Lonely Bay, on the west side of Great Slave Lake, facilitated bison 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 (Chowns 1997). The fire enhanced movements from core areas in the south and facilitated further range expansion northward into unoccupied habitat (Chowns pers. comm. 2025).

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.

In the wake of a prolonged, multi-year drought, extreme fire events in 2014 and 2023 affected the Mackenzie, Nyarling, and Slave River Lowland bison ranges (Day *et al.* 2023; Figure 22). 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; Baltzer *et al.* 2025); 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 reburns (Whitman *et al.* 2019; Baltzer *et al.* 2025); and transition from forest to prairie or aspen parkland ecosystems after short interval reburns (Baltzer *et al.* 2025). 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 grasses and sedges are preferred forage for bison (Chowns pers. comm. 2025).

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).

APPENDIX A₄ – HISTORIC RANGE AND SEARCH EFFORT

Historic Range in the NWT

Wood bison have an affinity for the soils of glacial lake basins after waters recede, which provide favourable conditions for sedge-grass vegetation preferred by bison (Porsild and Cody 1980; see *Habitat Requirements* for more on former glacial lake basins). Figure A₄ 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.

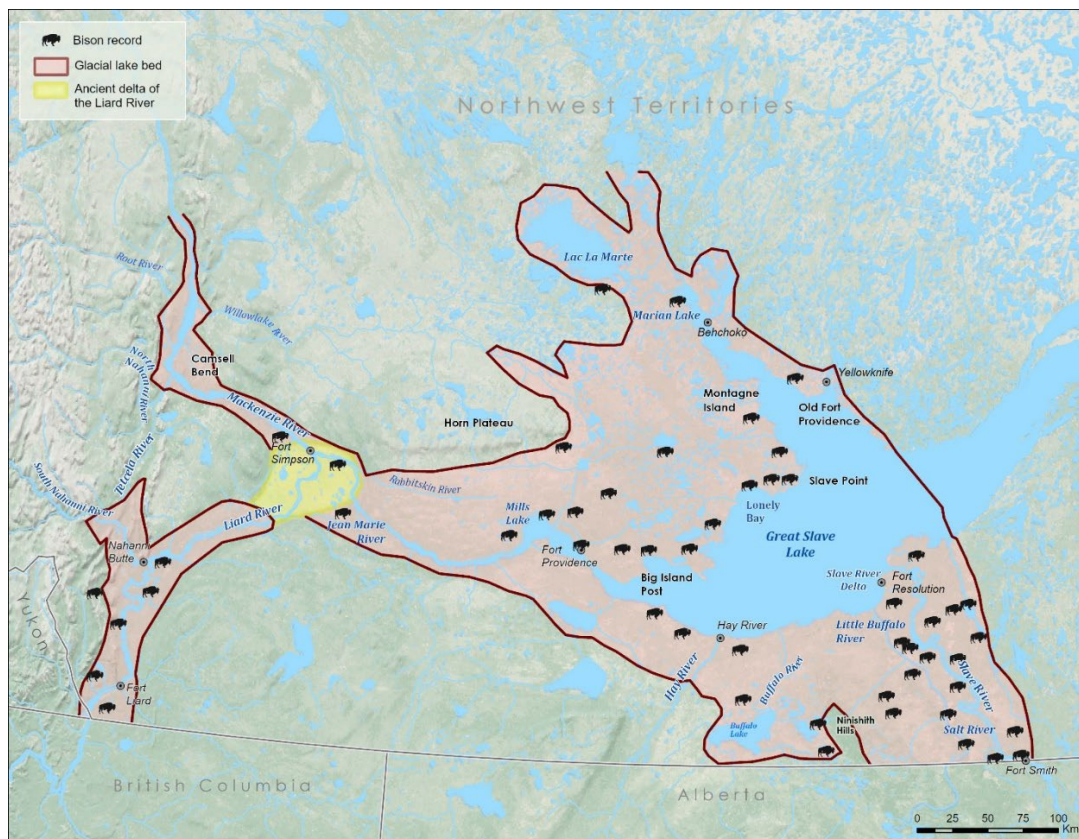


Figure A₄. Historical records from late 1700s to approximately 1900 of wood bison observations and area of glacial lake basins (McConnell, Mackenzie, Tetcela, and Liard) within the upper Mackenzie drainage of the NWT. Smith (1992; 1994) and Crosbie (1978) should be consulted for the full extent of glacial basins. 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). Data adapted from Cameron (1922), Craig (1965), Day (1966), Ford (1976), Rostad et al. (1976), Crosbie (1978), Rutter and Boydell (1981), Piet (1992), Smith (1992 and 1994), Lemmen et al. (1994), Bednarski (2008), Brown (2012), and Ford (2017). Map by B. Fournier.

Slave River Lowlands

Documented references to historic range in the NWT 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 groups 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. Wood bison were known to range from Buffalo Lake to the Little Buffalo River, justifying 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.

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 P ere 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. 1980).

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° or 64°, 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 groups 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 groups 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 populations: 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 bison populations. 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 group 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 populations remained (Mulloy 1912). West of the Ninishith Hills, Mulloy (1912) observed bison signs 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 population 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 population was separated from the southern population 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 populations 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 populations 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 km²) 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 miles² (21,240 km²) in eastern and central portions of the park, whereas 9,100 miles² (23,570 km²) 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 groups 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 bison. The Nyarling subpopulation was studied in detail with the intention of using it for establishing disease-free populations 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 bison 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 population 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 subpopulation 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 more than 39,600 km² has been searched several times per year, by ground and by air, for the purpose of removing bison (Case *et al.* 2025). 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. Meanwhile, in the Slave River Lowlands, the Hook Lake subpopulation 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).

Permanent transects in the high-density areas of Wood Buffalo National Park were established in 1991. Before that, search effort changed almost every year (Bradley and Wilmshurst 2005). Lower density areas that were covered by reconnaissance flights depended on available funding.

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

By the early 2000s, GPS and tracking with onboard laptop computers were advances in technology that aided in the prevention of double counting. 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.

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.

In 2002, permanent transects were established in the lower density areas of Wood Buffalo National Park, resulting in an annual effort exceeding 100 hours. 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 $1,790 \pm 323$, 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 $1,555 \pm 146$, about 22% less than the 2000 estimate of $1,998 \pm 163$ bison (Armstrong 2010). In addition, since the first Mackenzie bison anthrax outbreak in 1993 (Gates *et al.* 1995), regular, widespread searches were carried out in the summer season for carcass detection (CMA 2025).

2012 to 2024

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). The 2012 Mackenzie population estimate was reanalysed with 2013 data, producing an estimate of $1,531 \pm 257$. Following the outbreak, the Mackenzie population declined to its lowest point in three decades, estimated at only 714 animals ± 156 in 2013 (Armstrong 2013b).

Bison monitoring of the new Tłı̄ch̄q 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 (TG and Firelight 2025a). 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

Impacts of predation on wood bison populations are influenced by various factors, including season, age structure, habitat heterogeneity, disease vulnerability, and availability of large numbers of weakened or dead bison (surplus carrion).

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.

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

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).

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.

In Yellowstone National Park, Smith *et al.* (2000) observed that wolves primarily kill calves and debilitated older adult bison. 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%). 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.

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 A5 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 populations 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.

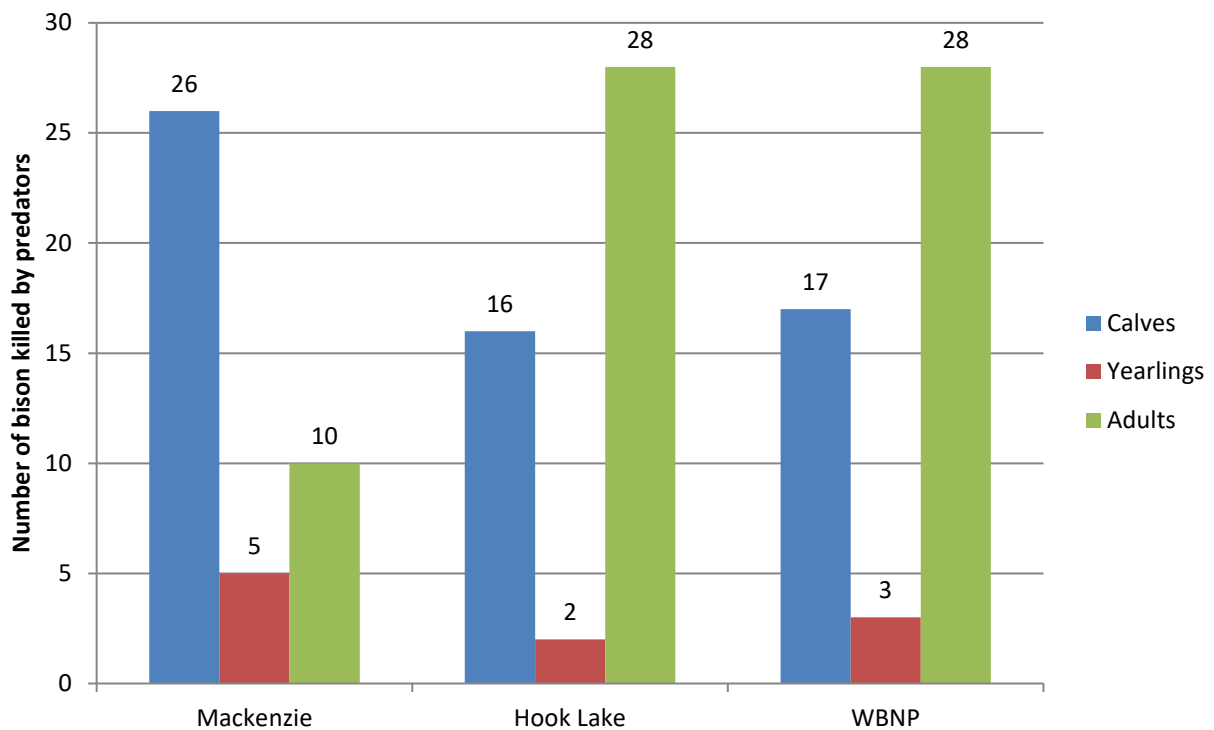


Figure A5. Predation and age class. Data for Mackenzie population from Larter *et al.* (1994), 1989-1992; data for Hook Lake from Van Camp (1987), 1975-1978; data for Wood Buffalo National Park (WBNP) from Carbyn *et al.* (1993), 1978-1981.

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). 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.

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 expansive open habitats, which lack escape cover, contain highly predictable bison concentrations for wolves, and provide fewer moose as alternate prey.

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, as the availability of substantial numbers of debilitated bison maintains larger numbers of wolves, which would, in turn, result in greater losses of calves because they are the most vulnerable to predation. This was termed the 'disease-predation hypothesis' by Gates (1993). Until the early 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). After 1971, the wolf control program was essentially over and the Greater Wood Buffalo metapopulation began to decline rapidly in the presence of both disease and more wolves; bison were the primary prey (Van Camp and Calef 1987; Carbyn *et al.* 1993).

Stochastic population simulations carried out by Joly and Messier (2004b) indicated that disease-free bison populations were likely to persist at high densities that would be regulated by food competition, while a bison population with bovine tuberculosis and brucellosis was likely to decline to low densities, regulated by wolf predation. However, Bradley and Wilmshurst (2005) discounted the 'disease-predation hypothesis' on the grounds that all subpopulations in the Greater Wood Buffalo metapopulation did not decline, even though all were diseased. Their analysis indicated the decline between the 1970s and the 1990s would have occurred regardless

of the disease status of the Greater Wood Buffalo metapopulation. They argued 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.

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 amount 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 populations/subpopulations.

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 in Saskatchewan, Simon *et al.* (2019) observed that wolves still selected areas intensively used by plains 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 older, weak, injured or very young individuals which are vulnerable to attack.

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 Behchokò (Armstrong pers. comm. 2025b).

Case History: Impacts during an increasing Mackenzie Bison Population (1963-1992)

From 1963 when 18 bison founded the Mackenzie population, the mean exponential growth rate was 24% until 1975 when the population 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: 132), but bounties continued to be paid for wolves until 1974. Boreal caribou and moose were abundant on the bison range (Jacobson 1976; Kimble pers. comm. *in* SARC 2016: 90), 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: 132). 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 8). 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 subpopulation 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 ASSESSMENT¹¹

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		

¹¹ 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 – Bovine tuberculosis and brucellosis High
- Threat 3 – Overharvesting Medium
- Threat 4 – Vehicle collisions Medium
- Threat 5 – Severe weather events Medium
- Threat 6 – Drowning Medium
- Threat 7 – Predation Low-Medium
- Threat 8 – Low genetic diversity Low-Medium

Detailed Threats Assessment

Threat #1. Anthrax	
Specific threat	Although it is naturally occurring, anthrax is an extremely lethal pathogen, with serious implications for wood bison in the NWT.
Stress	<p>Anthrax is caused by the bacterium <i>Bacillus anthracis</i>, 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.</p> <p>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.</p> <p>No cases of anthrax have been found in the Nahanni population.</p>
Extent	Localized (<50%)
Severity	High
Temporality	Seasonal
Timing	Short-term
Probability	High
Causal certainty	High
Overall level of concern	High

Threat #2. 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	<p>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). The presence of the two diseases and the potential spread to currently non-infected populations have been identified as major obstacles to species recovery.</p> <p>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%.</p> <p>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 active disease.</p> <p>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 population seems to be the removal of all infected animals, as well as all exposed susceptible animals.</p> <p>The prevalence of disease in a bison population may also increase predation rates. The availability of substantial numbers of debilitated bison maintains larger numbers of wolves, which would, in turn, result in greater losses of calves because they are the most vulnerable to predation.</p>	
Extent	Localized (<50%)	
Severity	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	High
--------------------------	------

Threat #3. 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	<p>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.</p> <p>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.</p> <p>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.</p>
Extent	Localized (<50%)
Severity	High
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	<p>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.</p> <p>About 89% of vehicle-bison collisions in the NWT occur in the Mackenzie bison range. Nighttime travel along Highway 3 has increased overall since the placement of the Deh Cho Bridge near Fort Providence in 2012. Bison are also expected to continue to move northward along the Tłı̨chǫ Highway (Highway 9) toward Whatı, increasing the potential for vehicle-bison collisions.</p>
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	<p>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.</p> <p>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.</p>
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. While predation is a natural and normal part of the bison ecosystem, wolf predation was identified as a prominent factor when the Greater Wood Buffalo metapopulation was in decline in the mid-1970s. Communities around Wood Buffalo National Park have also expressed concerns that low calf survival in bison 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 <i>et al.</i> (2000) stated that this bison population appeared to be regulated by food supply, despite considerable wolf predation on calves.
Extent	Widespread (>50%)
Severity	Low-Medium
Temporality	Continuous
Timing	Happening now
Probability	High
Causal certainty	High
Overall level of concern	Low-Medium

Threat #8. Low genetic diversity	
Specific threat	The historic decline in population size for wood bison from thousands to hundreds of individuals would have reduced the genetic integrity of wood bison. Further, 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. Forced isolation of NWT populations through disease control measures (e.g., Bison Control Area) further stifles gene flow.
Stress	<p>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. While bison exclusion zones (e.g., Bison Control Area) provide important protection against infection of disease-free bison, they also restrict genetic mixing and reduce possibility of rescue.</p> <p>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. At present, there are no privately owned herds of mixed lineage</p>

	bison within the range of wood bison in the NWT, and the introduction of cattle genes to NWT wood bison is unlikely to occur.	
Extent	Widespread (>50%)	
Severity	Unknown	
Temporality	Continuous	
Timing	Happening now	
Probability	Unknown	
Causal certainty	Low	
Overall level of concern	Low-Medium	