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NWT Climate Change Vulnerability Assessment
Species at Risk

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PREFACE

Reflecting the magnitude and extent of current and projected climate change impacts in the Northwest Territories (NWT), the Office of the Auditor General, in a 2017 audit of the Government of the Northwest Territories' (GNWT) climate change response, found that the Department of Environment and Natural Resources (ENR) had not adequately identified risks associated with climate change or adaptation strategies in response to climate change and had not ensured access to information necessary to respond effectively to climate change. Further, efforts that had been taken were assessed as being piecemeal and reactive.

The audit recommended that ENR identify the significant climate change risks faced by the NWT and put in place appropriate adaptation measures. Specifically, the audit recommended:

- Conducting an assessment of risk to ensure that all climate change risks to wildlife have been identified,
- Collecting the information required to understand climate change impacts on wildlife, including the status of species in the territory,
- Taking action to address the risks identified and
- Working to fulfill those commitments ENR had already identified as important to addressing climate change impacts on wildlife (e.g. species management plans and recovery strategies).

These recommendations were accepted by ENR in their response to the audit.

This vulnerability assessment primarily addresses the first bullet above, specific to species at risk in the NWT. A subsequent Phase 2 assessment will scope in additional species not currently classified as species at risk in the NWT (e.g. other harvested species, culturally significant species, etc.) and will complete this step. In addition, this document can be used to inform future management actions, including a Wildlife Climate Change Adaptation Strategy currently under development.

In addition to responding to the recommendations of the Auditor General, this vulnerability assessment supports the actions described in ENR's *2030 NWT Climate Change Strategic Framework* and *Action Plan* and will be part of a suite of vulnerability assessments completed for various sectors of government (e.g. forests, health, infrastructure).

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

This *Climate Change Vulnerability Assessment: Species at Risk* provides a broad overview of the vulnerability of NWT species at risk to climate change. It describes the factors contributing to species vulnerability and provides guidance for application of results to future management decisions. It includes all species at risk in the NWT, designated through either the *Species at Risk (NWT) Act* or the federal *Species at Risk Act*.

Global climate change and its associated impacts are becoming increasingly noticeable and are expected to intensify over the course of the 21st century. The effects are expected to be particularly pronounced in northern regions like the NWT. Impacts will vary considerably across the landscape, but in general, climatic shifts northwards in latitude and upwards in altitude are projected.

Temperatures in the NWT are projected to increase by up to 8°C by the end of the century. Fewer days below -25°C and more days above 25°C are expected. Projections of precipitation intensity and frequency across the NWT show a general increasing trend over the course of the 21st century. Both increases in temperature and precipitation are likely to be more pronounced in more northern areas of the territory. The growing season is projected to lengthen, sea level is projected to rise and the permafrost line is expected to contract northwards. Forest composition may change and growth may increase in response to shifts in temperature, precipitation and permafrost. Changes to area burned and fire season length are possible, although this appears to depend strongly on future moisture availability. Insect/parasite outbreaks and establishment of new species are expected to increase in the territory in response to climate change. Declines in sea ice, one of the most iconic characteristics of the Arctic environment and highly vulnerable to climate change, are expected to continue, building on to-date cumulative losses of almost 500,000 km^2. Surface water availability is projected to decline as a result of increases in temperature and evaporation, although this may be offset by increases in precipitation. In contrast, annual high-water flows are expected to increase across much of the north and seasonal events such as spring freshet may shift in timing.

These changes may have important implications for northern ecosystems, particularly given that northernmost ecosystems have limited capacity to shift elsewhere as temperatures warm. In response to these changes, species populations may decline, move, adapt, or shift, which may create novel species communities.

Overall, climate change is the most serious threat to species at risk in the NWT, with 39 of the 46 species considered in this assessment likely to be negatively impacted by climate change.

A summary of the assessment results for the 46 species considered in this assessment are included in the table below. Ratings and information describe (a) climate change sensitivity in relation to habitat, abiotic factors (e.g. temperature) and biotic factors (e.g. food availability, parasites, etc.), (b) sensitivity to potentially interacting non-climate stressors (e.g. human disturbance) and (c) adaptive capacity (reproductive and dispersal capacity and genetic diversity). Interpretive detail for the colour-coding, as well as additional detail by species group is included below the table. Additional detail may be found in Methods (pg. 39), Results (pg. 47) and Appendix B (pg. 146).

Assessed species	Climate change sensitivity[1]	Non-climate stressors[2]	Adaptive capacity[3]
AMPHIBIANS			
Northern leopard frog			
Western toad			
MAMMALS			
Generalists			
Grizzly bear			
Wolverine			
Sea ice/Arctic specialists			
Dolphin and Union caribou			
Peary caribou			
Polar bear			
Alpine specialists			
Collared pika			
Northern mountain caribou			
Grassland/meadow specialists			
Wood bison			
Old forest specialists			
Barren-ground caribou			
Boreal caribou			
Marine mammals			
Bowhead whale			
Grey whale			
Bats			
Little brown *myotis*			
Northern *myotis*			
BIRDS			
Aerial insectivores			
Bank Swallow			
Barn Swallow			
Common Nighthawk			

[1] The average of habitat, abiotic and biotic factors.

[2] Scored based on threats in the NWT only. This does not imply that there are not significant threats elsewhere in the range that may have an influence on the species in the NWT.

[3] Based primarily on reproductive and dispersal capacity and modified by genetic diversity in some cases.

Assessed species	Climate change sensitivity[1]	Non-climate stressors[2]	Adaptive capacity[3]
Olive-sided Flycatcher			
Forest birds			
Canada Warbler			
Evening Grosbeak			
Harris' Sparrow			
Rusty Blackbird			
Marine birds			
Ivory Gull			
Raptors			
Peregrine Falcon			
Short-eared Owl			
Waterfowl			
Horned Grebe			
Red-necked Phalarope			
Other water birds			
Buff-breasted Sandpiper			
Eskimo Curlew			
Red Knot (*islandica*)			
Red Knot (*rufa*)			
Whooping Crane			
Yellow Rail			
FISH			
Anadromous			
Dolly Varden			
Marine			
Northern wolffish			
Lake/stream			
Bull trout			
Shortjaw cisco			
INSECTS			
Gypsy cuckoo bumble bee			
Transverse lady beetle			
Western bumble bee			
Yellow-banded bumble bee			
PLANTS			
Hairy braya			
Mackenzie hairgrass			
Nahanni aster			

Colour-coding interpretation:

Climate change sensitivity[4]	Non-climate stressors	Adaptive capacity[5]	Interpretation for managers
Likely not sensitive	Likely not sensitive	Good to moderate-good	Monitor
Somewhat sensitive/ possibly very sensitive	Somewhat sensitive/ possibly very sensitive	Moderate	Decrease uncertainty by increasing knowledge
Likely very sensitive	Likely very sensitive	Moderate-poor	Mitigate impacts
Known very sensitive	Known very sensitive	Poor to very poor	Mitigate impacts

Summary Assessment Results

Amphibians: Higher spring and summer temperatures may enhance development and egg survival in amphibians, as well as facilitate potential range expansion. However, aggregation events (e.g. group breeding) make both species vulnerable to the effects of extreme weather conditions, such as drought or freezing temperatures. Habitat connectivity may also be impaired by drought conditions.

Mammals

Sea ice/Arctic specialists**:** Unsurprisingly, sea ice and Arctic specialists (Dolphin and Union caribou, Peary caribou and polar bear) are expected to be highly vulnerable to the effects of climate change. This reflects potentially substantial shifts in climatic conditions within their ranges and reliance on habitats that are likely to be impacted severely over the long term (e.g. sea ice). Climate change is, ultimately, expected to limit survival of polar bears across most populations.

Old forest specialists**:** Old forest specialists (barren-ground caribou and boreal caribou) also show a fairly high level of vulnerability to the effects of climate change. For these species, forage availability, fidelity to key habitats, predation, insect harassment and the need for habitat connectivity inform their high degree of vulnerability.

Alpine specialists**:** The two alpine specialists considered in this report (northern mountain caribou and collared pika) are expected to be moderately vulnerable to climate change. While these species demonstrate unique behavioural adaptations to climatic variability within their ranges, they also have habitat associations (e.g. reliance on ice patch habitat)

[4] The highest value for sensitivity based on habitat, abiotic and biotic factors.
[5] Based largely on the average of reproductive and dispersal capacity.

and physiological tolerances (e.g. susceptibility to heat stress) that increase their vulnerability. Changes to vegetation composition within the ranges of these species may also affect forage availability.

Bats: Hibernating bats (little brown *myotis* and northern *myotis*) may see both benefits and drawbacks to climate change. Warming temperatures may increase the forage period, decrease the duration of hibernation and facilitate northward range expansion (contingent upon roost availability). Conversely, changes to temperature and humidity conditions in hibernacula could adversely impact health and survival. How climate change will impact the spread and virulence of white-nose syndrome is uncertain, although increases in hibernacula temperatures could encourage growth of the fungus that causes white-nose syndrome.

Marine mammals: The impact of climate change on the two marine mammals considered here (bowhead whale and grey whale) is less consistent. Although both species have exceedingly long generation times, low reproductive capacity and high dispersal ability, grey whales are expected to benefit from climate change while bowhead whales are expected to be adversely affected. Grey whales may see the expansion of their feeding areas and, as a result of warming waters, may be able to stay in the north year-round, avoiding the resource expenditures associated with migration. In contrast, bowhead whales will likely see a decline in forage availability with the loss of highly productive ice edge habitat.

Meadow/grassland specialists: Wood bison, the sole meadow/grassland specialist being considered here, uses wetland meadow habitats interspersed with forest stands. Regular disturbance from fires and flooding/drawdowns are integral to building suitable habitat. If forest fire frequency increases, climate change may help increase habitat availability for this species.

Generalists: Grizzly bears and wolverines have broad ranges in the NWT and are not expected to be particularly sensitive to the effects of climate change (they may actually see benefits).

Birds

Marine birds: Only one marine bird is considered in this report. The ivory gull, given its year-round use of ice edge habitat, limited number of suitable breeding sites and relatively poor reproductive capacity, is expected to be highly vulnerable to the effects of climate change.

Other water birds: With the exception of the yellow rail, the water birds considered here (buff-breasted sandpiper, eskimo curlew, red knot (*islandica* and *rufa*) and whooping crane) show a degree of habitat- or forage-specificity that, combined with low reproductive rates, makes them moderately to highly vulnerable to climate change.

Raptors: Peregrine falcons and short-eared owls are not expected to be strongly vulnerable to climate change, particularly short-eared owls. Both species are generalists with wide ranges, which substantially reduces their sensitivity overall. However, peregrine falcon reproduction and survival may be adversely affected in cases of extreme events (i.e., temperature, storms), by the expanding ranges of pest species and if prey availability declines.

***Waterfowl*:** Horned grebes and red-necked phalaropes, the two waterfowl species considered in this report, are both strongly water-associated species, with wetlands, coastal areas and oceans essential throughout their life cycles. Given the vulnerability of these habitats to climate change (e.g. drying, permafrost melt, etc.); these species are likely to be quite sensitive to the effects of climate change.

***Aerial insectivores*:** The aerial insectivores in this report (bank swallow, barn swallow, common nighthawk and olive-sided flycatcher) are considered moderately vulnerable to the effects of climate change. Declines in the abundance of insect prey and the timing of insect emergence are particularly concerning, although extreme weather events, river bank collapse and increased forest fire frequency/intensity may also affect these species.

***Forest birds*:** Forest birds considered in this report (Canada warbler, evening grosbeak, Harris' sparrow and rusty blackbird) are likely moderately vulnerable to climate change. As with aerial insectivores, declines in insect abundance and the development of mismatches in the timing of breeding and insect prey emergence is particularly concerning. Extreme weather events, forest fires and erosion of nest sites may also negatively impact these species. The rusty blackbird is expected to experience pronounced range contraction in response to impacts to its habitat.

Fish: High habitat specificity and sensitivity to temperature changes increases the vulnerability of the fish species considered in this report (dolly varden, bull trout, northern wolfish and shortjaw cisco), particularly dolly varden and bull trout, for which suitable habitat is also very limited. Significant range contraction is expected for both dolly varden and bull trout as temperatures increase and drying conditions prevail in some areas. Given the high degree of habitat specialization seen in both species, their ability to expand northwards is doubtful. Competition with other fish species may worsen in response to climate change (i.e., through temperature-dependent effects on competition or displacement). The spread of non-native species is a clear threat to both bull trout and shortjaw cisco, although the potential spread of whirling disease is likely the most pressing threat in the NWT.

Insects: Of the insects considered here (gypsy cuckoo bumble bee, yellow-banded bumble bee, western bumble bee and transverse lady beetle), the western bumble bee is expected to be the most vulnerable to climate change, linked to its body size and limited northern distribution. Declines in this species are expected in the long term related to increasing temperatures and heat waves. The potential for mismatches to develop between bee emergence and flowering times/host emergence as a result of climate change could impact all three bumble bee species and could result in severe population declines. The transverse lady beetle, in contrast, is not expected to be sensitive to climate change.

Plants: All three plant species (hairy braya, Nahanni aster and Mackenzie hairgrass) are endemic to Canada and are considered moderately to highly vulnerable to the effects of climate change, reflecting habitat specializations and small distributions.

Uncertainty is a clear barrier to climate change adaptation. However, uncertainty should not be used as a reason to delay action on climate change adaptation, particularly given clear understanding about the direction in which climate change is proceeding. As information improves and adaptation strategies are tested, approaches can be altered over time in response.

Moving forward, adaptation planning should start with a purposeful evaluation of existing goals and objectives, considering the vulnerabilities of the species included in this assessment. Those goals and objectives whose achievability is likely to be affected by climate change should be re-examined and revised (e.g. maintaining the historical distribution of a highly climate-vulnerable species, or maintaining the full suite of historical biodiversity in a localized area). New or revised adaptation strategies should aim to reduce exposure, reduce sensitivity, or enhance adaptive capacity of species/systems. They should also be future-focused (considering future climate/ecological conditions and potential range shifts) rather than using historical benchmarks and should provide benefits under multiple climate futures.

INTRODUCTION

The October 2017 Report of the Auditor General of Canada to the Legislative Assembly of the Northwest Territories (NWT) recommended that the Department of Environment and Natural Resources (ENR) identify the significant climate change risks faced by the NWT and put in place appropriate adaptation measures (Office of the Auditor General 2017). This is primarily being addressed through *the 2030 NWT Climate Change Strategic Framework* and its associated action plan, which address climate change mitigation and adaptation across all major sectors of the NWT. Assessment of the diverse impacts of climate change on the NWT's species at risk and the vulnerability of our species at risk to climate change is being addressed in more detail in this *Climate Change Vulnerability Assessment: Species at Risk*. A subsequent Phase 2 vulnerability assessment will scope in additional species not currently classified as species at risk in the NWT (e.g. other harvested species, species of cultural significance, see *Selecting Species and Grouping Species*, pg. 45).

This vulnerability assessment, insofar as is possible, describes the factors contributing to species vulnerability (see *Results*, pg. 47). This assessment also includes recommendations that can be considered in the development of species-specific interventions related to climate change (see *Management and Adaptation*, pg. 122). However, these represent methods of managing vulnerability only. Minimizing biodiversity loss is dependent upon maintaining ecological processes and functions and mitigating and removing threats to species, habitats and ecosystems, including significant and immediate decreases in global greenhouse gas emissions (Williams et al. 2008, Meltofte et al. 2013, CAFF 2013).

BIODIVERSITY IN THE NWT

The NWT is a vast region, accounting for about 13% of Canada. It includes variable and often harsh continental and marine environments, mixed forests, taiga and tundra. Estimates suggest up to 30,000 species occur here, although those most recognizable to us (e.g. large mammals, birds and fish) constitute only a small fraction of that total. This species diversity, together, fulfills important economic, ecological and cultural functions and helps define the region (Working Group on General Status of NWT Species 2016).

Biodiversity loss puts this in jeopardy. It is important to fully consider and appreciate the importance of biodiversity, associated ecological interconnections and the consequences of biodiversity loss in all management decisions.

Some species, like caribou, are so integral to the peoples, cultures, environment and economy of the NWT that they are considered in all current decision making. However, it is also important to consider less charismatic species as well. Bumble bees, for instance, are a key pollinator for rock cranberries (aka lowbush cranberry, lingonberry; *Vaccinium vitis-idaea*) in the NWT. While cranberries are recognized as an important harvestable species in the NWT, the interactions and processes that make cranberry harvesting possible are often overlooked. The loss of bumble bees in the NWT would not just mean the loss of these fascinating creatures; it would be devastating to species, like cranberries, that depend on them for pollination and, by extension, species and people that depend on cranberries for nourishment.

Ultimately, conservation of biodiversity in the face of threats like climate change is not a matter only for wildlife managers; it is relevant to everyone in the NWT and the world.

THE NWT'S CHANGING CLIMATE

Climate change is an ongoing concern that is expected to intensify over the course of the 21st century. Although the climate has consistently shown fluctuations and abrupt changes throughout geological history, human activities have increased greenhouse gas concentrations in the atmosphere beyond levels recorded in ice cores in the past 800,000 years (ENR 2010b).

It is generally understood that high latitude regions, such as the NWT, are projected to warm more rapidly than other areas of the world (ENR 2010b). This is due to phenomena such as arctic amplification, whereby declines in snow and ice cover reveal darker soil and vegetation surfaces that absorb more solar energy. As more solar energy is absorbed, more melting will result, creating a feedback loop. Further, some degree of progression in climate change is inevitable, regardless of management interventions, given delayed earth systems response to greenhouse gases already emitted. Although this 'locked-in' warming cannot likely be reversed by human actions, significant and immediate reductions in emissions will still benefit the climate (and us) in the long term. In considering the differences between climate change scenarios in subsequent sections of this report, this is an important factor to keep in mind (Marsh et al. n.d., Parker 2017a and b).

Emissions and Projections

Projections of future climate possibilities are based on models. These models use mathematical equations to simulate the interactions between the various components of the earth's climate and ecological systems (CCCS 2018). As there is much uncertainty associated with future anthropogenic greenhouse gas emissions, scenarios are used to help envision what the future may look like. Representative concentration pathways (RCPs) are a set of commonly used scenarios that cover a wide range of possible climate futures. They are derived from a range of possible future greenhouse gas emissions scenarios (CCCS 2018). The following RCP scenarios and their basic interpretation will be referenced in this report:

- RCP2.6: Low emissions scenario. This scenario accounts for stringent mitigation measures that limit warming below 2°C
- RCP4.5: Moderate emissions scenario
- RCP 8.5: High emissions scenario (Moss et al. 2010)

Unless otherwise noted, this report employs projections from www.climatedata.ca[6], relative to baseline conditions (the average of 1950-2005, although variations, based on source material, are noted as appropriate in the text).

Projections will be discussed using examples of the impacts expected to be seen at various locations throughout the territory. These locations are displayed in Figure 1. They represent a range of landscapes across the NWT; however, the NWT is a vast territory, with immense variation. These locations are intended as illustrative examples of the diversity of the territory and should not be interpreted as necessarily representative of the range of variation possible across the territory or even within the ecoregions in which they occur. The locations selected are as follows:

- **Sachs Harbour** occurs in the northern Arctic ecoregion. Overall, this ecoregion is characterized by maritime climatic influences, very low average annual temperatures (-11°C to -14°C along the southern coasts of Banks and Victoria Islands), an extremely short growing season, as well as low species diversity. The entire ecoregion is underlain by continuous permafrost. The area around Sachs Harbour is somewhat warmer and supports a relatively higher diversity of flora and fauna than most other areas within the ecoregion. The northern Arctic ecoregion supports only 13 regularly-occurring land mammals, which decline in abundance and diversity with increasing latitude. Marine mammals (e.g. whales, seals and walrus) and around 60 species of birds also inhabit this region for at least part of the year. Vegetation consists primarily of herbaceous and vascular plants and dwarf-shrubs. Sachs Harbour and Ulukhaktok are the only communities within the northern Arctic ecoregion (Ecosystem Classification Group 2013).
- **Tuktoyaktuk** and **Lake Providence[7]** occur in the southern Arctic ecoregion. Geographically, the ecoregion occurs above the treeline (although small coniferous trees can extend into topographic microclimates) and is split into tundra plains (in which Tuktoyaktuk occurs) and tundra shield (which includes Lake Providence). Broadly, the southern Arctic is characterized by low average annual temperatures (-11°C in the area around Tuktoyaktuk), a short growing season and continuous permafrost. Precipitation (130-190 mm/year) falls equally as rain and snow. The plains and shield portions of the ecoregion are influenced by marine and continental climates, respectively. Primary productivity in the plains is somewhat higher than is seen in the shield. The southern Arctic ecoregion supports about 30 regularly-occurring land mammals and at least 115 species of birds, most of which are

[6] This climate data is downscaled to a 10 km x 10 km resolution using version 2 of the Bias Correction/Constructed Analogues with quantile mapping reordering method (BCCAQv2). An ensemble of 24 climate models was used. Displayed is the 50th percentile (median) of the model outputs.

[7] Note that Lake Providence is not a community. In choosing locations across the NWT, two locations away from communities were selected, including Lake Providence. This lake is located at 64.70614739960975, -111.90399169921876.

migratory. Tuktoyaktuk and Paulatuk are the only communities in the southern Arctic ecoregion (Ecosystem Classification Group 2012).

- **Yellowknife** occurs in the taiga shield ecoregion. This ecoregion is underlain by the bedrock of the Canadian Shield and contains some of the oldest known rock in the world. It extends through approximately 30% of the central NWT, from the southern border with Alberta (AB) and Saskatchewan (SK), north to the border with Nunavut (NU). Lakes and rivers are a characteristic feature of the region. The region is relatively dry and characterized by long, cold winters and short summers, although given the geographic breadth of this region this can vary quite widely. Forest fires are part of the normal disturbance regime here and permafrost is sporadic to continuous. Forest composition varies throughout the ecoregion as well, including trembling aspen and paper birch in the southwest, jack pine and black spruce-dominant forests elsewhere in the ecoregion, white spruce near the treeline and tundra conditions in the northeastern-most areas. The ecoregion supports around 50 mammal species and over 200 bird species (Ecosystem Classification Group 2008).
- **Fort Smith** occurs in the taiga plains ecoregion, which contains some of the most productive habitats in the NWT. As with the taiga shield, the geographic breadth of this ecoregion includes substantial variation in climatic conditions and species communities. Mean annual temperature ranges from -1°C to -13°C, from south to north and average annual precipitation ranges from 250-500 mm. Permafrost is discontinuous to continuous. Forests include aspen, white spruce and jack pine in the south and shift to closed, then progressively more open, black and white spruce-dominated forests as you move northwards and scattered white spruce as you approach the treeline. Peat is a significant and important component of this ecoregion. The taiga plains include Canada's largest river, the Mackenzie River and two of the largest lakes in Canada, Great Slave Lake and Great Bear Lake. This ecoregion supports over 50 species of mammals and approximately 250 species of birds (Ecosystem Classification Group 2007)
- **Hay Creek**[8] occurs in the Cordillera ecoregion of the NWT, which includes the mountainous regions of the territory, concentrated along its western boundary. Mean annual temperatures range from -10°C to -4°C and mean annual precipitation from 210-600 mm. Permafrost can be either continuous or discontinuous. Vegetation cover varies substantially between lowland, subalpine and alpine areas within this region, but can include fir, aspen, spruce, lodge pole pine and jack pine, as well as treeless alpine areas. The cordillera supports about 60 mammal species, including some whose ranges are defined in part by elevation (e.g. dall's sheep,

[8] Note that Hay Creek is not a community. In choosing locations across the NWT, two locations away from communities were selected, including Hay Creek. This lake is located at 64.11899573566531, -128.72406005859378

mountain goats, northern mountain caribou and collared pikas) and about 200 species of birds (Ecosystem Classification Group 2010).

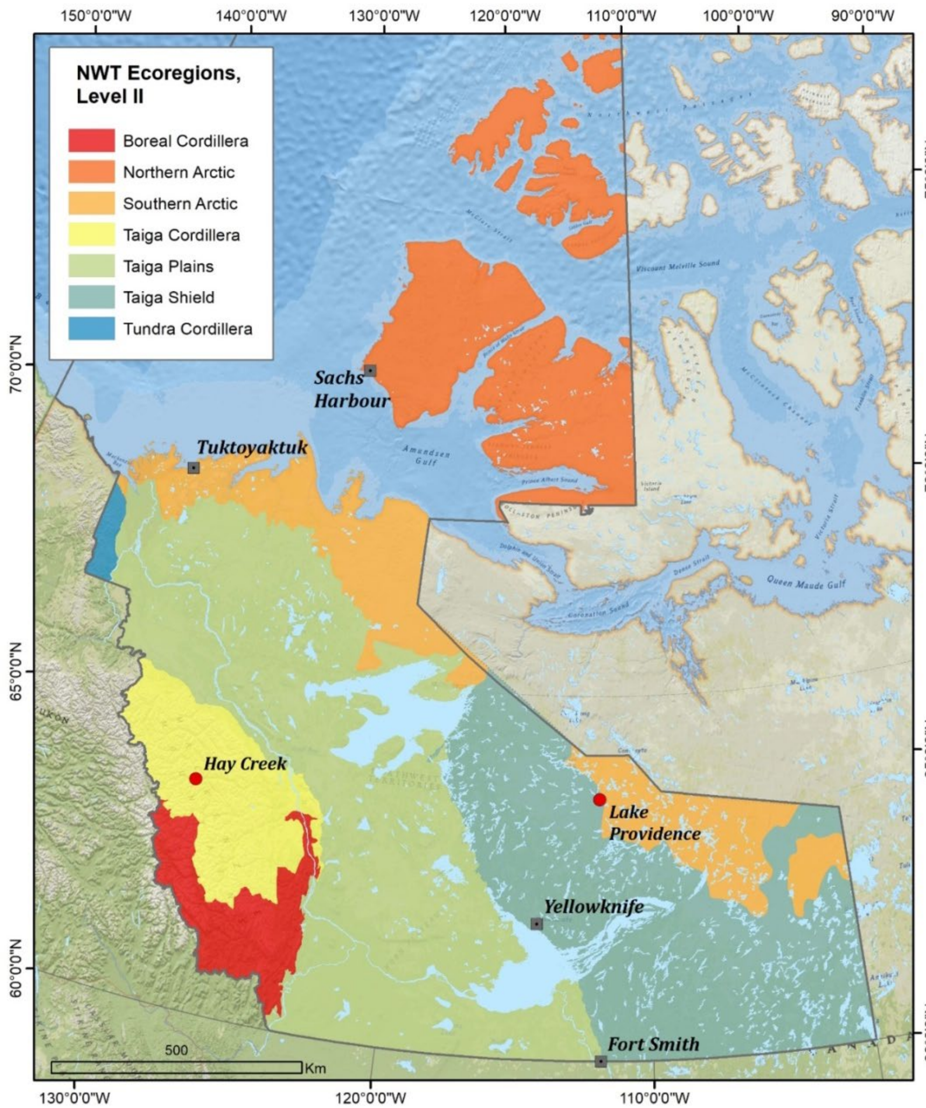

Figure 1. Spatial distribution of locations of focus for projections of climate variables (map courtesy B. Fournier, ENR).

Temperature

Considering low to high emissions scenarios, models suggest that an increase of as much as 8°C in average annual temperature would occur in the NWT by the end of the 21st century. The magnitude of this projected temperature change is expected to vary across the NWT depending on latitude and season.

Table 1 shows projected average change in annual and seasonal average temperatures under low, moderate and high emissions scenarios for the NWT as a whole, plus each selected locations, from 2006-2100, relative to a 1981-2010 baseline average. These data show that average increases in temperature are positively associated with latitude. For example, the projected average increase in annual mean temperature under a high emissions scenario for Sachs Harbour is approximately +10°C, compared to approximately +8°C in Fort Smith. Rapid rates of winter warming, relative to other seasons, can also be seen. For example, Tuktoyaktuk is projected to experience an increase of approximately +16°C in winter under a high emissions scenario, relative to a projected annual average increase of approximately +10°C.

Temperature increases are projected to continue through the 21st century under all emissions scenarios for all locations. It should also be noted, however, that increases in temperature are observed to level off under the low emissions scenario before the end of the century, suggesting capacity for policy changes implemented now to limit the impacts of anthropogenic climate change in the long term (van Vuuren et al. 2011).

Time series for annual and seasonal temperature averages from 1950-2100 are shown for selected locations across the NWT in Figures 2-13.

Table 1. Average change in temperature (°C) from 2006-2100, relative to 1981-2010 baseline average[9], displayed annually and by season under low, moderate and high emissions scenarios, for selected locations across the NWT and rounded to the nearest degree. BCCAQv2 variable datasets for 'mean temperature' from www.climatedata.ca were used. In this dataset, the 50th percentile (median) was derived from an ensemble of 24 climate models. Seasonal representations were calculated using a proxy month: winter (January), spring (April), summer (July) and autumn (October).

	Annual				Winter				Spring				Summer				Autumn			
		Mean temperature increase (°C)				Mean temperature increase (°C)				Mean temperature increase (°C)				Mean temperature increase (°C)				Mean temperature increase (°C)		
	1981-2010 mean temp,	Low	Mod.	High	1981-2010 mean temp.	Low	Mod.	High	1981-2010 mean temp.	Low	Mod.	High	1981-2010 mean temp.	Low	Mod.	High	1981-2010 mean temp.	Low	Mod.	High
NWT	-9	+1	+4	+8	-28	+2	+6	+13	-12	+1	+3	+7	12	+1	+2	+6	-6	+2	+2	+8
Sachs Harbour	-12	+2	+5	+10	-28	+3	+7	+18	-17	+1	+4	+8	7	+1	+2	+6	-10	+2	+5	+8
Tuktoyaktuk	-10	+2	+5	+10	-27	+2	+7	+16	-15	+1	+4	+8	11	+1	+2	+7	-7	+2	+4	+8
Lake Providence	-8	+1	+4	+8	-26	+2	+5	+12	-10	+1	+3	+6	11	+1	+2	+6	-9	+2	+4	+7
Yellowknife	-4	+1	+4	+8	-25	+2	+5	+11	-6	+0	+3	+6	17	+1	+2	+6	-1	+1	+3	+6
Hay Creek	-6	+1	+3	+7	-25	+1	+5	+9	-7	+1	+3	+5	13	+1	+2	+6	-7	+1	+3	+6
Fort Smith	-2	+1	+3	+8	-22	+2	+4	+10	-1	+1	+3	+6	17	+1	+3	+6	0	+1	+3	+6

[9] Note that seasonal datasets only have data up until 2099, while annual averages use data to 2100.

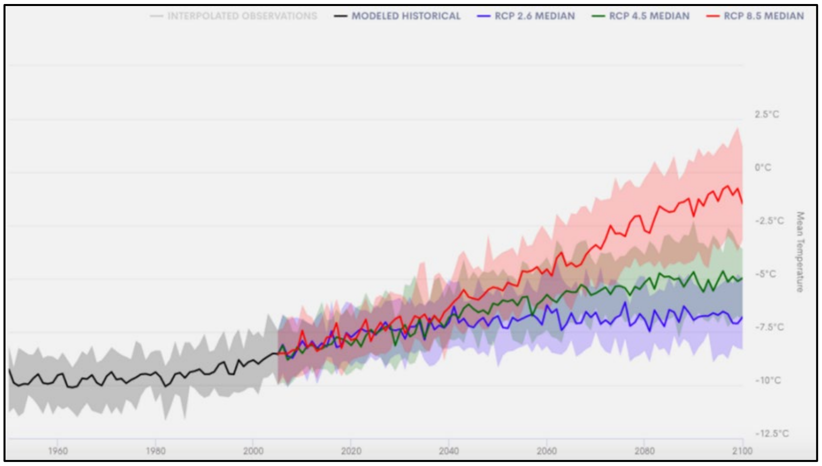

Figure 2. Mean annual temperature time series for Lake Providence, NWT, from 1950-2100. Modeled historical data are displayed for 1950-2005. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'mean temperature' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentiles.

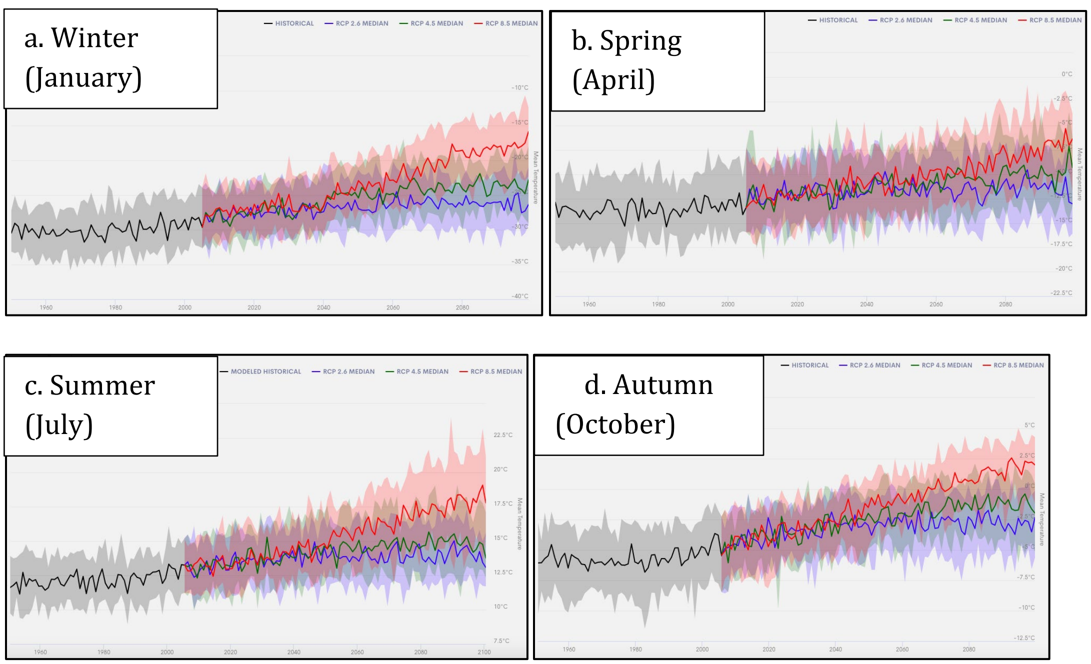

Figure 3. Mean seasonal temperature time series for Lake Providence, NWT, from 1950-2100. Modeled historical data are displayed for 1950-2005 for (a) winter, (b) spring, (c) summer and (d) autumn. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'mean temperature' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentiles.

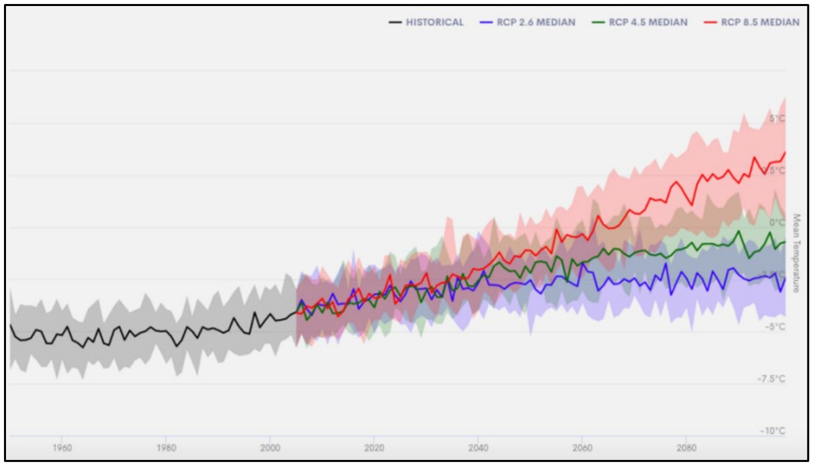

Figure 4. Mean annual temperature time series for Yellowknife, NWT, from 1950-2100. Modeled historical data are displayed for 1950-2005. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'mean temperature' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentiles.

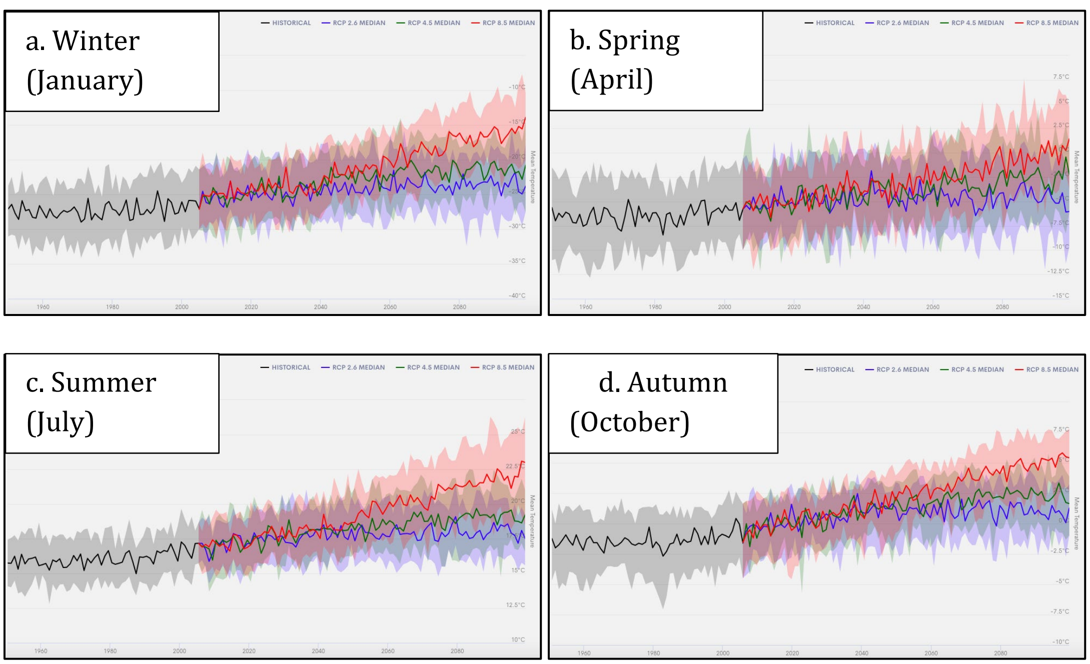

Figure 5. Mean seasonal temperature time series for Yellowknife, NWT, from 1950-2100. Modeled historical data are displayed for 1950-2005 for (a) winter, (b) spring, (c) summer and (d) autumn. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'mean temperature' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentiles.

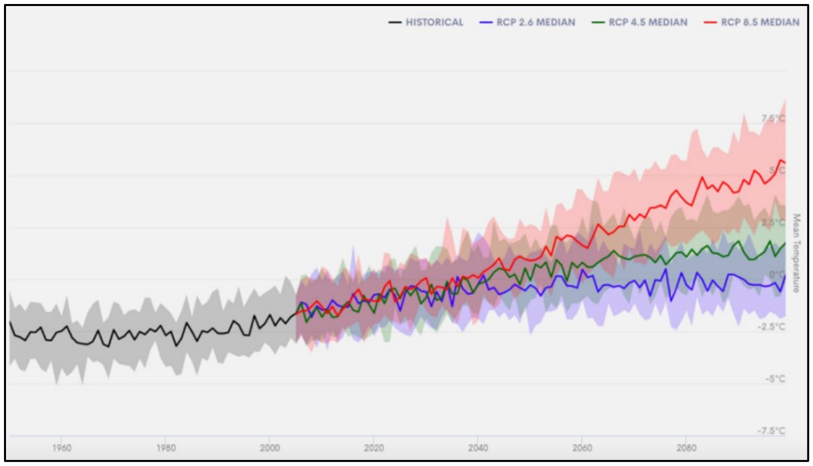

Figure 6. Mean annual temperature time series for Fort Smith, NWT, from 1950-2100. Modeled historical data are displayed for 1950-2005. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'mean temperature' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentiles.

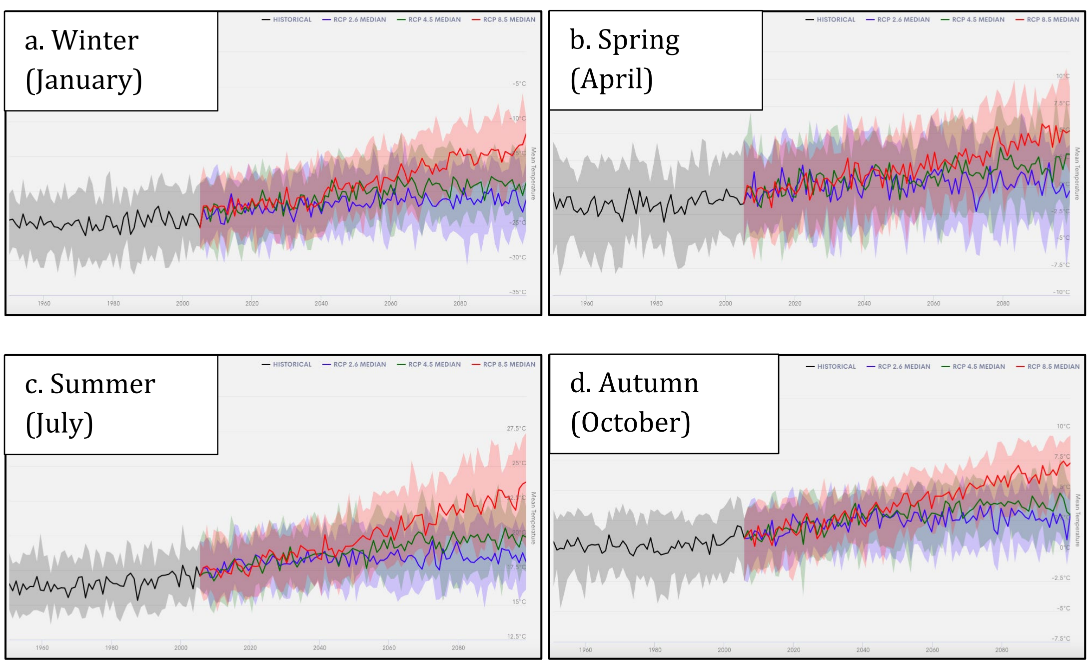

Figure 7. Mean seasonal temperature time series for Fort Smith, NWT, from 1950-2100. Modeled historical data are displayed for 1950-2005 for (a) winter, (b) spring, (c) summer and (d) autumn. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'mean temperature' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentiles.

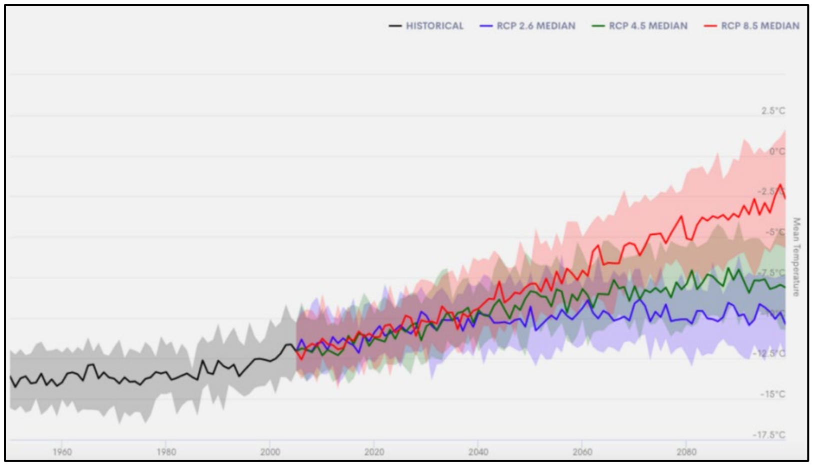

Figure 8. Mean annual temperature time series for Sachs Harbour, NWT, from 1950-2100. Modeled historical data are displayed for 1950-2005. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'mean temperature' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentiles.

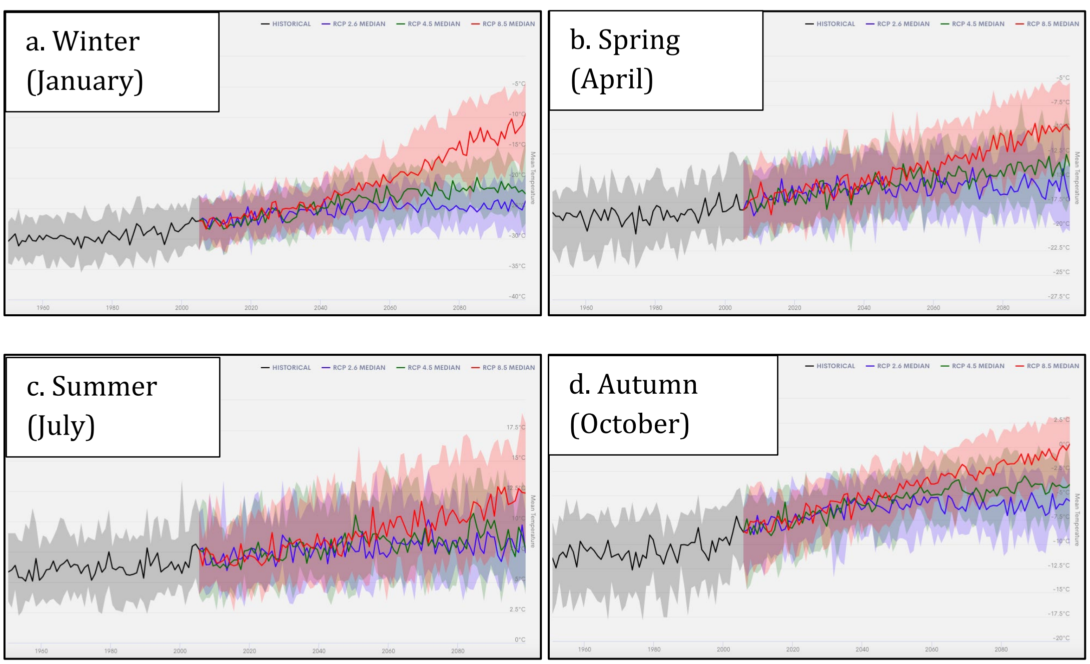

Figure 9. Mean seasonal temperature time series for Sachs Harbour, NWT, from 1950-2100. Modeled historical data are displayed for 1950-2005 for (a) winter, (b) spring, (c) summer and (d) autumn. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'mean temperature' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentile.

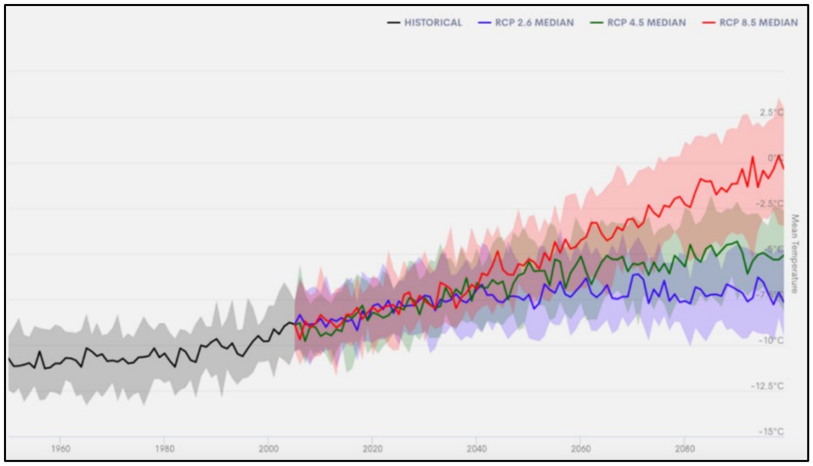

Figure 10. Mean annual temperature time series for Tuktoyaktuk, NWT, from 1950-2100. Modeled historical data are displayed for 1950-2005. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'mean temperature' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentiles.

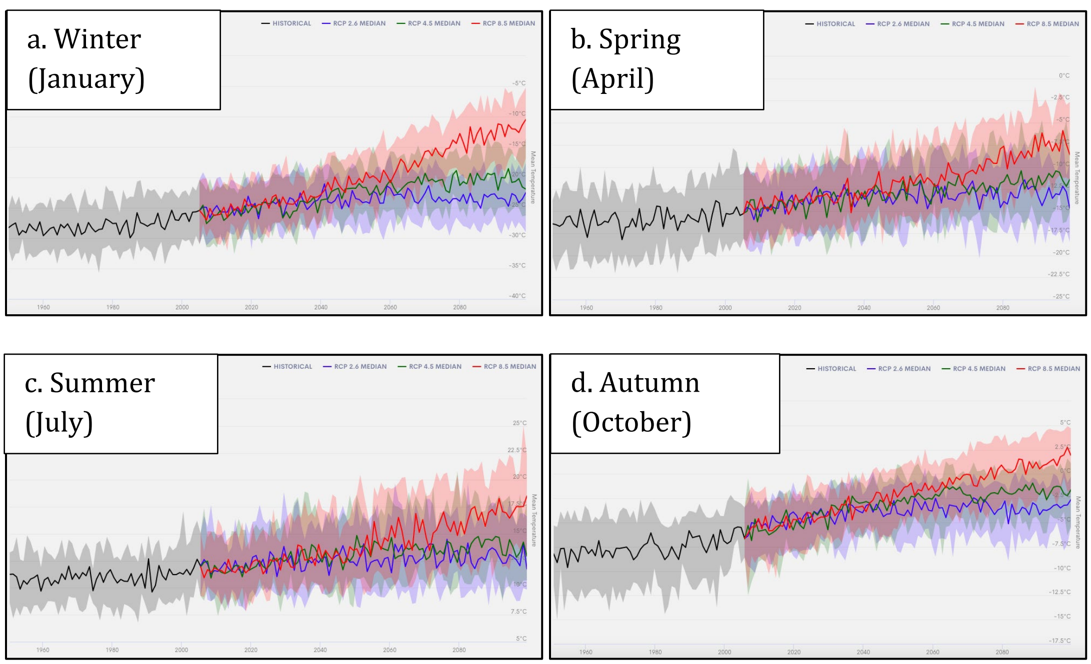

Figure 11. Mean seasonal temperature time series for Tuktoyaktuk, NWT, from 1950-2100. Modeled historical data are displayed for 1950-2005 for (a) winter, (b) spring, (c) summer and (d) autumn. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'mean temperature' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentiles.

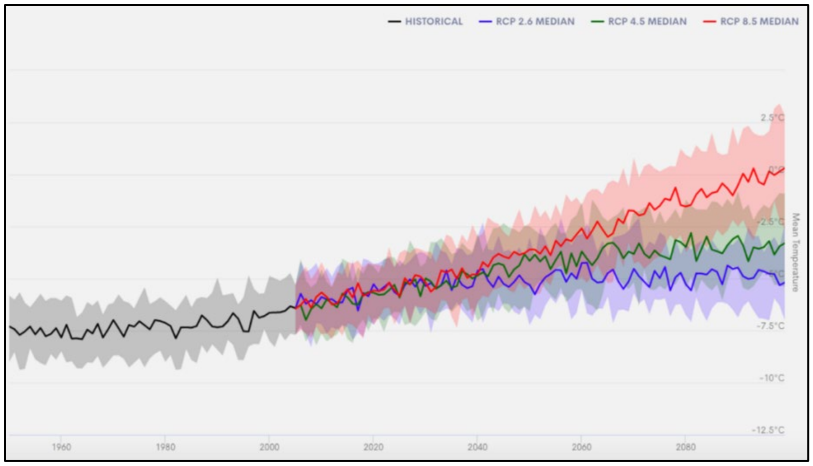

Figure 12. Mean annual temperature time series for Hay Creek, NWT, from 1950-2100. Modeled historical data are displayed for 1950-2005. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'mean temperature' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentiles.

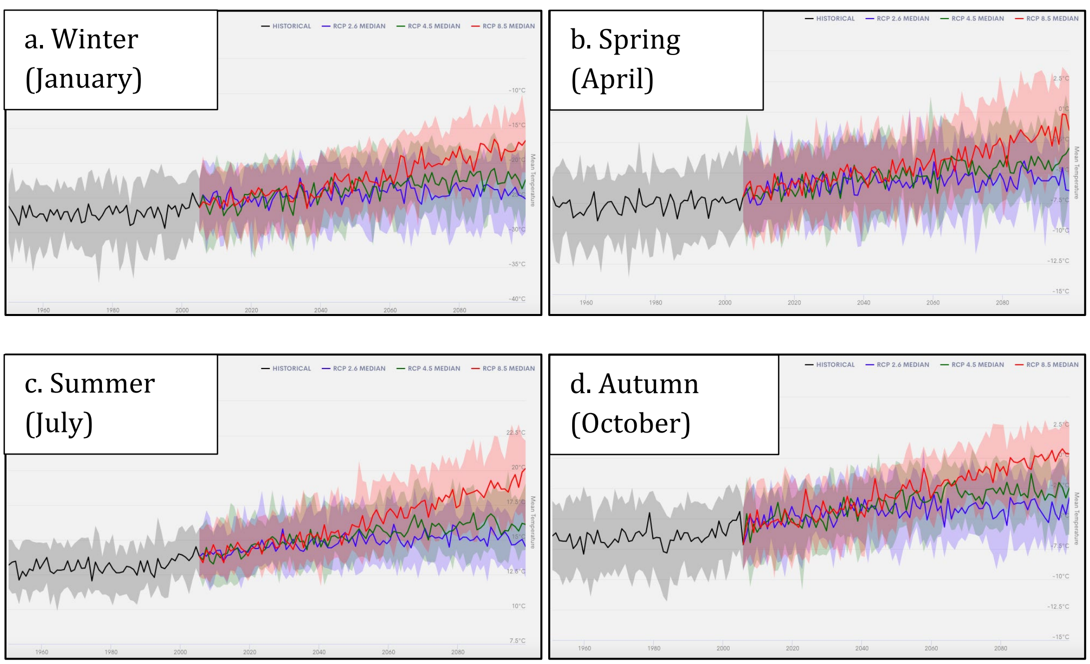

Figure 13. Mean seasonal temperature time series for Hay Creek, NWT, from 1950-2100. Modeled historical data are displayed for 1950-2005 for (a) winter, (b) spring, (c) summer and (d) autumn. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'mean temperature' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentile.

While these averages provide some indication of changes to the overall conditions experienced by wildlife throughout the year, equally important are temperature extremes, which may stress limits of physiological tolerances. Projections of temperature extremes, both high and low, are displayed in Tables 2 and 3 for the 2050s (2041-2070) and 2080s (2071-2100) under low, moderate and high emissions scenarios. These projections suggest that the number of cold days (days below -15°C and -25°C) will decline under all emissions scenarios, even by mid-century. Conversely, the number of days above 25°C and 27°C are expected to increase across most of the NWT (with the exception of Sachs Harbour).

Overall, to-date and projected changes in temperature in the NWT are likely to result in important and potentially permanent ecological shifts.

Table 2. Projected number of days where minimum temperature is below -15°C and -25°C, respectively, for the 2050s (2041-2070 average) and 2080s (2071-2100 average) under low, moderate and high emissions scenarios for selected locations across the rounded to the nearest day. The historical average was calculated by taking the average of yearly values from 1981-2010. BCCAQv2 variable datasets for 'days with Tmin >-15°C' and 'days with Tmin <-25°C' from www.climatedata.ca were used.

	Days with Tmin <-15°C							**Days with Tmin <-25°C**						
	Historical	**2050s (2041-2070)**			**2080s (2071-2100)**			**Historical**	**2050s (2041-2070)**			**2080s (2071-2100)**		
	1981-2010	**Low**	**Mod.**	**High**	**Low**	**Mod.**	**High**	**1981-2010**	**Low**	**Mod.**	**High**	**Low**	**Mod.**	**High**
NWT	166	150	142	132	150	135	100	105	82	71	59	82	64	29
Sachs Harbour	189	160	152	135	164	143	93	121	88	79	60	93	65	17
Tuktoyaktuk	175	154	144	128	155	136	82	106	76	63	46	77	49	13
Lake Providence	167	152	148	139	154	140	108	104	89	80	70	90	71	39
Hay Creek	155	143	136	126	141	131	103	80	69	59	51	68	54	30
Yellowknife	134	122	114	104	122	108	79	74	64	55	46	63	48	25
Fort Smith	111	103	95	85	100	89	62	54	49	42	34	47	35	17

Table 3. Projected number of days where maximum temperature is above 25°C and 27°C, respectively, for the 2050s (2041-2070 average) and 2080s (2071-2100 average) under low, moderate and high emissions scenarios for selected locations across the rounded to the nearest day. The historical average was calculated by taking the average of yearly values from 1981-2010. BCCAQv2 variable datasets for days with 'Tmax >25°C' and 'Tmax above 27°C' from www.climatedata.ca were used.

	Days with Tmax >25°C							Days with Tmax >27°C						
	Historical	2050s (2041-2070)			2080s (2071-2100)			Historical	2050s (2041-2070)			2080s (2071-2100)		
	1981-2010	Low	Mod.	High	Low	Mod.	High	1981-2010	Low	Mod.	High	Low	Mod.	High
NWT	5	9	11	14	9	13	25	2	4	5	8	4	7	16
Sachs Harbour	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Tuktoyaktuk	2	5	7	9	6	8	16	1	3	3	4	3	4	11
Lake Providence	2	3	5	7	4	6	17	1	1	2	3	1	2	8
Hay Creek	4	9	10	17	8	14	30	1	4	4	7	3	6	18
Yellowknife	9	17	21	30	17	25	50	3	8	10	16	8	13	34
Fort Smith	25	36	41	51	35	46	72	13	22	25	33	21	29	54

Precipitation

Precipitation projections across the NWT show a general increasing trend between 2006 and 2100, as displayed in Table 4. Increases in annual precipitation, including rain and snow, are generally expected to be more pronounced at higher latitudes. For example, Sachs Harbour is projected to experience approximately a 54% increase in precipitation from 2006-2100 under a high emissions scenario, compared to approximately a 22% increase projected for Fort Smith. Changes in precipitation are variable across seasons, but increases are projected for all seasons under all emissions scenarios at all locations considered. Time series for annual and seasonal precipitation from 1950-2100 for selected locations across the NWT are shown in Figures 14-25.

Table 4. Average change (approximate) in percent precipitation from 2006-2100, relative to baseline (1981-2010), shown annually and by season under low, moderate and high emissions scenarios for selected locations across the NWT, rounded to the nearest mm/%. Average change in percent precipitation was calculated by multiplying annual anomalies by 95 years (number of years from 2006-2100)[10]and then dividing by the historical average value. BCCAQv2 variable datasets for 'total precipitation' from www.climatedata.ca were used. Seasonal representations were calculated using a proxy month: winter (January), spring (April), summer (July) and autumn (October).

	Annual				**Winter**				**Spring**				**Summer**				**Autumn**			
		Change in precipitation (%)				**Change in precipitation (%)**				**Change in precipitation (%)**				**Change in precipitation (%)**				**Change in precipitation (%)**		
	1981-2010 (mm)	**Low**	**Mod.**	**High**	**1981-2010 (mm)**	**Low**	**Mod.**	**High**	**1981-2010 (mm)**	**Low**	**Mod.**	**High**	**1981-2010 (mm)**	**Low**	**Mod.**	**High**	**1981-2010 (mm)**	**Low**	**Mod.**	**High**
NWT	264	8	16	35	15	12	19	45	11	2	15	39	36	5	12	20	26	11	22	46
Sachs Harbour	158	10	20	54	7	9	29	80	10	4	13	35	18	2	8	40	20	12	16	43
Tuktoyaktuk	195	9	16	41	12	2	12	39	9	3	13	33	26	0	13	38	21	10	19	34
Lake Providence	278	9	14	31	13	15	21	42	13	1	14	19	34	2	12	20	28	9	20	47
Hay Creek	384	8	15	36	26	8	19	29	15	10	17	40	53	8	6	20	37	12	21	48
Yellowknife	299	8	12	27	18	14	17	29	11	7	5	23	38	5	12	17	31	5	18	39
Fort Smith	355	4	11	22	19	18	17	39	13	6	7	34	53	6	3	4	32	8	12	29

[10] Seasonal datasets only have data up until 2099; therefore, 94 years was used in these cases.

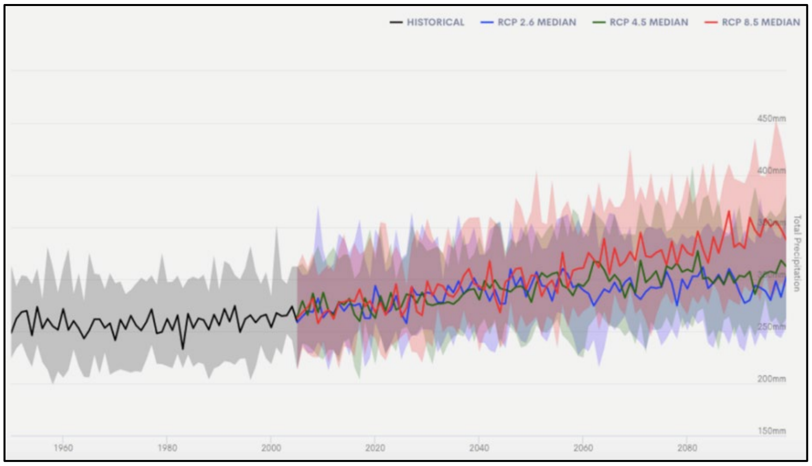

Figure 14. Mean annual total precipitation time series for Lake Providence, NWT, from 1950-2100. Modeled historical data are displayed for 1950-2005. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'total precipitation' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentiles.

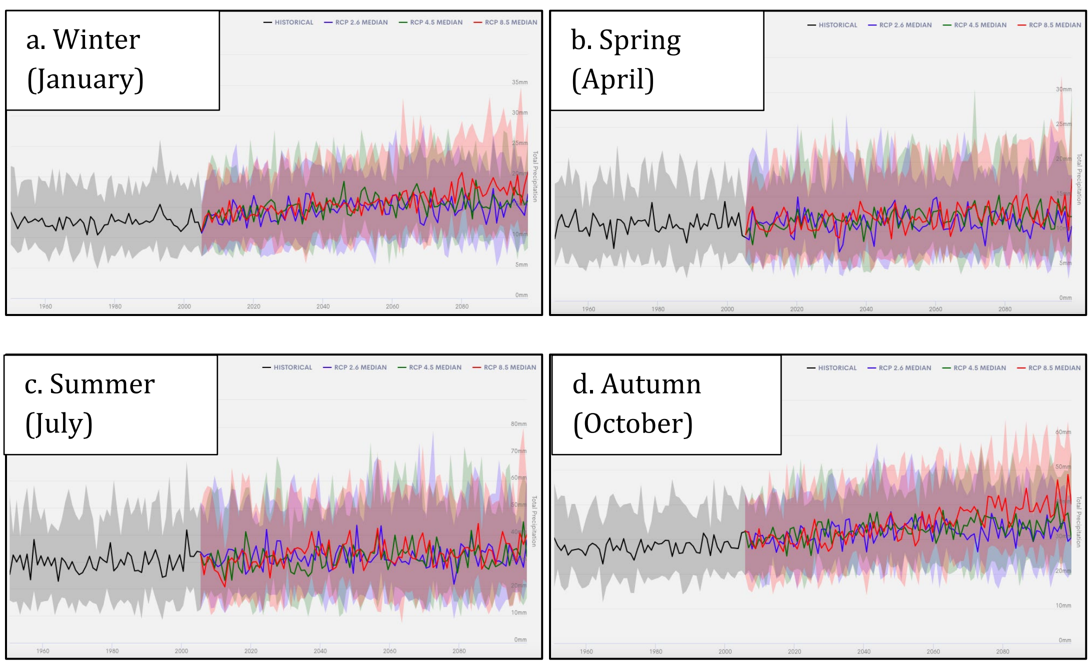

Figure 15. Mean seasonal total precipitation time series for Lake Providence, from 1950-2100. Modeled historical data are displayed for 1950-2005 for (a) winter, (b) spring, (c) summer and (d) autumn. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'total precipitation' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentiles.

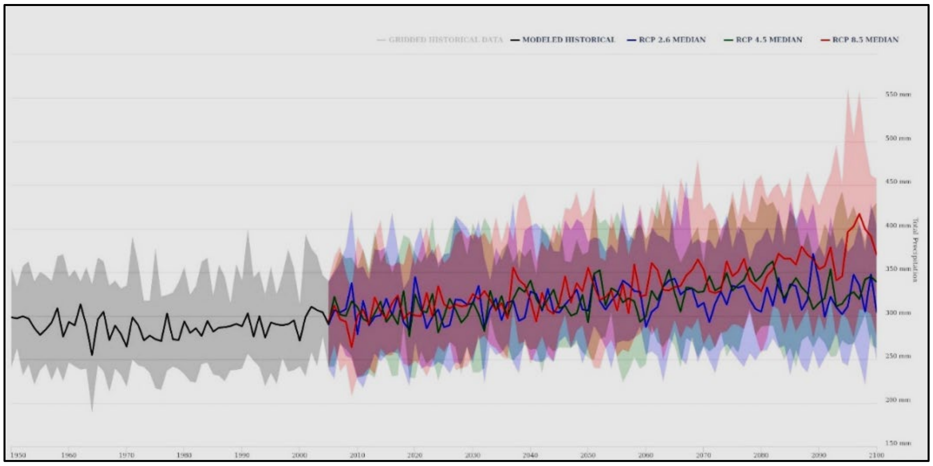

Figure 16. Mean annual total precipitation time series for Yellowknife, NWT, from 1950-2100. Modeled historical data are displayed for 1950-2005. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'total precipitation' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentiles.

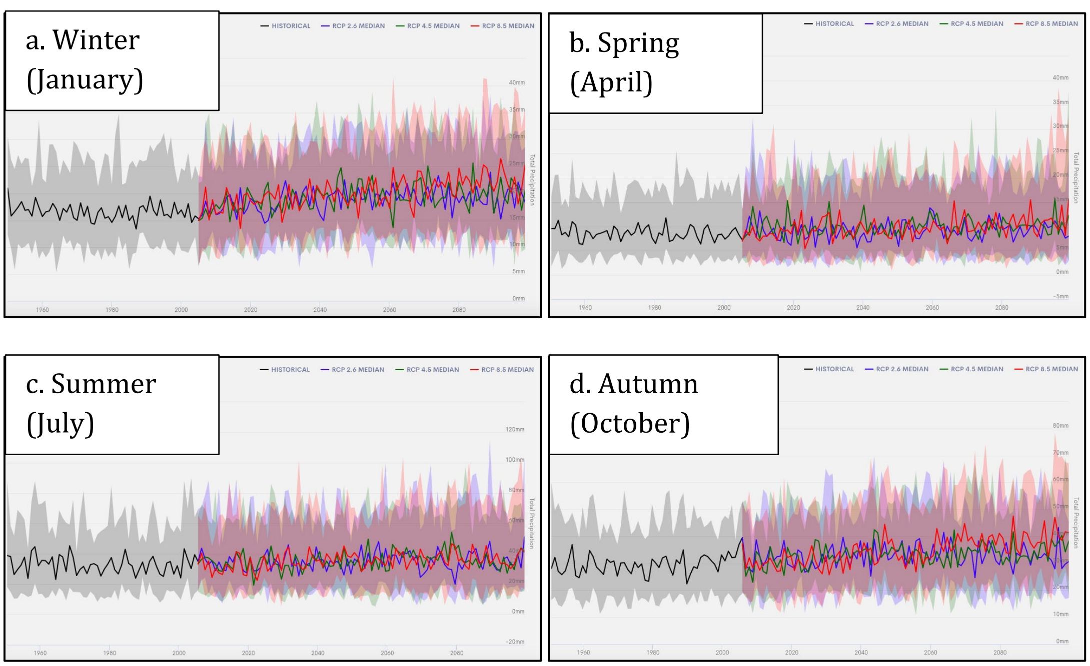

Figure 17. Mean seasonal total precipitation time series for Yellowknife, NWT, from 1950-2100. Modeled historical data are displayed for 1950-2005 for (a) winter, (b) spring, (c) summer and (d) autumn. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'total precipitation' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentiles.

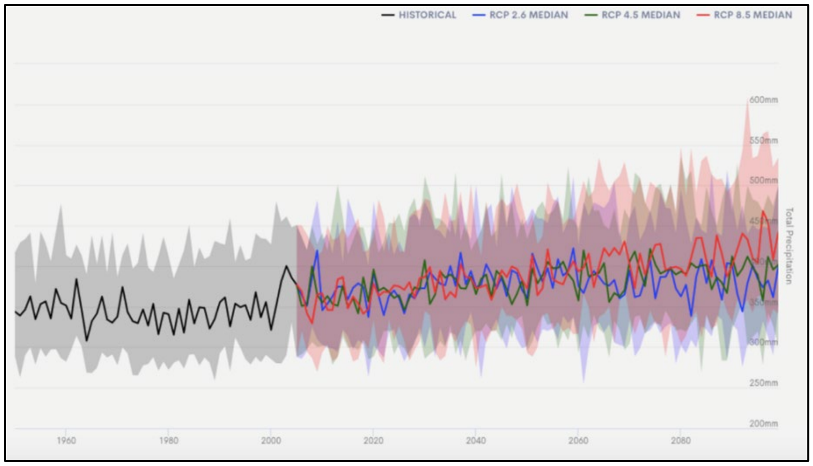

Figure 18. Mean annual total precipitation time series for Fort Smith, NWT, from 1950-2100. Modeled historical data are displayed for 1950-2005. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'total precipitation' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentiles.

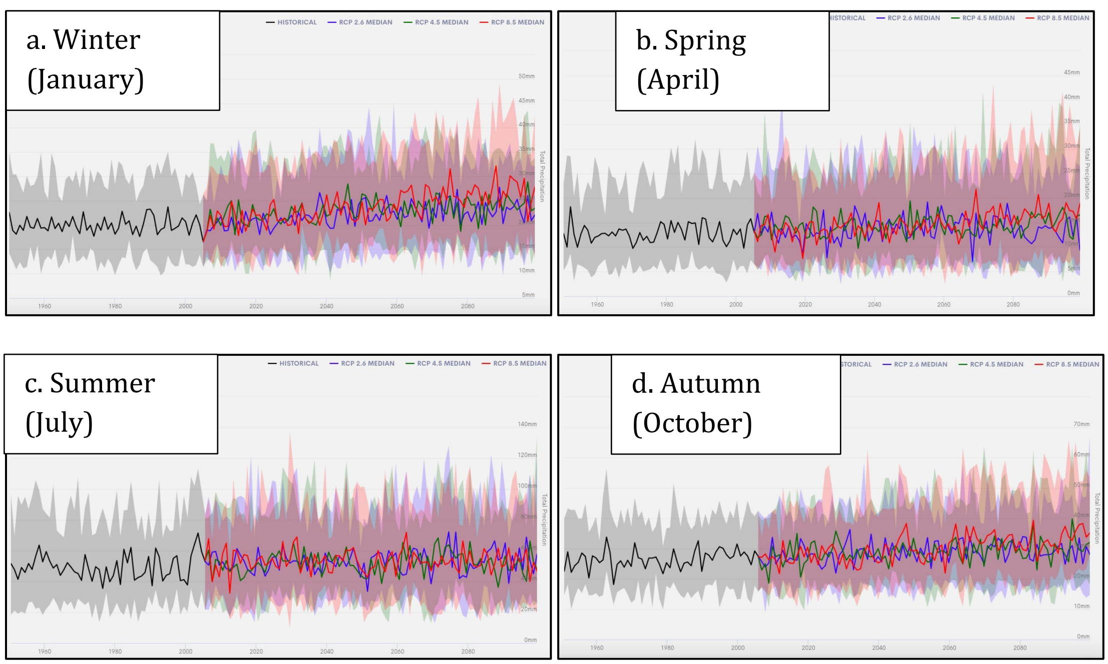

Figure 19. Mean seasonal total precipitation time series for Fort Smith, NWT, from 1950-2100. Modeled historical data is displayed for 1950-2005 for (a) winter, (b) spring, (c) summer and (d) autumn. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'total precipitation' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentile.

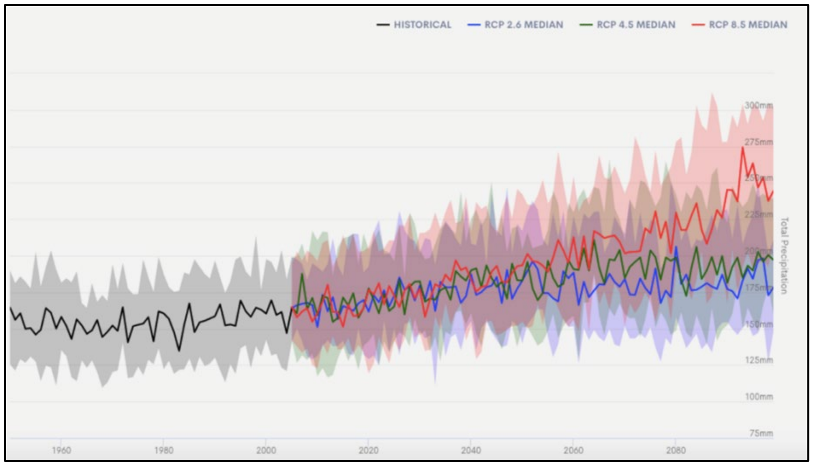

Figure 20. Mean annual total precipitation time series for Sachs Harbour, NWT, from 1950-2100. Modeled historical data are displayed for 1950-2005. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'total precipitation' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentiles.

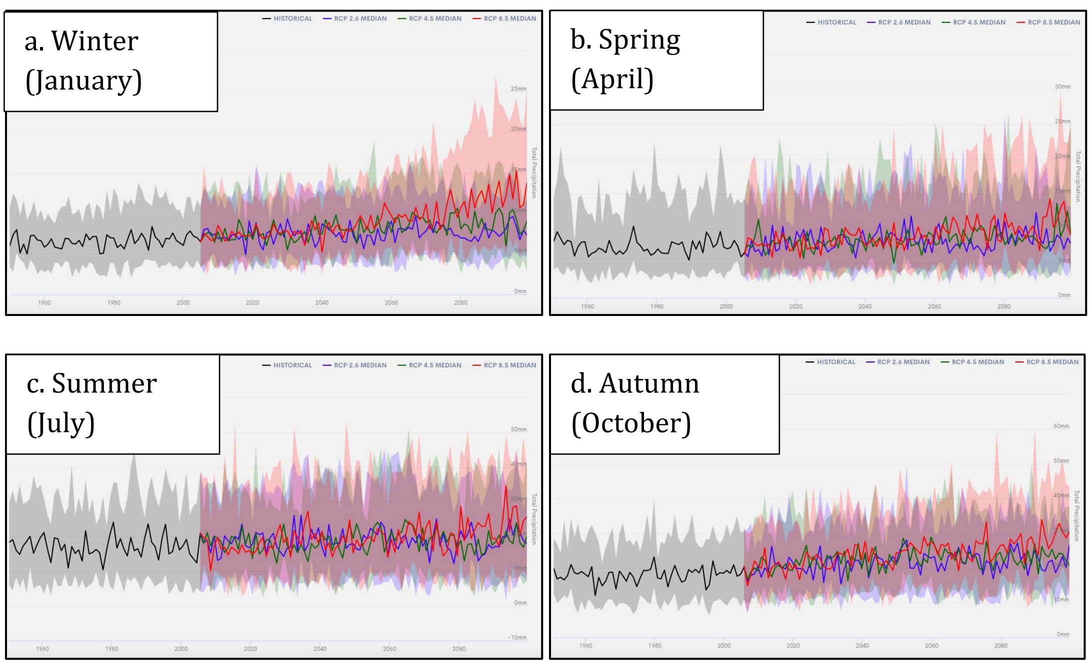

Figure 21. Mean seasonal total precipitation time series for Sachs Harbour, NWT, from 1950-2100. Modeled historical data are displayed for 1950-2005 for (a) winter, (b) spring, (c) summer and (d) autumn. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'total precipitation' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentiles.

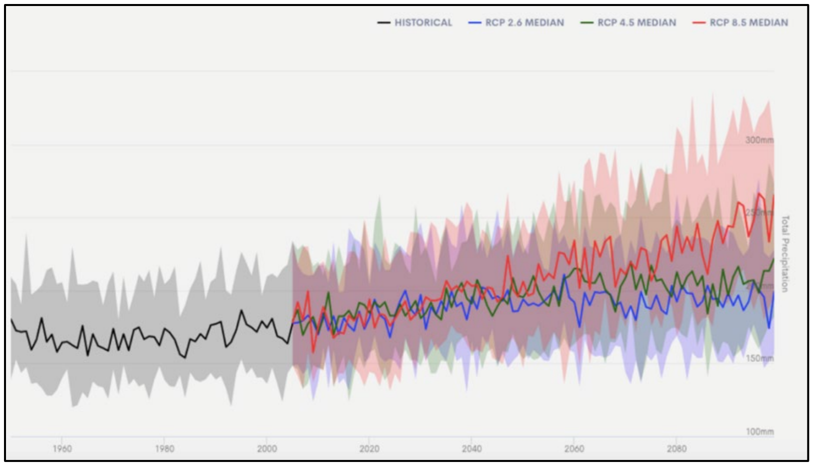

Figure 22. Mean annual total precipitation time series for Tuktoyaktuk, NWT, from 1950-2100. Modeled historical data are displayed for 1950-2005. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'total precipitation' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentiles.

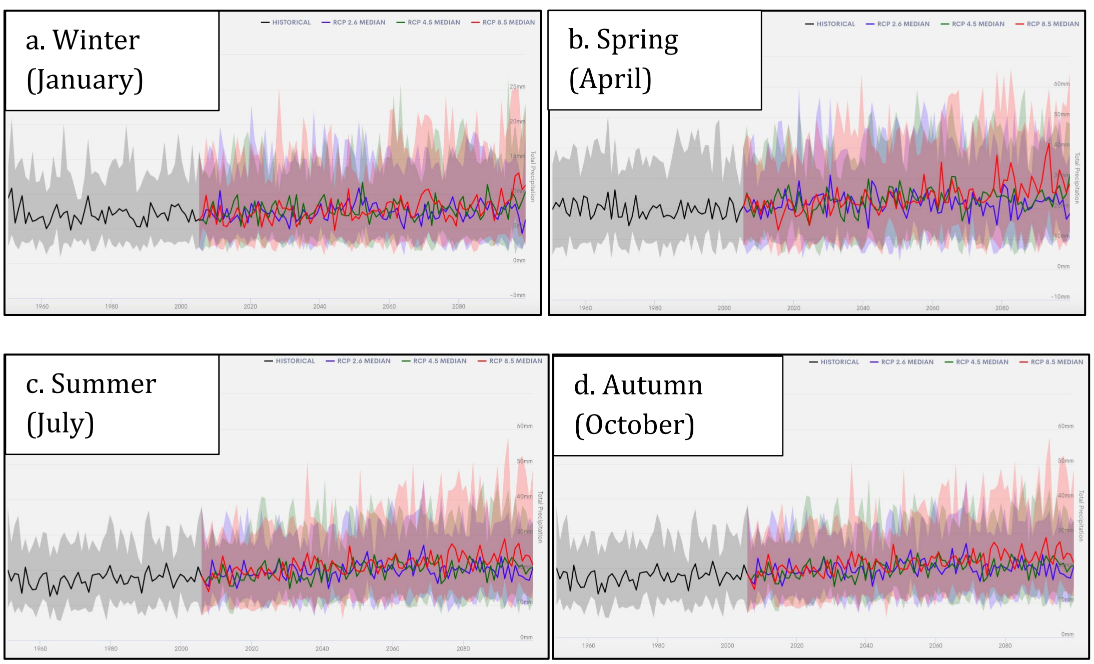

Figure 23. Mean seasonal total precipitation time series for Tuktoyaktuk, NWT, from 1950-2100. Modeled historical data are displayed for 1950-2005 for (a) winter, (b) spring, (c) summer and (d) autumn. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'total precipitation' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentile.

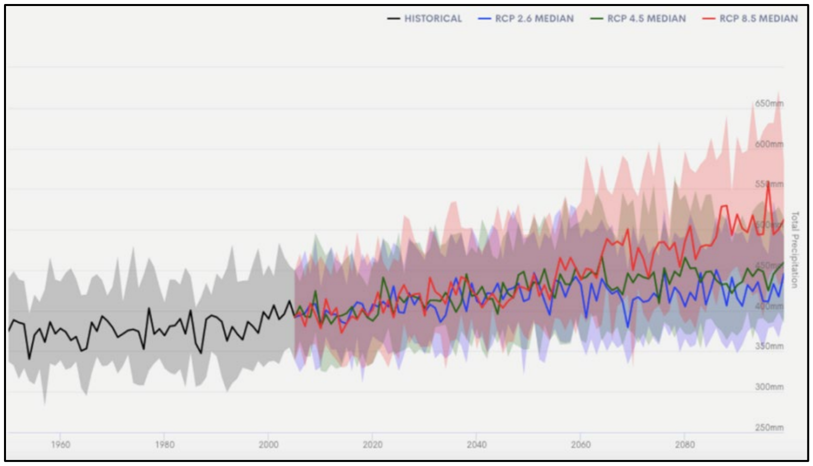

Figure 24. Mean annual total precipitation time series for Hay Creek, NWT, from 1950-2100. Modeled historical data are displayed for 1950-2005. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'total precipitation' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentiles.

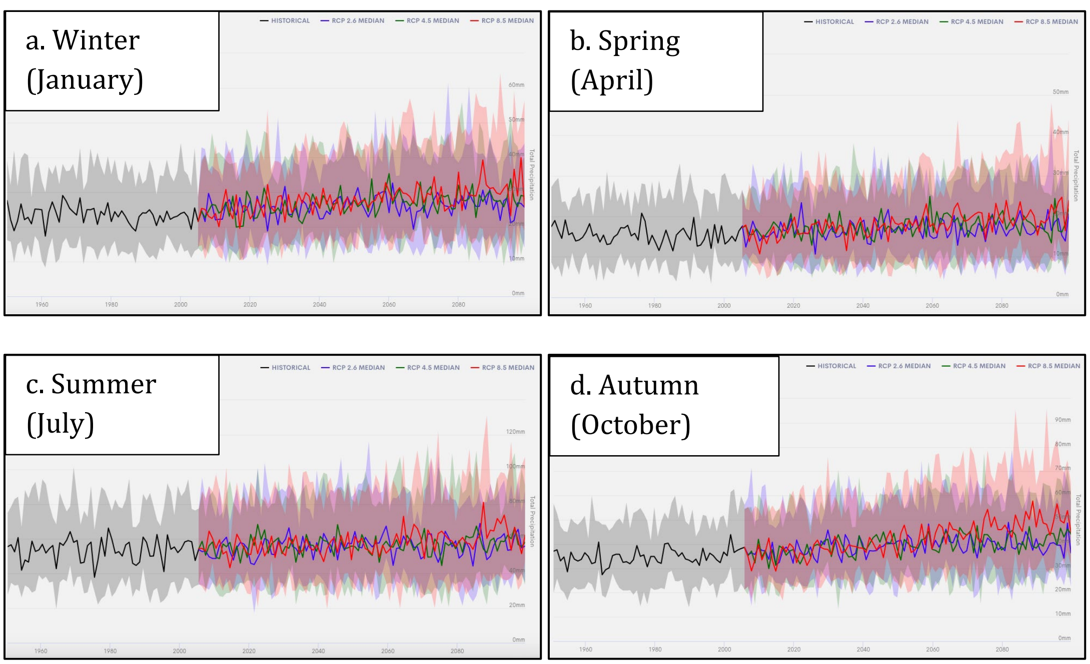

Figure 25. Mean seasonal total precipitation time series for Hay Creek, NWT, from 1950-2100. Modeled historical data are displayed for 1950-2005 for (a) winter, (b) spring, (c) summer and (d) autumn. Future projections are shown for low (blue), moderate (green) and high (red) emissions scenarios. BCCAQv2 variable datasets for 'total precipitation' from www.climatedata.ca were used. The bold line represents the 50th percentile (median) from an ensemble of 24 climate models and the shaded areas represent the 10th and 90th percentiles.

Sea Ice

Sea ice is perhaps the most iconic characteristic of the Arctic and has a large impact on local and global climates. This active platform is not a uniform sheet, but rather, consists of a mosaic of ice types (e.g. annual sea ice, multi-year sea ice) and physical processes (e.g. pressure ridges, leads, polynyas) that inform ecological processes (e.g. storm surges, erosion) and support terrestrial, marine and avian species. This area is undoubtedly highly vulnerable to the effects of climate change and, unlike many other ecosystems, has limited room and capacity to allow for a shift elsewhere. Decline is already occurring and is expected to continue through the 21st century, bringing with it important consequences for the species that rely on this unique, cold-weather habitat.

Declines in sea ice are being observed in all basins of the Canadian Arctic Ocean, although there is substantial variation by region. The most significant declines are being seen in the Beaufort Sea, Canadian Arctic Archipelago, Baffin Bay and Hudson Bay. Cumulative sea ice loss among these four regions is almost 500,000 km^2. From 1968-2016, areal declines in sea ice have occurred at a rate of 7% per decade. Over the same time period, overall sea ice declines of 3.1% and 9.6% in the northern and southern Northwest Passage routes were detected. When considering only multi-year ice, the declines in the Northwest Passage were documented at 6.7% and 10.0% for the northern and southern routes, respectively. The risk of an ice-free September (<5% sea ice cover) by 2050 is significant for the Beaufort Sea and Canadian Arctic Archipelago. The loss of sea ice will have important implications for arctic amplification and is likely to facilitate or exacerbate other threats (e.g. offshore oil and gas, marine shipping) (ECCC 2019a).

Sea Level

Sea level rise and increasing coastal sensitivity are projected in a large portion of the NWT's coastal areas by the end of the 21st century. This is particularly concerning in permafrost-rich shoreline areas, where changes in storm frequency, sea ice, wave action and water/air temperatures are expected to have particularly pronounced effects (ENR 2010b).

To date, global sea levels have risen at a mean rate of 1.7±0.2 mm per year between 1901-2010, although this rate has accelerated in more recent decades (i.e., between 1993 and 2010, the average rate of sea level rise was 3.2±0.4 mm/year). Sea level rise in the Beaufort Sea region has been progressing more rapidly than the global average as a result of glacial isostatic adjustment (GIA) (which results in land subsidence in some areas, like the Beaufort Sea area and uplift in other areas, like Hudson Bay) (Figure 26) (Atkinson et al. 2016).

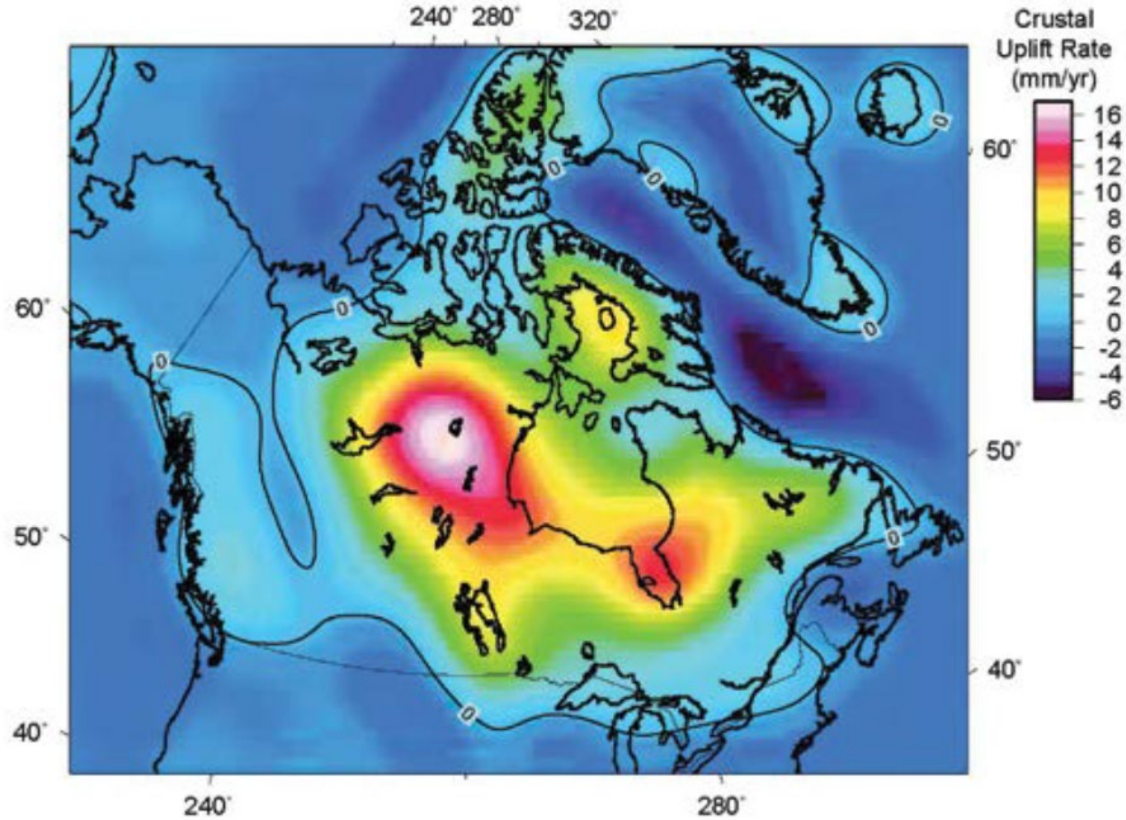

Figure 26. Vertical land motion (mm/year) generated by glacial isostatic adjustment, based on the ICE-5G-model (reproduced from Peltier 2004 *in* Atkinson et al. 2016).

Considering both global sea level rise projections and isostatic adjustment, as well as the potential effect on local sea level rise, the coastal NWT is expected to experience some degree of sea level change by the end of the century, although the range of projected change is quite large (from small declines in sea level to sea level rise up to one meter) (ENR 2015b) (Figure 27). Figure 28 shows projected changes in sea level between 2006 and 2099 under a high emissions scenario across coastal Canada.

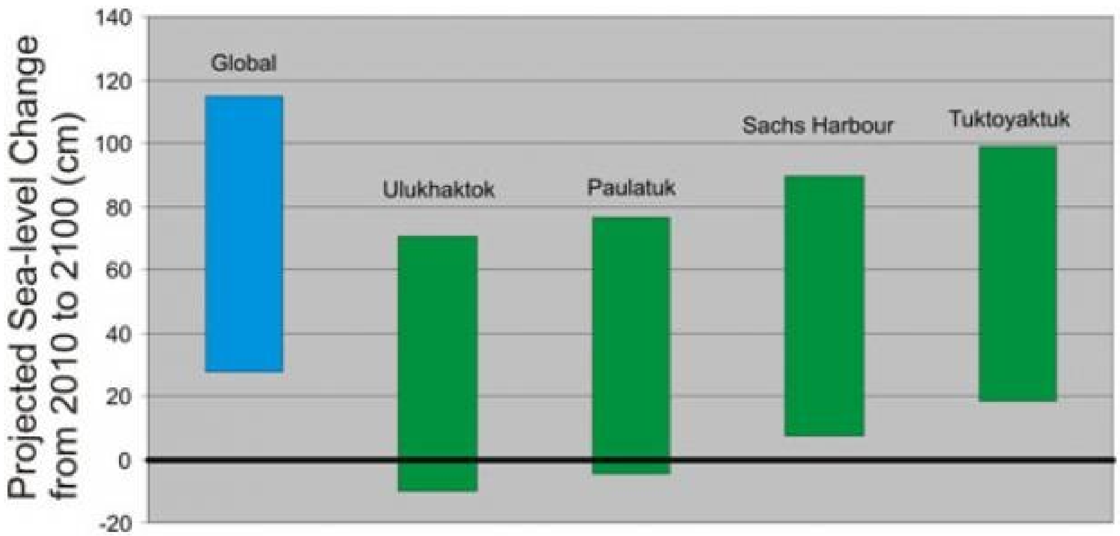

Figure 27. Mean sea level change projections for four coastal communities in the NWT, based on James et al. (2011), considering isostatic movement and the local effects of melting ice caps. Reproduced from ENR (2015b).

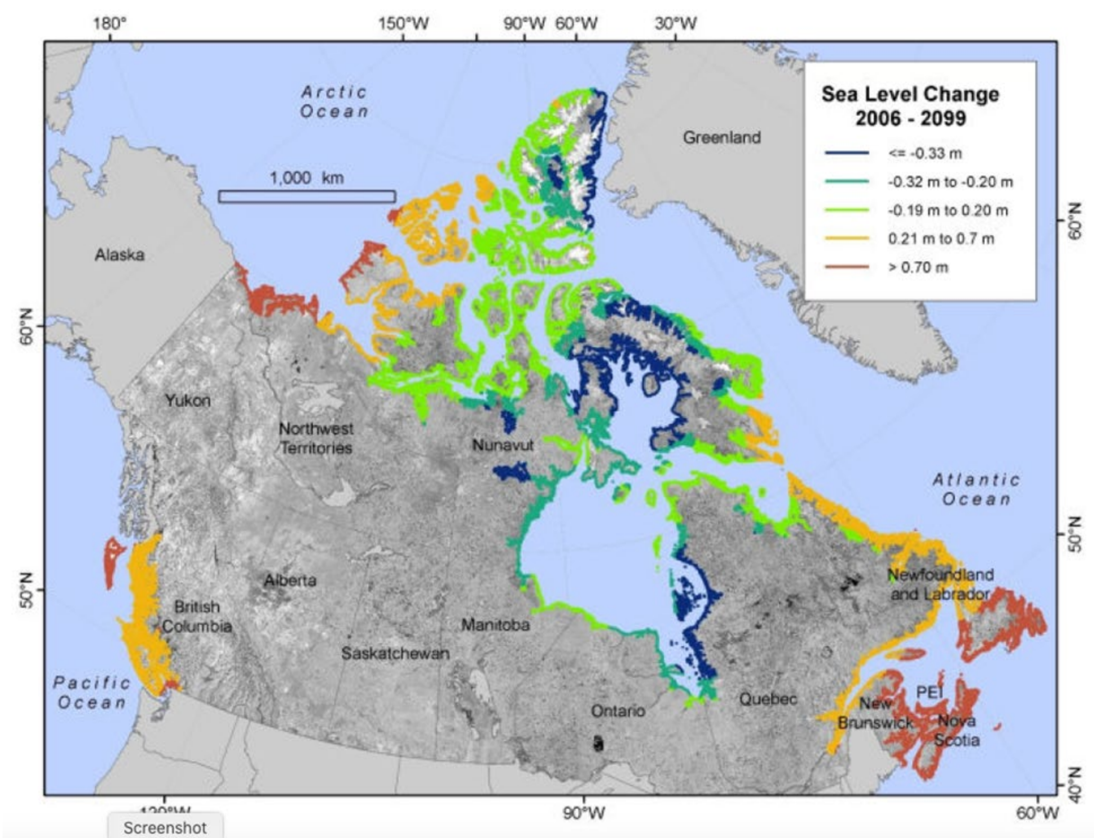

Figure 28. Change in sea level between 2006 and 2099 across Canada under a high emissions scenario (reproduced from Manson et al. 2019).

Freshwater Environments

Freshwater is one of the defining features of the NWT environment. With the Great Slave and Great Bear lakes, the Mackenzie River and delta (drainage for the largest water basin in Canada) and thousands of smaller lakes, rivers and wetlands (Bonsal et al. 2019), the importance of water in the NWT is impossible to overstate. The function and health of these systems is determined by interactions among many ecological components, including topography, sediments, precipitation, evaporation, permafrost and flora and fauna, both within the NWT and upstream.

Climate change is expected to have an important influence on the NWT's water bodies. Impacts may be felt through changes to temperature, precipitation, runoff, ice and snow cover, timing of seasonal flow events and permafrost (ENR 2010a). While projections show that substantial climatic and environmental changes are likely in the NWT over the course of this century, trends to date in freshwater availability, flow and peaks are still highly variable. With upstream water management, it is difficult to tease out the influence of climate change versus other anthropogenic water uses (e.g. extraction, diversion). Natural climate variability (e.g. El Niño, Pacific Decadal Oscillation and North Atlantic Oscillation) may also influence events such as droughts and flooding. Likewise, limited monitoring in many areas of the north impairs the ability to detect shifts over time (Bonsal et al. 2019).

Broadly, surface water availability is projected to decline in many areas, including the north, reflecting projected increases in temperature and evaporation. However, this may be offset to a greater or lesser extent by projected increases in precipitation. The NWT though, relies primarily on snow and ice melt for freshwater and is therefore expected to be particularly strongly affected, relative to areas that rely primarily, or more so, on precipitation for freshwater (Bonsal et al. 2019). Surface water availability is also affected by permafrost. Permafrost thaw is already being observed in the NWT and is expected to continue as temperatures warm (see *Permafrost*, pg. 30). As permafrost melts, some areas may see increasing surface water (most likely in zones of continuous permafrost; i.e., the creation of small waterbodies as a result of permafrost melt), while others may see drainage of surface water (ENR n.d.; Smith 2011; Bonsal et al. 2019). This type of drainage was evident in the Mackenzie delta area of the NWT between 1950-2000, but the rate of loss has since slowed (Bonsal et al. 2019).

Annual flows are projected to increase across much of the north. Increasing annual flows have been documented in the Mackenzie River over approximately the last 30 years, but otherwise, no significant trends have been observed in other areas surveyed in the NWT (Liard River and Peel River). Spring peak flow timing has shifted in Canada, in association with warming. In the Mackenzie Basin as a whole, freshet has advanced by approximately 2.7 days/decade over the last 25 years. Although trends in the NWT are not considered significant at this time, high emission scenario projections suggest earlier spring snowmelt and freshet by the late 21st century. Annual low flows, on the other hand, have shifted later in the NWT already. Data suggests variability in ice jam frequency in the NWT, but these events are expected to decline in frequency in the Peace-Athabasca delta, a possibility relevant to downstream Slave River in the NWT (Bonsal et al. 2019).

Length of the Growing Season

The growing season begins on the date the mean temperature is above 5°C for over five consecutive days and ends when mean temperatures are below 5°C for over five consecutive days. Growing and cumulative degree days are the values typically used in projections of growing season. Degree days should be interpreted as a measure of heat accumulation rather than days in the typical sense. Growing degree days are estimated based on the number of days where average temperatures exceed a threshold considered appropriate for plant growth (5°C is used as the threshold in this report). Cumulative degree days are the sum of days with an average temperature over 0°. Both measures may provide a basis for understanding potential changes in such linked factors as primary productivity, phenology and habitat suitability (for both native species and alien/exotic species) (e.g. Cayton et al. 2015). Overall, projected changes in growing and cumulative degree days suggest a positive trend for all locations in both the 2050s and 2080s and all emissions scenarios (Table 5). Increases in degree days are, in fact, already being observed in the NWT, with shifts between 11-67° days observable across the NWT between 1961-1990 and 1981-2010 (Huberman et al. 2020).

Table 5. Projected number of growing degree days (5°C) and cumulative degree days above 0°C for the 2050s (2041-2070 average) and 2080s (2071-2100 average) under low, moderate and high emissions scenarios for selected locations in the NWT, rounded to the nearest degree day. The historical baseline is the average from 1981-2005. BCCAQv2 variable datasets for 'growing degree days (5°C)' and 'cumulative degree days above 0°C' from www.climatedata.ca were used.

	Growing degree days[11] (5°C)							Cumulative degree days >0°C						
		2050s (2041-2070)			2080s (2071-2100)				2050s (2041-2070)			2080s (2071-2100)		
	1981-2005	**Low**	**Mod.**	**High**	**Low**	**Mod.**	**High**	**1981-2005**	**Low**	**Mod.**	**High**	**Low**	**Mod.**	**High**
NWT	585	733	796	901	739	858	1175	1151	1357	1443	1576	1364	1532	1944
Sachs Harbour	150	234	252	304	219	270	466	490	659	715	777	638	723	1063
Tuktoyaktuk	458	609	662	710	597	710	1015	981	1188	1300	1368	1190	1336	1743
Lake Providence	578	703	770	879	703	852	1160	1143	1331	1423	1576	1355	1531	1957
Hay Creek	682	866	927	1069	875	1036	1398	1331	1569	1647	1818	1568	1773	2205
Yellowknife	1023	1231	1298	1461	1237	1408	1853	1765	2031	2129	2319	2042	2261	2820
Fort Smith	1227	1457	1547	1709	1455	1659	2127	2068	2350	2468	2637	2343	2591	3149

[11] Note that this is a measure of heat accumulation, not actual days.

Forests

Climate change has the potential to impact forests in the NWT in a number of ways, through changes to temperature, moisture availability and permafrost. Impacts may be seen in forest growth, productivity and composition.

Increases in average summer temperature and soil moisture affect tree growth and, ultimately, the treeline. Limited increases in productivity may be expected. Conversely, declines in moisture availability; that is, increases in drought conditions, may affect survival in some species, although most tree species are expected to have sufficient adaptive capacity to shift their distribution as necessary over time. Permafrost thaw, degradation and contraction may influence forest composition with shifts from spruce/lichen-dominated forests to sedge-moss communities possible, depending on how permafrost thaw occurs and the impact on hydrology (Huberman et al. 2020).

Forest fires are a characteristic and important source of disturbance in the boreal forest, helping to renew forest stands, create habitat and control diseases and pests (NRCan 2020b). The forest fire disturbance regime in the boreal forest, the time to regeneration for important forage species like lichens and the mosaic these disturbances create on the landscape, demand consideration of the impact of fire on forested habitats over many decades.

In the NWT, an average of 600,000 hectares (ha) is burned by forest fires each year, although this can vary substantially year-to-year. Most of these fires are started by lightning (ENR 2015a). An increase in area burned and fire season length is typically projected for the NWT by climate models, consistent with increasing temperatures and evaporation/evapotranspiration and decreasing moisture availability (Flannigan et al. 2008, ENR 2010b, NRCan 2020a). Projections completed for boreal caribou habitat in the southern NWT suggest that moisture availability is a key determinant for future fire conditions. Warmer and drier climate conditions may result in increases in the number and size of wildfires in this region by the end of the century, while warmer and wetter conditions suggest little change in the average or maximum number and size of wildfires (Figures 29 and 30) (Blyth et al. 2016). Change to the fire regime in the NWT also has the potential to influence forest composition (Huberman et al. 2020).

(a) (b)

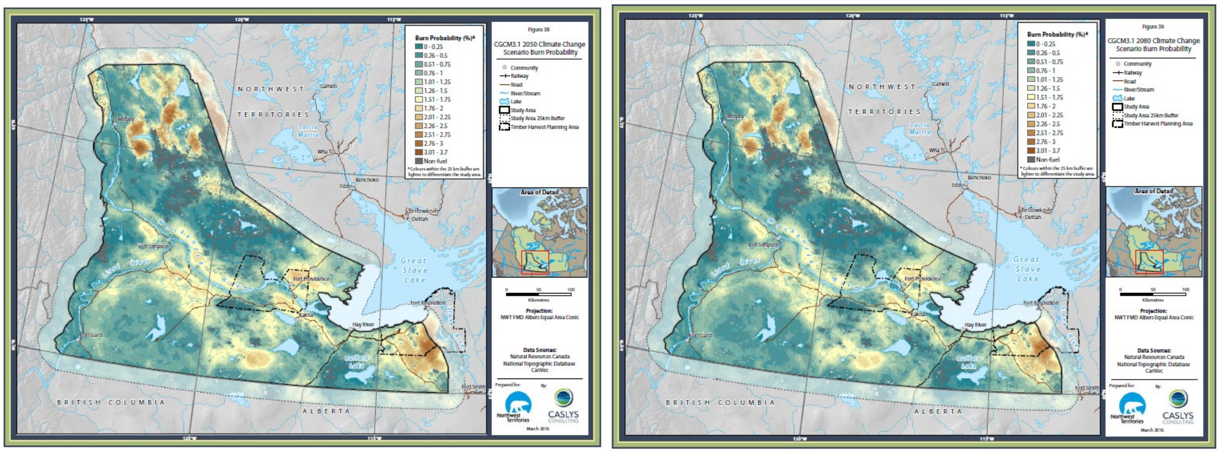

Figure 29. Burn probability as assessed under a warmer and wetter climate scenario at (a) mid- and (b) late-century. Reproduced from Blyth et al. (2016).

(a) (b)

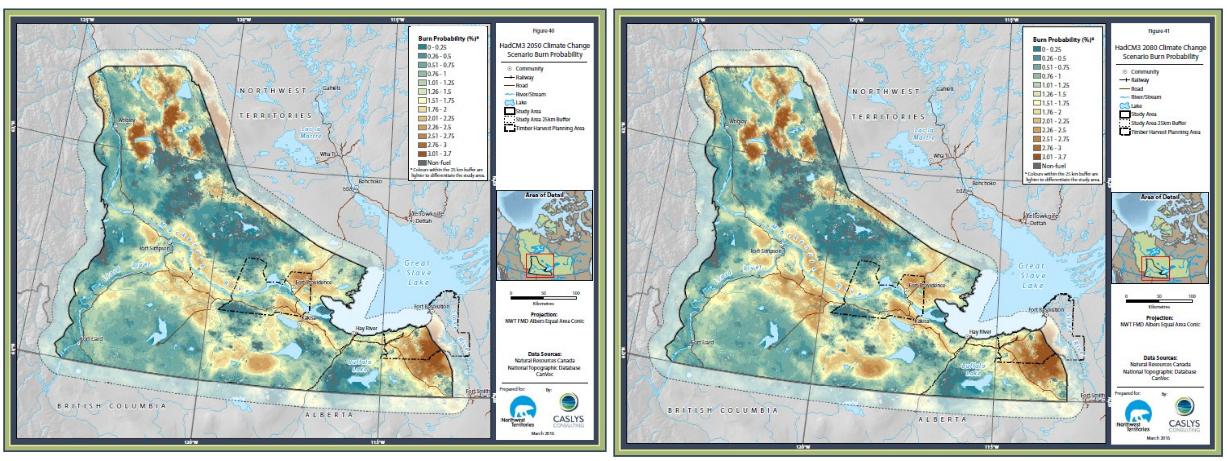

Figure 30. Burn probability as assessed under a warmer and drier climate scenario at (a) mid- and (b) late-century. Reproduced from Blyth et al. (2016).

Permafrost

Permafrost is ground (including soil, rock and/or organic material) that has remained at or under 0°C for at least two consecutive years (Smith 2011). It influences the hydrology and landscape of the NWT, as well as other northern environments. As shown in Figure 31, which displays the distribution of permafrost across Canada, the NWT landscape is underlain by various permafrost zones:

- Continuous: permafrost that underlies 90-100% of the landscape.
- Discontinuous: permafrost that underlies 50-90% of the landscape.
- Sporadic: permafrost that underlies 0-50% of the landscape.

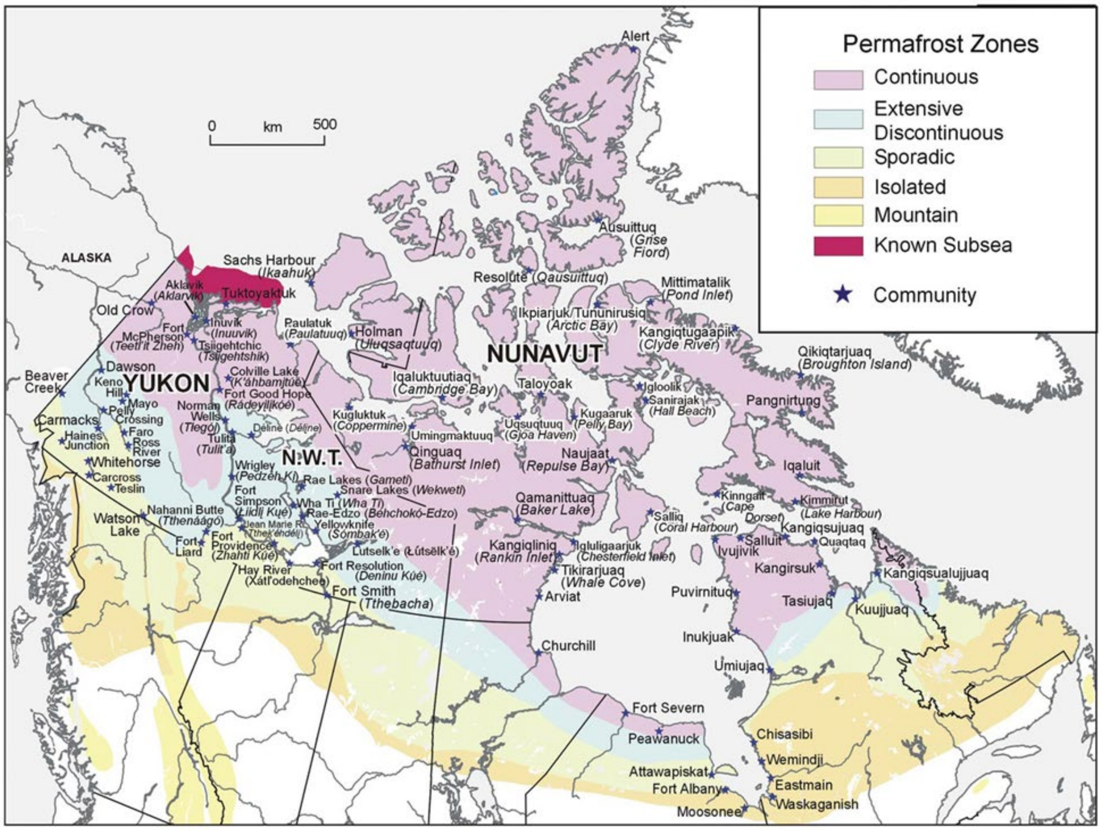

Figure 31. Spatial distribution of permafrost zones across Canada (reproduced from Lemmon et al. 2008).

The active layer is the layer of ground on top of permafrost that is subject to seasonal thawing during warmer months. If this layer begins to penetrate more deeply or remains thawed for longer periods of time (e.g. if the summer season lengthens), the permafrost layer underneath may thin (NRCan 2019). Thawing permafrost is an important concern in the NWT. The loss of permafrost can affect drainage, leaching, ground water flow and carbon storage, influence expansion or drainage of lakes and/or wetlands, cause deposition of sediments into lakes and streams and cause changes to vegetation (Smith 2011). However, landscape changes will likely be contingent on how permafrost responds to climate change, as well as implications to associated hydrological processes (Huberman et al. 2020).

Permafrost deterioration and loss is already being observed in the NWT and research suggests that this trend will continue (ENR 2010b). Permafrost in the discontinuous zone is considered particularly vulnerable to temperature changes (Huberman et al. 2020). Permafrost temperatures have increased at sampling sites across the north, including around Yellowknife (Wolfe and Kokelj 2019), the central/northern Mackenzie valley (+0.2°C -0.9°C since 2000 (Derksen et al. 2019); or +0.3°C -0.6°C/decade since the 1980s), the Tuktoyaktuk Peninsula (+0.02°C -0.06°C/year at 28 m between 1990-2002), some tundra areas of the Mackenzie delta (+1°C -2°C near surface between early 1970s-2007, or +0.1°C -0.2°C/decade), Herschel Island (Yukon (YT); +1.9°C at 20 m over the last century), the Macmillan Pass area (+0.1°C/year near surface between 1991-2000) and Norman Wells (+0.3°C/decade) (summarized from Smith 2011, unless otherwise noted). Declines in frozen peat areas have also been documented in the Macmillan Pass area (>1%/year) and southern Mackenzie valley (10-50%) (Smith 2011). Further temperature increases and increasing active layer depth are projected for the future and the permafrost line is projected to contract northwards (Walsh et al. 2005, Zhang et al. 2008).

Non-native Species, Pests and Pathogens

The NWT has, until recently, been thought of as somewhat safe from new species moving into the territory, reflective of its cold climate and relatively little human disturbance. However, as climate change progresses and especially if it occurs alongside increases in development (i.e., roads, traffic, etc.), the number, diversity and impact of non-native species can be expected to increase in the future. Although not all these species will cause harm, some of these species, often called ‘invasive species’, can threaten the environment, economy, or society.

Based on current monitoring, about 3.% of NWT species are considered non-native, including approximately 140 plant species (Figure 32) and over 60 insect species (Working Group on General Status of NWT Species 2021-2025, Oldham and Delisle-Oldham 2017). To date, only a few vascular plants are considered to have a medium or high level of impact in the NWT (e.g. white sweet-clover (*Melilotus alba*)). All invasice species found in the NWT so far are terrestrial species (primarily vascular plants, but also insects and some birds). Many potentially invasive plants (mostly vascular plants) and insects (mostly beetles, but also butterflies/moths, true bugs, sawflies and wood wasps) have also been identified as a potential risk to the NWT, including a number of forest pests (Snyder and Anions 2008). Movement of some forest pests northwards, including spruce budworm and mountain pine beetle, is a possibility and outbreaks of forest pests in the NWT may become more frequent. However, tree mortality following spruce budworm infestation tends to be low and NWT forests are not expected to be strongly susceptible to mountain pine beetle outbreaks (Huberman et al. 2020). No aquatic invasive species have been reported in the NWT to date, but concern has been expressed by residents regarding the potential for introduction via contaminated recreational equipment (e.g. boats, trailers, fly-fishing equipment). In terms of mammals, the introduction of wild pigs or chronic wasting disease are commonly cited concerns in the NWT, given their potential for devastating ecological consequences. The potential for some vector-borne diseases[12], such as West Nile virus and Lyme disease, to extend their ranges into the NWT, is also highly concerning. Beyond the influence

[12] Human illnesses carried by animal hosts/arthropod vectors (CCH 2019).

climate change may have on host/vector distribution, abiotic factors such as increasing temperatures may enhance survival of certain pests and pathogens (e.g. winter temperatures directly influence tick survival). However, the interactions between hosts, vectors and pests/pathogens and the impact climate change may have on those interactions, has not been well-studied in the north (CCH 2019).

Introduction of non-native species to the NWT has been largely unintentional to date; transportation to the NWT is most likely via plants/propagules (e.g. birch leafminer (*Profenusa thomsoni*)), vehicles, transportation corridors and ships/barges/boats. Remediation activities also represent a potentially important pathway into the NWT (Snyder and Anions 2008).

The GNWT recently led the development of a NWT Council on Invasive Species, Pests, and Pathogens to help coordinate and support efforts to prevent, manage and control invasive species in the NWT. The hope is that the Council will be able to help move forward work on key research and monitoring requirements articulated in the *NWT Agriculture Strategy* and the *2030 Climate Change Framework* and associated Action Plan. This work could include conducting risk assessments, engaging in targeted interventions for high-risk/high-impact species, encouraging and facilitating reporting of species and assisting with identification. However, the ability for the Council to engage in these actions is dependent on its ability to secure adequate funding.

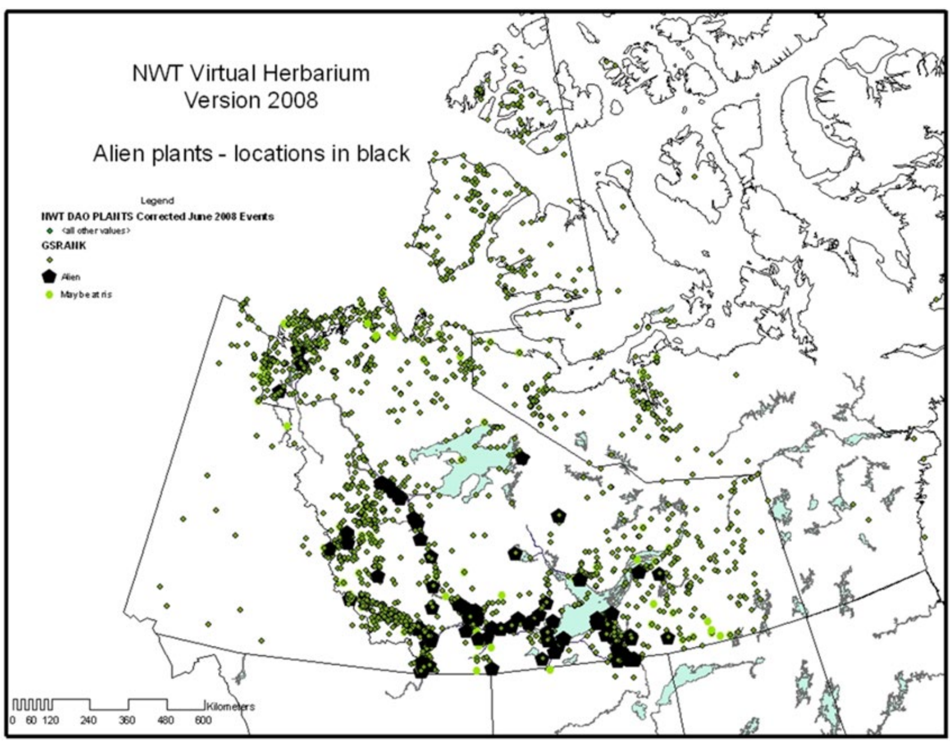

Figure 32. NWT Virtual Herbarium, 2008, scope and reach of non-native plants in the NWT (ENR 2008).

Projected Ecological Shifts

Projections indicate that the average climatic conditions associated with ecological communities (cliomes) are, in general, likely to shift and in some cases contract, northwards in response to climate change. These projected shifts are primarily representative of expected changes in temperature and precipitation variables characteristic of a region. Notwithstanding the complexities of ecological community response to changes in climatic variables, in the interim, those areas experiencing the greatest climatic shifts are likely to see increasing levels of stress to species, which may affect their health and survivorship.

The Scenarios Network for Arctic Planning (SNAP) completed an assessment of projected cliome shifts in Alaska, YT and the NWT in 2012. Three different emissions scenarios (B2 (optimistic), A1B (midrange) and A2 (pessimistic)) were used, drawn from the fourth report of the Intergovernmental Panel on Climate Change (IPCC). At the time of publication (2012), the A2 (pessimistic) scenario was considered most likely. These emissions scenarios are now somewhat out of date (Seiben pers. comm. 2019), but the results of the report are still useful for envisioning future climatic possibilities in the NWT. Figure 33 shows baseline (1961-1990) cliomes selected for use in the assessment. Figures 34 and 35 show projected cliome shifts and projected regional change and resilience, respectively, under the three emissions scenarios noted above (SNAP 2012).

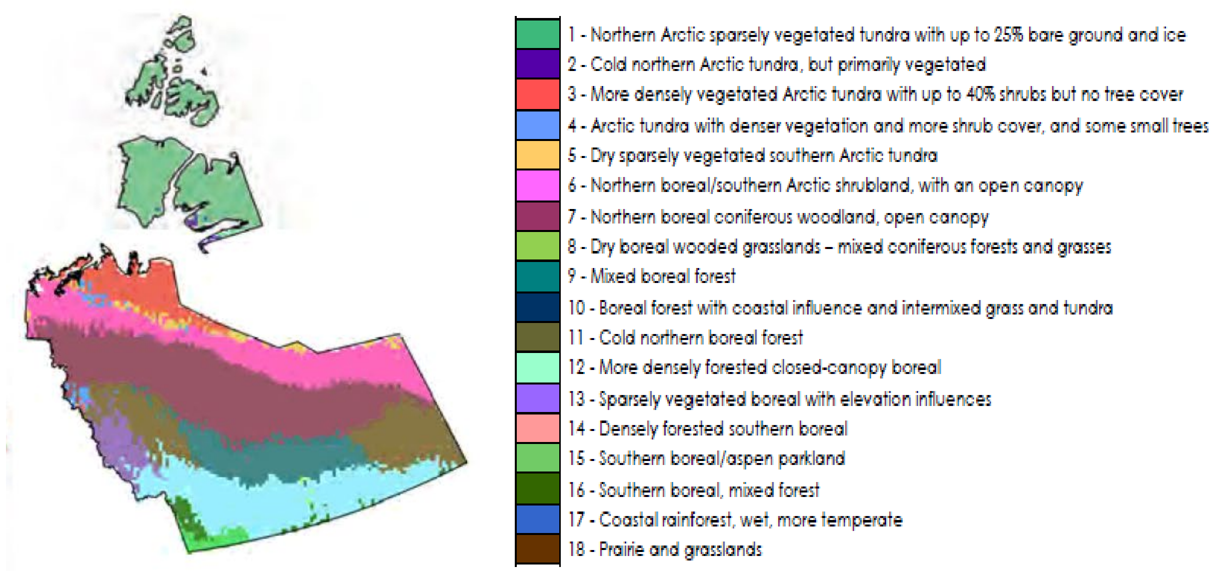

Figure 33. Modeled cliomes for the historical baseline years, 1961-1990. The NWT is shown at 18.4 km resolution. Note that not all 18 cliomes appear in the study area. Modified from SNAP (2012).

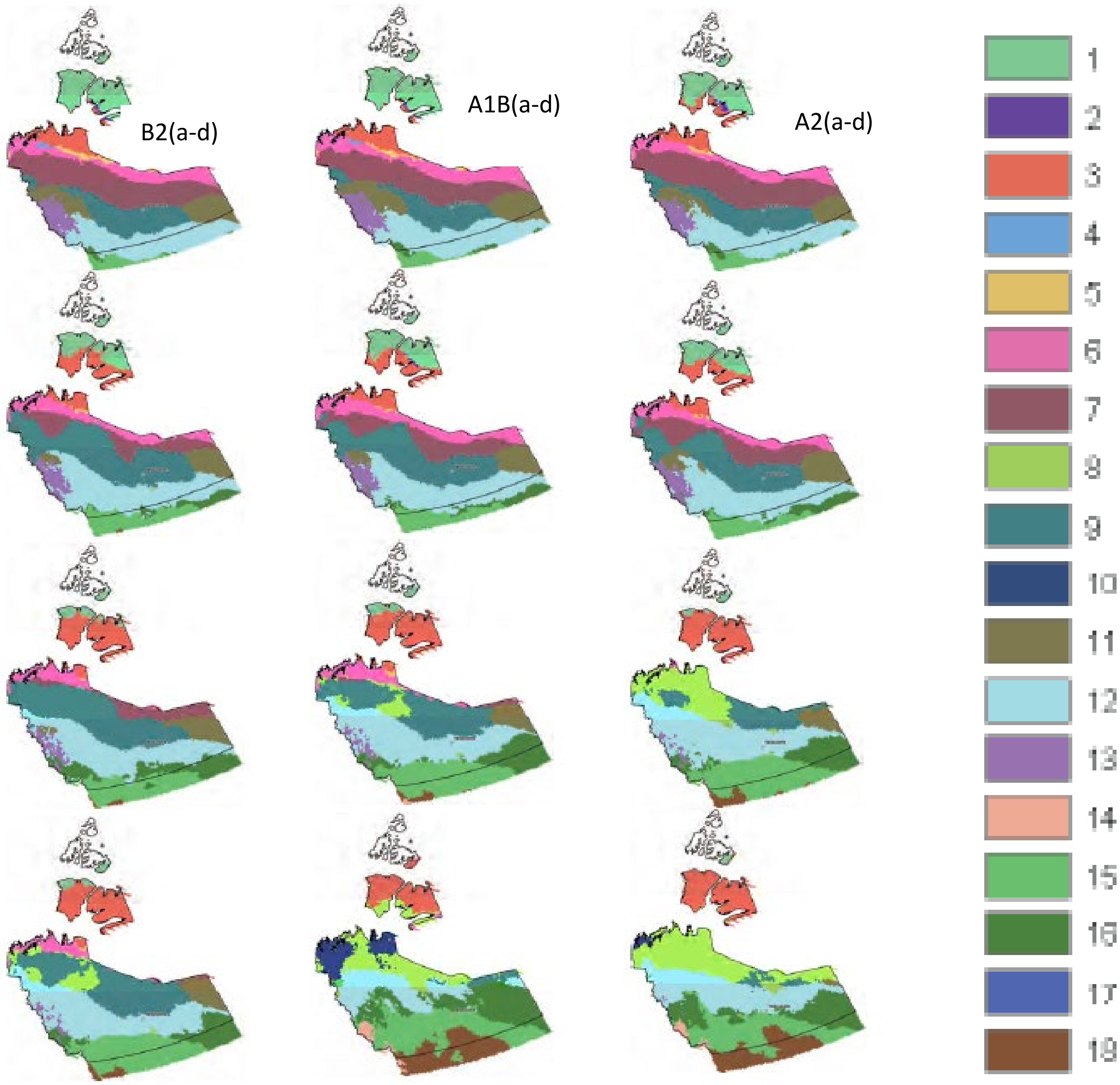

Figure 34. Projected cliomes for the B2 (optimistic), A1B (mid-range) and A2 (pessimistic) emissions scenarios, for the 2000s, 2030s, 2060s and 2090s (a-d, read from top to bottom in columns). NWT projections reproduced from SNAP (2012). See Figure 33 for more detailed legend.

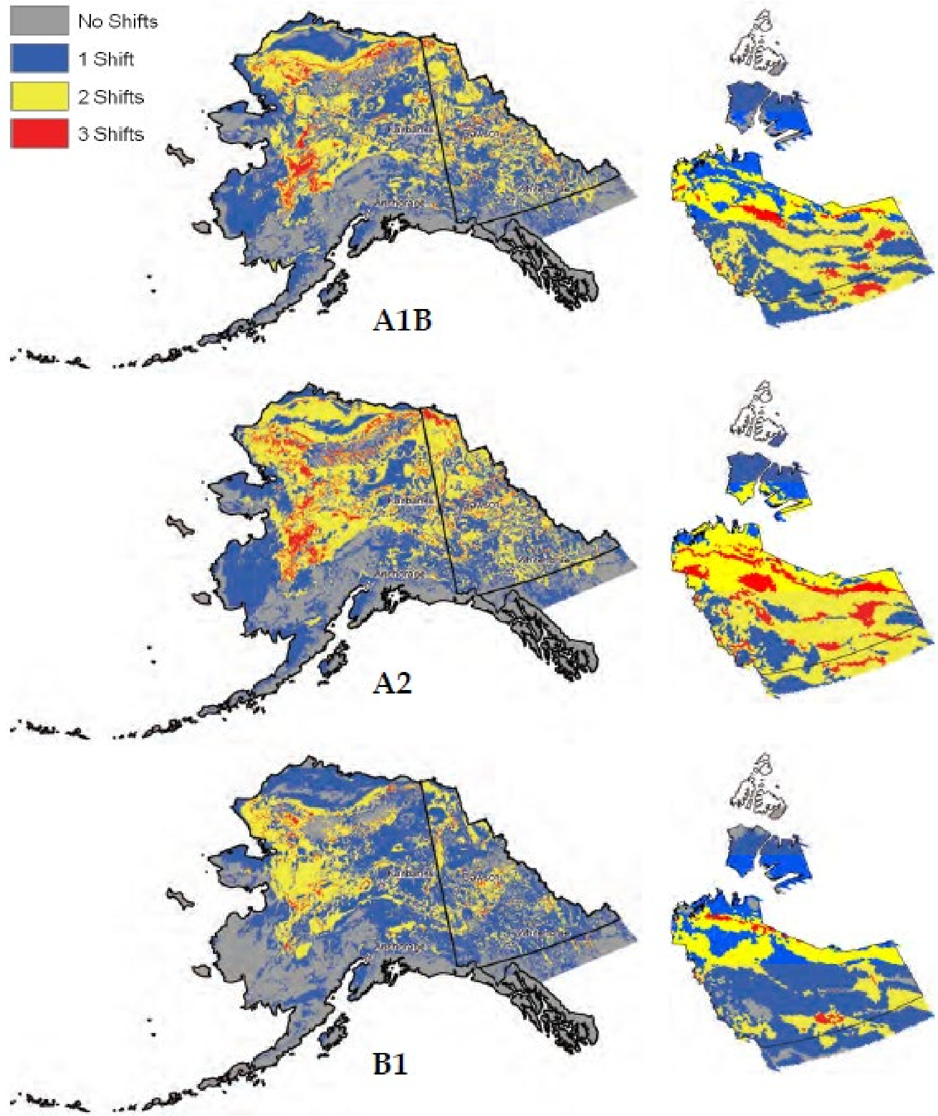

Figure 35. Projected change and resilience under three emission scenarios in Alaska, YT and the NWT. These maps depict the total number of times models predict a shift in cliomes between the 2000s and the 2030s, the 2030s and the 2060s and the 2060s and the 2090s. Note that the number of shifts does not necessarily predict the overall magnitude of the projected change. Reproduced from SNAP (2012).

From the perspective of the NWT, it is notable that, relative to other areas considered within the scope of the SNAP (2012) assessment, central (particularly the central NWT) regions are expected to be the most vulnerable to these shifts (Figure 35). Overall, the results suggested that no areas of the NWT will retain their current cliomes, with northward contraction of existing cliomes, as well as the disappearance of several northern cliomes. Cliome 18 (prairie and grasslands), which can currently be found in the southernmost areas of the prairie provinces, is projected to extend into the southern NWT by the end of the century. Similarly, large shifts are expected in cliomes 8 (dry boreal wooded grasslands – mixed coniferous forests and grasses), 10 (boreal forest with coastal influence and intermixed grass and tundra) and 15 (southern boreal/aspen parkland). Cliome 3 (more densely vegetated Arctic tundra with up to 40% shrubs but no tree cover) may shift to the Arctic islands. Large contractions in cliomes 7 (northern boreal coniferous woodland, open canopy) and 9 (mixed boreal forest) are also projected. Cliomes 1 (northern Arctic sparsely vegetated tundra with up to 25% bare ground and ice, with an extremely short growing season), 6 (northern boreal/southern arctic shrubland, with an open canopy) and 7 (northern boreal coniferous woodland, open canopy) may disappear entirely. Although the magnitude of change varies among emissions scenarios, Figure 35 shows the general trend of northward shift holds true even in the lowest emission scenario (SNAP 2012).

Climate analogues may also be used to help visualize the meaning and potential implications of shifts in climate. These analogues take the projections for a specific location (typically a community), time period and emissions scenario and find an analogue (comparable) location (also typically a community). This can provide a more tangible picture of what future conditions may look like, although the same caveats as previously noted (i.e., complex interactions between the climate and ecological communities that are likely to result in non-linear and often unpredictable responses) apply to the use of analogues as well. No analogues have yet been developed for northern Canada, but the below describe familiar North American analogues for illustration (Fitzpatrick and Dunn 2019). These analogues were all developed using a high emissions scenario and are projected to the year 2080.

- Anchorage, Alaska → Powell River, BC. Powell River's summer is, on average, 5.4°C warmer and 5.4% wetter than that seen in Anchorage.
- Calgary, AB → Spearfish, North Dakota. Spearfish's winter is, on average, 4.6°C warmer and 19% wetter than that seen in Calgary.
- Edmonton, AB → Mendota Heights, Minnesota. Mendota Height's summer is, on average, 5.5°C warmer and 28.7% wetter than that seen in Edmonton.
- Fairbanks, Alaska → Kenora, Ontario (ON). Kenora's summer is, on average, 3.2°C warmer and 78.5% wetter than that seen in Fairbanks.

Based on these projections and recognizing that uncertainties remain related to emissions, model assumptions and ecological response, we can be reasonably sure that change in climatic variables will occur (indeed, will continue to occur) in the NWT and that there will be implications to ecological communities in the NWT.

CLIMATE CHANGE VULNERABILITY ASSESSMENTS

Climate change vulnerability assessments (CCVAs) assess the overall vulnerability of ecological units (e.g. species, communities, ecosystems) to the effects of climate change. There is no one correct way to conduct a vulnerability assessment and approaches can range from coarse to detailed and qualitative to quantitative. CCVAs are often used to rank vulnerability, but they are also helpful in gaining a better understanding of the source(s) of vulnerability and, therefore, for developing and prioritizing adaptation strategies and appropriate monitoring and evaluation (Young et al. 2012, 2015; Stein et al. 2014, Gross et al. 2016).

Vulnerability is a measure of risk or potential harm and speaks to susceptibility to the effects of climate change and the ability to respond (adapt) to, or cope with, these changes. Vulnerability is typically defined by exposure, sensitivity and adaptive capacity (Bagne et al. 2011, Stein et al. 2014, Foden and Young 2016, Price and Daust 2016, Gross et al. 2016).

Exposure refers to what the system is likely to experience in terms of climate change, including where, when and how severe the impacts of climate change will be on the ecological component being assessed. It typically includes consideration of changes to the physical environment, such as temperature, precipitation, moisture availability and habitat quality or availability, among other factors, depending on the approach to assessment used (e.g. Stein et al. 2012, 2015; Price and Daust 2016, Gross et al. 2016). Exposure is typically derived from climate model outputs (Gross et al. 2016).

Sensitivity considers the traits of a system that may make it susceptible to the effects of climate change (e.g. climate-relevant habitat specificity, physiological tolerance limits, community/species interactions, disturbance regimes, etc.). Essentially, it speaks to how a system may be affected by climate change (e.g. Young et al. 2012, Stein et al. 2014, Price and Daust 2016, Gross et al. 2016).

Finally, adaptive capacity speaks to the ability of a species or system to respond to or cope with the effects of climate change. Adaptive capacity[13] is often a function of reproductive capacity (e.g. ability to recover following a decline or build from a small founding population), dispersal capacity (e.g. ability to move somewhere else if current conditions become untenable), genetic diversity (evolutionary potential and vulnerability to stochastic events) and the ability to modify behaviour in response to change (e.g. adjust timing of migration) (Bagne et al. 2011, Price and Daust 2016, Gross et al. 2016).

[13] This refers to adaptive capacity in the ecological sense, rather than the organizational sense (i.e., the ability of an organization to respond to climate change).

METHODS

As noted previously, there are a number of ways to conduct a CCVA. These range from vulnerability indices like NatureServe's Climate Change Vulnerability Index, to in-depth quantitative distribution modeling, to more simple expert elicitation methods. The method chosen and its complexity should reflect the use, to which the results will be put, as well as information and resource availability (Stein et al. 2014, Gross et al. 2016).

The approach used in this report constitutes a simple, qualitative, species-[14] and trait-based[15] vulnerability assessment. It largely replicates the approach described in Price and Daust (2016), with some modifications put forward by Dr. Chris Shank. This method permitted relatively rapid assessment of multiple species at low cost, while allowing presentation of results in a simple, readable layout and, recognizing uncertainties, in a manner that avoids perception of high precision. It considers species sensitivity (to climate-relevant changes in habitat and abiotic/biotic factors, as well as potentially interacting, non-climate stressors) and adaptive capacity. Indirect effects of climate change such as disease, changes to disturbance regimes, phenological mismatches, microclimates and barriers to dispersal were captured in the scoring where information was available. The inclusion of non-climate stressors was considered particularly important, given the potential for additive or cumulative effects (e.g. Stein et al. 2014).

Factors such as population size/trends have not been included. Species that are, for instance, subject to significant populations declines, will likely already be captured in species at risk processes. Further, inclusion of factors such as population size or trends has the potential to skew vulnerability results (Young et al. 2012).

Vulnerability assessments for each species were based largely on species status reports (compilations of best available information about a species at risk). Where possible, status reports from the NWT Species at Risk Committee were used (for all species assessed under the *Species at Risk (NWT) Act*), as these typically provide strong regional characterizations of status. Where NWT assessments for species were not available, status reports from the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) were used. Species experts were solicited to review summaries of the information, largely reproduced from the status reports, to ensure their completeness and accuracy. These experts were also given the opportunity to participate in the scoring of vulnerability. Detailed scoring and species information can be found in Appendix B (pg. 146).

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[14] That is, the vulnerability of specific species (versus communities or ecosystems) is assessed in this report.
[15] Trait-based assessments use species traits (habitat selection, physiological tolerances, species/community interactions, reproductive capacity, etc.) as predictors of vulnerability (Young et al. 2015, Gross et al. 2016).

The scores for sensitivity and adaptive capacity reflect the range of the species as a whole. This reflects the global and interconnected nature of climate change, the likelihood of species shifts and recognizes that mitigation and adaption responses must be undertaken cooperatively. Scores for non-climate stressors were derived from the threat trends assessment described in Threat Trends Assessment (pg. 144). Scores here are jurisdictional in nature, reflecting the NWT's clear jurisdictional responsibility for addressing these threats. It is our hope that this approach provides a clear picture of species vulnerability in the NWT, making the results more immediately understandable and relevant for wildlife managers.

Protocols for vulnerability assessment scoring (sensitivity and adaptive capacity) follow, along with overall vulnerability interpretation. Unless otherwise noted, these sections are drawn verbatim from Price and Daust (2016).

Sensitivity

The sensitivity score is the average of subscores for habitat, abiotic and biotic sensitivities. This differs from the approach of Price and Daust (2016), who did not combine factors into a single value. Price and Daust (2016) noted that combining ratings can reduce transparency and can, for example, dilute a critical sensitivity to temperature by a low rating for biotic factors and vice versa. Shank (pers. comm. 2020); however, recommended using the average of the three subscores, recognizing that these factors may interact and the use of a single subscore to represent overall sensitivity may mislead readers. However, detailed scoring for all factors is included within Appendix B for reference.

Dependence on habitats that are sensitive to climate change

Examples of habitats that are sensitive to climate change include wetlands, seasonal streams, alpine and coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. This factor includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution. Scoring break-down is as follows:

Score	Description
1	Broad generalist
2	Generalist, but some sensitive habitats are important
3	Depends on sensitive habitats that are not rare
4	Depends on sensitive habitats that are rare

Sensitivity to climate-relevant abiotic factors

Examples of climate-relevant abiotic factors could include temperature, desiccation, snowpack, dissolved oxygen and pH. This factor addresses physiological tolerances. Scoring break-down is as follows:

Score	Description
1	Not sensitive
2	Somewhat sensitive or possibly very sensitive
3	Likely very sensitive
4	Known very sensitive

Sensitivity to climate-relevant biotic factors

Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, and disease). Scoring break-down is as follows:

Score	Description
1	Not sensitive
2	Somewhat sensitive or possibly very sensitive
3	Likely very sensitive
4	Known very sensitive

Non-climate Stressors

Potentially interacting non-climate stressors might include habitat loss, invasive species, or pollution. Sensitivity to climate change may be affected by the extent to which other factors pose a threat. Scoring break-down is as follows:

Score	Description
1	No pressures
2	Moderate pressures or possibly major pressures
3	Likely major pressures
4	Known major pressures

These scores were informed by a threat trends assessment that was completed alongside this vulnerability assessment. The threat trends assessment was completed using a modified version of the International Union for the Conservation of Nature's (IUCN) standardized threat classification system (primary and secondary threat levels only) (Salafsky et al. 2008). Threats were scored based on the assessment unit as a whole (species, subspecies, or distinct population) insofar as the threat may be directly relevant to wildlife managers in the NWT. In this respect, this can be considered a jurisdictional review of threats to species at risk in the NWT. For species whose ranges cross into other jurisdictions (many of the species considered in this report), the scoring therefore does not represent threats to species throughout their range and does not capture the impacts distant threats may have on species populations. This is not to suggest that threats elsewhere in a species' range are not important, nor that those threats do not have an influence throughout the range. Rather, this approach was chosen as a way of focusing attention on those impacts that are the direct responsibility of the NWT as a jurisdiction. Therefore, while information about all threats was included in the detailed species scoring (Appendix B, pg. 146), if a threat was not reported as occurring in the NWT, it was scored as not applicable. Threats were ranked as high, medium, low, or negligible/not applicable for each species. Methods, instructions to expert reviewers and detailed scoring can be found in Appendices A and B (pg. 141 and 146).

Adaptive Capacity

Adaptive capacity addresses long term resilience to climate change and is related to life history strategy, dispersal ability, genetic diversity and physiological or behavioural plasticity. Organisms that mature early and produce many offspring can colonize newly disturbed areas and repopulate quickly; those with few young who invest deeply in parental care are well-adapted to stable environments, but are generally less flexible to changing situations. Actual reproductive rate will vary with individual body condition and ecological context (e.g. food availability, population density). Dispersal ability defines the spread of individuals over a landscape; good dispersers will be more likely to be able to follow shifting ecosystems in the absence of barriers. Over the long term, high genetic diversity likely provides a better foundation for climate-based selection provided that the diversity exists in climate-relevant traits. Plasticity allows individuals to respond physiologically or behaviourally to changes over the short term (within a generation), by such mechanisms as the time or location of an activity and using microhabitat refugia.

Reproductive capacity

Reproductive capacity describes life history strategy of different species (along the continuum between r and K selection[16]). Reproductive capacity ratings are based on

[16] Species that are r-selected have high potential for population growth, poor competitive abilities and high dispersion potential (e.g. insects). K-selected species have lower reproductive potential but strong

averages provided in sources. Scoring is as below, as recommended by Shank (pers. comm. 2020).

	First reproduction ≤2 yrs.	First reproduction >2 yrs.
Few young (number of young or eggs produced ≤3)	2 - Early reproduction/few offspring score	4 - Late reproduction/few offspring score
Many young (number of young or eggs produced >3)	1 - Early reproduction/many offspring score	3 - Late reproduction/many offspring score

Dispersal capacity

Dispersal distances are taken from maxima noted in sources. For some species, these may be extrapolated from species of similar size (i.e., using a reasonable assumption). Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; important barriers are noted and included in the summary information for adaptive capacity. Modified scoring (Shank pers. comm. 2020) is below. Note that for migratory species, dispersal distance does not refer to total migratory distance; rather, it reflects the maximum distance between birth and subsequent reproduction (Shank pers. comm. 2020).

Score	Description
1	>10km
2	1-10km
3	0.25-1km
4	<0.25km

Overall adaptive capacity is scored as the mean of reproductive capacity and dispersal ability, modified by genetic diversity or phenotypic plasticity, if known. Scores can be interpreted as follows:

1	Good
1.5	Moderate-good
2	Moderate
2.5	Moderate-poor
3	Poor
>3.5	Very poor

Price and Daust (2016) did not rate genetic diversity or phenotypic plasticity, owing to typically limited availability of information. This approach was carried forward here for

competitive abilities (e.g. large mammals). K-selected species are generally considered to be at a higher risk of extinction.

phenotypic plasticity. However, upon review of information available on genetic diversity (and clear indication of very low genetic diversity in a number of species), a blanket rating of 0.5 was used where genetic diversity was low and considered to be problematic at the population level. Where used, this score modifies the overall adaptive capacity score (increases the score; that is, worsens the adaptive capacity score).

Overall Vulnerability Interpretation

This method does not combine factors into a single vulnerability score for each species, due to high uncertainty associated with many factors as well as the strong likelihood of unpredictable feedbacks and cascading impacts. This provides transparency and allows managers to assess where to focus mitigation. Interpretation for the colour-coded scores for sensitivity, non-climate stressors and adaptive capacity are included below, along with coarse suggestions of general implementation actions. The intent is that anything with a rating of 3 or 4 is a flag for management attention and that a rating of 2 requires further investigation. Some high-level recommendations are included in the section Management and Adaptation (pg. 122); however, a detailed *Wildlife Climate Change Adaptation Plan* is currently being developed by ENR and so detailed management actions have not been proposed in this assessment.

Colour-coding and coarse management interpretation

Sensitivity[17]	**Non-climate stressors**	**Adaptive capacity**[18]	**Interpretation for managers**
Likely not sensitive	Likely not sensitive	Good to moderate-good	Monitor
Somewhat sensitive / possibly very sensitive	Somewhat sensitive / possibly very sensitive	Moderate	Decrease uncertainty by increasing knowledge
Likely very sensitive	Likely very sensitive	Moderate-poor	Mitigate impacts
Known very sensitive	Known very sensitive	Poor to very poor	Mitigate impacts

[17] The average of habitat, abiotic and biotic factors.
[18] Based largely on the average of reproductive and dispersal capacity, modified by genetic diversity in some cases.

SELECTING SPECIES AND GROUPING SPECIES

Species considered to be of high priority for climate change vulnerability assessment include species of conservation concern in the NWT (assessed as at risk under either the *Species at Risk (NWT) Act* or the federal *Species at Risk Act*), keystone and characteristic species and species that are regularly harvested or that have cultural/spiritual significance to the people of the NWT. This list is likely to evolve over time. These species were also considered to be those most likely to have sufficient data available about them to enable effective assessment (Table 6). Following Price and Daust (2016), these species were grouped roughly by climate-relevant habitat preferences.

As introduced previously, the NWT's wildlife climate change vulnerability assessment is being completed in two phases: the first phase (this report) includes species at risk in the NWT (noted in bold below), while the second phase will scope in other keystone, charismatic, harvested and culturally/spiritually significant species.

Table 6. Species selected for climate change vulnerability assessment in the NWT. Species in **bold** are those included in this report.

AMPHIBIANS	
Boreal chorus frog	**Northern leopard frog**
Canadian toad	**Western toad**
Wood frog	
MAMMALS	
GENERALISTS	
American black bear	Muskoxen
Grey wolf	Porcupine
Grizzly bear	Red fox
Lynx	Snowshoe hare
Moose	**Wolverine**
Woodchuck	
SEA ICE/ARCTIC SPECIALISTS	
Arctic fox	**Dolphin and Union caribou**
Arctic ground squirrel	Northern collared lemming
Arctic hare	**Peary caribou**
Barren-ground caribou	**Polar bear**
GRASSLAND/MEADOW SPECIALISTS	
Wood bison	
RIPARIAN SPECIALISTS	
Beaver	
OLD FOREST SPECIALISTS	
American marten	Northern flying squirrel
Boreal caribou	Red squirrel
MARINE MAMMALS	
Bearded seal	Narwhal
Bowhead whale	Ringed seal

Grey whale	
BATS	
Big brown bat	Long-eared *myotis*
Eastern red bat	Long-legged *myotis*
Hoary bat	**Northern *myotis***
Little brown *myotis*	Silver-haired bat
BIRDS	
AERIAL INSECTIVORES	
Banks Swallow	**Evening Grosbeak**
Barn Swallow	**Olive-sided Flycatcher**
Common Nighthawk	
FOREST BIRDS	
Canada Warbler	Ptarmigan
Harris' Sparrow	Snow Goose
Rusty Blackbird	
Grouse	
MARINE BIRDS	
Ivory Gull	
RAPTORS	
Peregrine Falcon	**Short-eared Owl**
WATERFOWL	
Horned Grebe	**Red-necked Phalarope**
OTHER WATER BIRDS	
Buff-breasted Sandpiper	**Red Knot (*rufa*)**
Eskimo Curlew	**Whooping Crane**
Red Knot (*islandica*)	**Yellow Rail**
FISH	
ANADROMOUS FISH	
Dolly Varden	Arctic char
MARINE FISH	
Northern wolffish	
LAKE AND/OR STREAM RESIDENTS	
Bull trout	**Shortjaw cisco**
INSECTS	
Gypsy cuckoo bumble bee	**Western bumble bee**
Transverse lady beetle	**Yellow-banded bumble bee**
PLANTS	
Hairy braya	**Mackenzie hairgrass**
Nahanni aster	

RESULTS

A total of 46 species were assessed for this vulnerability assessment: two amphibians, 14 mammals, 19 birds, four fish, four insects and three plants. Summary results for both the climate change vulnerability assessment and the threat trends assessment (which informs the assessment of non-climate stressors) are presented in the pages that follow. Additional details, including scoring rationale, may be found in Appendix B (pg. 146). Please refer to this appendix for further detail about each species discussed here.

Threats were scored based on the assessment unit as a whole (species, subspecies, or distinct population) insofar as the threat may be directly relevant to wildlife managers in the NWT. Climate change sensitivity is described in relation to habitat, abiotic factors and biotic factors, potentially interacting non-climate stressors (supported by a threats assessment for each species, Appendix B, pg. 146). Adaptive capacity is primarily a function of reproductive rate and dispersal capacity (and, where information exists, genetic diversity).

Results – Threat Trends Assessment

No single threat to biodiversity acts in a vacuum; additive effects and interactions among threats are important to consider in terms of stress to species and impacts to their overall health (CAFF 2013).

Table 7 provides a complete summary of threats to the species considered in this assessment (including non-climate stressors and climate change). Additional detail on the threats experienced by each species can be found in Appendix B (pg. 146).

As can be seen in Table 7, climate change is the most important threat to the species considered in this report in the NWT, with 39 of the 46 species (approx. 85%) being negatively impacted (at low, medium, or high levels) by climate change, including through changes to habitat (35 of 46; 76%), drought (16 of 46; 35%), temperature extremes (18 of 46; 39%)and storms/flooding (20 of 46; 43%). This was also a conclusion of the Arctic biodiversity assessment (Meltofte et al. 2013), although at a substantially larger scale and considering a much wider range of species. Beyond acting as a threat/stressor in its own right, climate change has the potential to facilitate, accelerate, or aggravate other, ostensibly non-climate, threats (e.g. agriculture and livestock grazing, offshore oil and gas development, marine shipping, forest fires and fire suppression activities, alien and invasive species, pests, pathogens, disease and landslides). As such, as climate change progresses, we may see the overall level of concern associated with these other threats increase over time.

Nationally, climate change is often considered a 'potential' or 'unknown' threat in species at risk assessments, reflecting uncertainties in the projections, scenarios and responses of species (McCune et al. 2013, Leaman and Mooers 2018). The fact that climate change ranks so highly in the NWT likely reflects the faster progression of climate change in this region (i.e., climate change is already clearly observable in the NWT and other northern regions). It may also be reflective of the geography, population and economy of the NWT to some degree. With such a large geographic area, small population and low density of development, coupled with the widespread impact of climate change, it may stand out relative to other threats.

Despite its prominence, climate change is not the only threat affecting the species considered in this report and nor should its overall importance to this group of species as a whole overshadow the important influences of other, non-climate, threats. The most important non-climate threats to the species considered here are (including scores of low, medium, or high; see Table 7):

- Mining = 13/46 species (28%)
- Fire and fire suppression = 12/46 species (26%)
- Noise = 12/46 species (26%)
- Harvesting (intentional, non-intentional, or for control) = 11/46 species (24%)
- Competition/predation = 11/46 species (24%)
- Roads = 10/46 species (22%)
- Alien/invasive species = 10/46 species (22%)
- Oil and gas drilling = 8/46 species (17%)
- Ecosystem modifications (largely declines in prey/forage availability) = 8/46 species (17%)
- Species/diseases of unknown origin = 8/46 species (17%)
- Industrial effluents = 6/46 (13%)
- Airborne pollutants (primarily mercury) = 6/46 (13%)
- Flight paths = 5/46 species (11%)
- Marine shipping = 5/46 species (11%)
- Logging = 5/46 species (11%)

This threat break-down is reflective of the economy of the NWT and is likely to change over time as/if the economy shifts, or, as noted above for some threats, as climate change progresses. Other threats, less severe at this time and with fewer than 10% of species affected, include: tourism/recreation, agriculture, livestock, renewable energy, utility and service lines, fishing, dams and water management/use, urban wastewater, garbage/solid waste and landslides.

Table 7. Threat trends assessment for all species considered in this report. This was completed using a modified version of the International Union for the Conservation of Nature's standardized threat classification system (primary and secondary threat levels only) (Salafsky et al. 2008). Threats were scored based on the assessment unit as a whole (species, subspecies, or distinct population) insofar as the threat may be directly relevant to wildlife managers in the NWT. Detailed scores and rationale, as well as scoring methods, may be found in Appendices A and B (pg. 142 and 146). Legend below table.

		Mammals														Birds																			Fish				Amphibians		Insects				Plants		
		Barren-ground caribou	Boreal caribou	Bowhead whale	Collared pika	Dolphin and Union caribou	Grey whale	Grizzly bear	Little brown *myotis*	Northern mountain caribou[19]	Northern *myotis*	Peary caribou	Polar bear	Wolverine	Wood bison	Bank Swallow	Barn Swallow	Buff-breasted sandpiper	Canada Warbler	Common Nighthawk	Eskimo Curlew	Evening Grosbeak	Harris' Sparrow	Horned Grebe	Ivory Gull	Olive-sided Flycatcher	Peregrine Falcon	Red Knot (*islandica*)	Red Knot (*rufa*)	Red-necked Phalarope	Rusty Blackbird	Short-eared Owl	Whooping Crane	Yellow Rail	Bull trout	Dolly varden	Northern wolffish	Shortjaw cisco	Northern leopard frog	Western toad	Gypsy cuckoo bumble bee	Transverse lady beetle	Western bumble bee	Yellow-banded bumble bee	Hairy braya	Mackenzie hairgrass	Nahanni aster
1. Residential and commercial development	Housing and urban areas																																														
	Commercial and industrial areas																																														
	Tourism and recreation areas																																														
2. Agriculture and aquaculture	Annual and perennial non-timber crops																																														
	Wood and pulp plantations																																														
	Livestock farming and grazing																																														
	Marine and freshwater aquaculture																																														
3. Energy production and mining	Oil and gas drilling																																														
	Mining and quarrying																																														
	Renewable energy																																														
4. Transportation and service corridors	Roads and railroads																																														
	Utility and service lines																																														
	Shipping lanes																																														
	Flight paths																																														

[19] Note that scoring for northern mountain caribou is based on the threats assessment completed by SARC in 2020 (SARC 2020). Mining and quarrying, roads and railways, hunting and collecting terrestrial animals and recreational activities are given a score of medium in this table, but these threats were actually classified as Low-Medium by SARC (see Appendix B, pg. 146).

5. Biological resource use (intentional, unintentional, or for control)	Hunting and collecting terrestrial animals
	Gathering terrestrial plants
	Logging and wood harvesting
	Fishing and harvesting aquatic resources
6. Human intrusion and disturbance	Recreational activities
	War, civil unrest and military exercises
	Work and other activities
7. Natural system modifications	Fire and fire suppression
	Dams and water management/ use
	Other ecosystem modifications
8. Invasive and other problematic species, genes and diseases	Invasive non-native/alien species/diseases
	Problematic native species/diseases
	Introduced genetic material
	Problematic species/diseases of unknown origin
	Viral/prion-induced diseases
	Diseases of unknown cause

9. Pollution	Domestic and urban wastewater
	Industrial and military effluents
	Agricultural and forestry effluents (including erosion)
	Garbage and solid waste
	Airborne pollutants
	Excess energy (noise/light pollution)
10. Geological events	Volcanoes
	Earthquakes/ tsunamis
	Avalanches/ landslides
11. Climate change and severe weather	Habitat shifting and alteration
	Droughts
	Temperature extremes
	Storms and flooding
	Other
Other threats	

Legend:

Not applicable/negligible	
Low	
Medium	
High	

Results – Climate Change Vulnerability Assessment

Table 8. Summary of vulnerability assessment results for all species considered in this report.

Assessed species	Climate change sensitivity[20]	Non-climate stressors[21]	Adaptive capacity[22]
AMPHIBIANS			
Northern leopard frog	2	2	1.5
Western toad	2	2	2
MAMMALS			
Generalists			
Grizzly bear	1	2	2.5
Wolverine	1	1	2.5
Sea ice/Arctic specialists			
Dolphin and Union caribou	2.7	3	2.5
Peary caribou	2	2	2.5
Polar bear	3.3	2	3
Alpine specialists			
Collared pika	2.7	1	2
Northern mountain caribou	3	2	2.5
Grassland/meadow specialists			
Wood bison	1.3	3	3
Old forest specialists			
Barren-ground caribou	3	4	2.5
Boreal caribou	2.7	4	2.5
Marine mammals			
Bowhead whale	2.3	2	2.5
Grey whale	1.5	1	2.5
Bats			
Little brown *myotis*	2	2	1.5
Northern *myotis*	2	2	1.5
BIRDS			
Aerial insectivores			
Bank Swallow	2	1	1
Barn Swallow	1.7	1	2.5
Common Nighthawk	2	1	2
Olive-sided Flycatcher	2	1	2
Forest birds			
Canada Warbler	2.3	1	1.5
Evening Grosbeak	2.5	1	1
Harris' Sparrow	1.7	1	1
Rusty Blackbird	2.5	1	1
Marine birds			

[20] The average value for sensitivity based on habitat, abiotic and biotic factors.
[21] Scored based on threats in the NWT only. This does not imply that there are not significant threats elsewhere in the range.
[22] Based primarily on reproductive and dispersal capacity.

Assessed species	Climate change sensitivity[20]	Non-climate stressors[21]	Adaptive capacity[22]
Ivory Gull	3	1	2.5
Raptors			
Peregrine Falcon	1.3	1	2.5
Short-eared Owl	1	1	1
Waterfowl			
Horned Grebe	2.3	1	1.5
Red-necked Phalarope	2.7	1	1.5
Other water birds			
Buff-breasted Sandpiper	1.7	1	1
Eskimo Curlew	2.5	1	2
Red Knot (*islandica*)	3	1	1.5
Red Knot (*rufa*)	3.5	1	1.5
Whooping Crane	2.3	1	3
Yellow Rail	2	1	1
FISH			
Anadromous			
Dolly Varden	3	2	3
Marine			
Northern wolffish	1.7	1	2.5
Lake/stream			
Bull trout	3.3	2	2.5
Shortjaw cisco	1.7	1	2.5
INSECTS			
Gypsy cuckoo bumble bee	1.7	2	1.5
Transverse lady beetle	1	1	1
Western bumble bee	2.3	2	1.5
Yellow-banded bumble bee	1.7	2	1.5
PLANTS			
Hairy braya	3	1	3.5
Mackenzie hairgrass	3	1	1.5
Nahanni aster	2	1	1.5

Amphibians

There are only two at-risk amphibian species in the NWT at this time: northern leopard frog and western toad. Both species may benefit from warmer spring/summer temperatures, through the potential for increased fecundity, increased developmental success and potential range expansion. However, aggregation events make both species vulnerable at a population scale to the effects of extreme conditions, such as drought or freezing temperatures. Habitat connectivity may also be impaired by drought conditions. Disease is the primary non-climate stressor to both species in the NWT, although the impact of ultraviolet blue (UVB) radiation is also concerning, especially given the potential for it to act synergistically with other threats (e.g. droughts). Mass mortality events are a concern for western toads in the NWT.

Table 9. Summary of vulnerability assessment results for amphibians at risk.

Assessed species	Climate change sensitivity[23]	Non-climate stressors[24]	Adaptive capacity[25]
Northern leopard frog	2	2	1.5
Western toad	2	2	2

Northern Leopard Frog

The northern leopard frog occurs throughout northeastern and central North America. In the NWT, it can be found in a small area south of Great Slave Lake, which represents the northernmost limit of this species' distribution (Figure 36). Northern leopard frogs are ectotherms. Activity levels increase with temperature, to a maximum of 20°C -29°C. Rate and success of egg hatching and development are dependent upon water temperature. Northern leopard frogs are vulnerable to desiccation, however, behavioural adaptations, including burrowing and habitat selection, help mitigate this risk. This species is not freeze-tolerant and typically overwinters by going dormant under water or at terrestrial sites below the frost line with adequate moisture. Overwintering sites likely represent an important range limiting factor. Adaptive capacity is moderate, with northern leopard frogs having short generation times, synchronous and communal reproduction, 600-7,000 eggs in each egg mass and limited dispersal ability.

The effects of climate change may be either positive or negative for northern leopard frog. Higher average temperatures and earlier springs may favour range expansion and earlier breeding. Conversely, random and severe weather events (e.g. freezing temperatures, drought) have the potential to impact large portions of the population simultaneously, given synchronous, communal breeding and aggregation events. Habitat connectivity may also be impaired by droughts.

The overall impact of non-climate stressors on northern leopard frog in the NWT is considered to be low at this time. Diseases, including chytridiomycosis and ranavirus, are considered to be the most serious plausible threats. These diseases are already present in the NWT, but have not yet been detected in northern leopard frogs. Boats, float planes and fishing equipment may represent potential vectors for spread of these diseases between water bodies. Hydroelectric developments that reduce water levels or alter current conditions are also thought to represent a threat to northern leopard frogs in the NWT. Increasing UVB radiation, the result of a thinning ozone layer, may also adversely affect northern leopard frogs (SARC 2013a).

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[23] The average of habitat sensitivity and abiotic and biotic factors.

[24] Scored based on threats in the NWT only. This does not imply that there are not significant threats elsewhere in the range.

[25] Based primarily on reproductive and dispersal capacity.

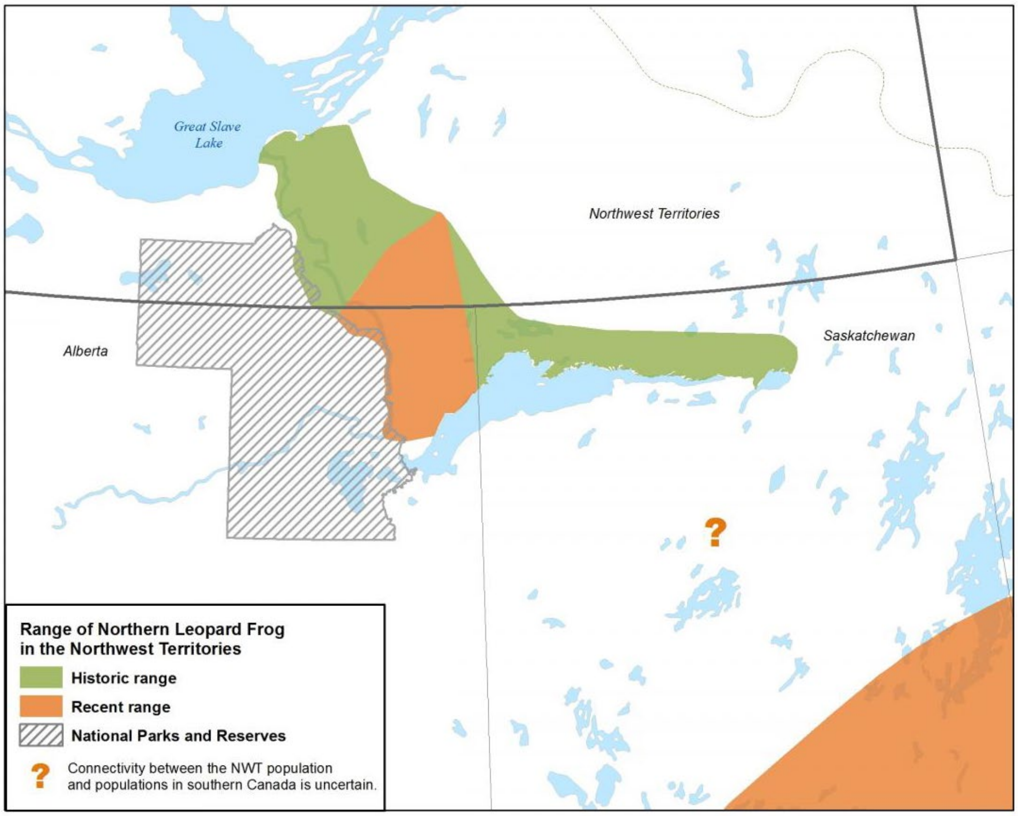

Figure 36. Range of NWT northern leopard frog population (NWT Species at Risk 2020).

Western Toad

In the NWT, the western toad occurs only in the southwestern corner of the territory (Figure 37), which represents the known northern limit of its range. Its population is considered small and, owing to biological limiting factors including long lifespan and relatively limited reproductive capacity, is considered vulnerable to declines. Distance between breeding, hibernation and foraging sites is a possible range limiting factor in the NWT. Refugia that provide protection and moisture likely constitute critical habitat. Western toads are ectotherms with a relatively wide thermal tolerance range and some degree of tolerance to desiccation. They hibernate through the winter below the frost line and near water to mitigate dehydration. Dispersal capacity of western toads is relatively strong compared to other amphibians.

Climate change is expected to have some positive impacts on western toads. Warmer water temperatures may enhance development and survival of eggs and larvae. Increased snow accumulation (providing insulation) and earlier springs (allowing earlier breeding) may permit range expansion in the NWT. Warmer temperatures may also result in higher body temperatures in western toads, potentially facilitating the elimination of chytridiomycosis from the body, which is a key threat to western toads. Conversely, shifting environmental conditions associated with climate change may facilitate the expansion of chytridiomycosis and other diseases into areas where they are not currently present. Climate change may also result in an increase in summer drought conditions, which has the potential to adversely impact whole populations of western toads. Drought conditions may also increase exposure to UVB radiation, which may act synergistically with other threats to western toads. Early emergence from hibernation caused by warmer winter and spring temperatures may make western toads vulnerable to subsequent drops in temperature.

The primary non-climate threats to western toads in the NWT are related to disease (chytridiomycosis and ranavirus) and mass mortality events. Chytridiomycosis and ranavirus are already present in the NWT, although there is little evidence at this time of these diseases causing population-level impacts. Potential synergistic interactions between these diseases and other stressors are concerning however, particularly if the impact of these other stressors (e.g. UVB radiation) increases in the future. Mortality from road collisions is a common concern in other jurisdictions and has been receiving additional attention in the NWT following reports of collisions in the Fort Liard area (Wilson pers. comm. 2020). Other non-climate stressors to western toads in the NWT include habitat degradation, wildfires and resource exploration and development (SARC 2014a).

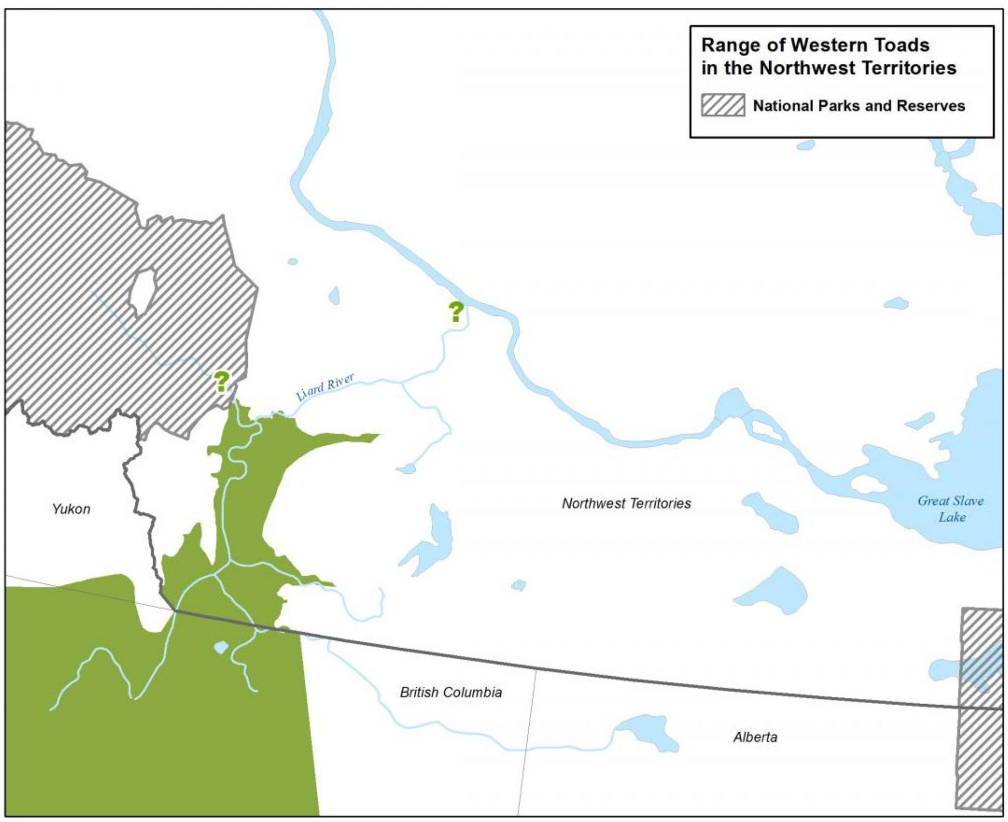

Figure 37. Range of western toads in the NWT (NWT Species at Risk 2020).

Mammals

Fourteen mammal species at risk were included in this vulnerability assessment, including generalists, sea ice/Arctic specialists, alpine specialists, a grassland/meadow specialist, old forest specialists, marine mammals and bats. Taken in the context of the NWT's biodiversity, these species, many of which are important ecological and cultural keystone species, represent some of the best studied and managed species in the territory (with some exceptions).

Environmental changes within the ranges of these species are already being observed; in fact, they have been observed increasingly since the 1970s-1980s. These include changes to snow conditions, permafrost, vegetation communities, freeze-thaw/icing events, insect harassment, parasites/diseases and a suite of changes to sea ice. In addition to these observable changes, forest fire frequency and intensity may increase in the future. Phenological mismatch (typically between timing of forage availability and peak forage requirement) represents a potentially significant future climate change-associated threat, as does the potential for heat stress. Each of these changes could be important by itself but taken together, are expected to affect such aspects of species life history as range, food availability/accessibility, migration, health and survivability.

Most of the mammal species considered here have moderate-low adaptive capacity, reflecting long generation times, delayed maturity and relatively few offspring. This is likely to affect their ability to recover from declines. As is expected for these (mostly) large mammals, dispersal capacity is generally strong, although there are some effective barriers to movement, including large water crossings (e.g. Dolphin and Union caribou), disturbed areas (e.g. boreal caribou) and anthropogenically imposed barriers (i.e., bison control area). For all species, reproductive success is linked to factors affecting fitness, such as food availability. Low genetic diversity is apparent in both polar bears and wood bison.

Non-climate threats vary in severity by region/species, but at this time include industrial development activities (mining, oil/gas, hydroelectricity), disrespectful harvesting, access (particularly associated with roads and ATV use), shipping, forestry, vehicle collisions, pollution/contaminants, alien/invasive species, diseases/parasites and predation. Human-animal conflicts are a concern for both carnivores and wood bison. For sea ice/Arctic specialists and marine mammals, most non-climate threats are expected to be facilitated or compounded by climate change. These include marine traffic (shipping and ice-breaking primarily), offshore oil and gas exploration and development, release of contaminants/pollution and introduction of alien/invasive species. Disease spread from livestock operations is considered a potential future threat tied to increasing agricultural activity.

Table 10. Summary of vulnerability assessment results for mammals at risk.

Assessed species	Climate change sensitivity[26]	Non-climate stressors[27]	Adaptive capacity[28]
Generalists			
Grizzly bear	1	2	2.5
Wolverine	1	1	2.5
Sea ice/Arctic specialists			
Dolphin and Union caribou	2.7	3	2.5
Peary caribou	2	2	2.5
Polar bear	3.3	2	3
Alpine specialists			
Collared pika	2.7	1	2
Northern mountain caribou	3	2	2.5
Grassland/meadow specialists			
Wood bison	1.3	3	3
Old forest specialists			
Barren-ground caribou	3	4	2.5
Boreal caribou	2.7	4	2.5
Marine mammals			
Bowhead whale	2.3	2	2.5
Grey whale	1.5	1	2.5
Bats			
Little brown *myotis*	2	2	1.5
Northern *myotis*	2	2	1.5

Generalists

The two generalist species considered here, grizzly bears and wolverines have broad ranges in the NWT. They are not expected to be particularly sensitive to the effects of climate change. However, they are likely vulnerable to population declines in the NWT central barrens area, reflecting declines in prey/forage species (particularly barren-ground caribou (BGC)) and harvest pressure.

Grizzly Bears

Although grizzly bears exhibit some clear habitat preferences (e.g. abundant resources, shade, eskers), they are considered generalists in terms of both habitat and diet selection and are well-adapted to environmental variability (Figure 38). Hibernation is an important aspect of grizzly bear life cycles. The relatively long hibernation periods displayed by grizzly bears in the NWT can make them vulnerable to changes in their environment (e.g. food availability). Density of grizzly bears throughout the NWT is naturally low and is

[26] The average of habitat, abiotic and biotic factors.
[27] Scored based on threats in the NWT only. This does not imply that there are not significant threats elsewhere in the range.
[28] Based primarily on reproductive and dispersal capacity.

considered very low outside the Mackenzie and Richardson mountains. Some degree of range expansion has been noted in the NWT, although the reasons for this expansion are not fully clear. Home range sizes in the NWT are very large and single-year movements can be impressive (maxima in sources is >32,000 km^2). Dispersal ability is excellent, with few barriers to movement. Grizzly bears are long-lived, with low reproductive capacity and delayed age of maturity (8.1 years in the eastern barrens). Reproduction is also influenced by habitat and by body size, which is in turn linked to primary productivity.

The impact that climate change may have on grizzly bears is considered to be largely speculative at this time. Longer growing seasons may facilitate more range expansion in the NWT, while other changes to habitat (e.g. fires, flooding, drought, warmer summer temperatures, shifts in the timing of seasons, mismatches between spring den emergence and food availability) and vegetation (e.g. shifts in vegetation communities) may impact food availability.

Non-climate stressors to grizzly bears in the NWT are thought to be low to moderate at this time. Human-caused mortality is the most significant factor influencing grizzly bear mortality in the NWT, although it is considered to be at generally sustainable levels. There are, however, concerns related to the cumulative impact of harvest in the central barrens, given the very low levels of primary productivity in this area and harvest pressure from NU. Changes in grizzly bear behaviour in the Mackenzie Mountains has also been noted, which is resulting in increased instances of negative human-grizzly bear interactions. In this context, avoiding food rewards and discouraging habituation may become increasingly important. Population declines in important food sources are also being observed in the NWT (e.g. BGC, berries, sheep, muskrat) (SARC 2017a and d).

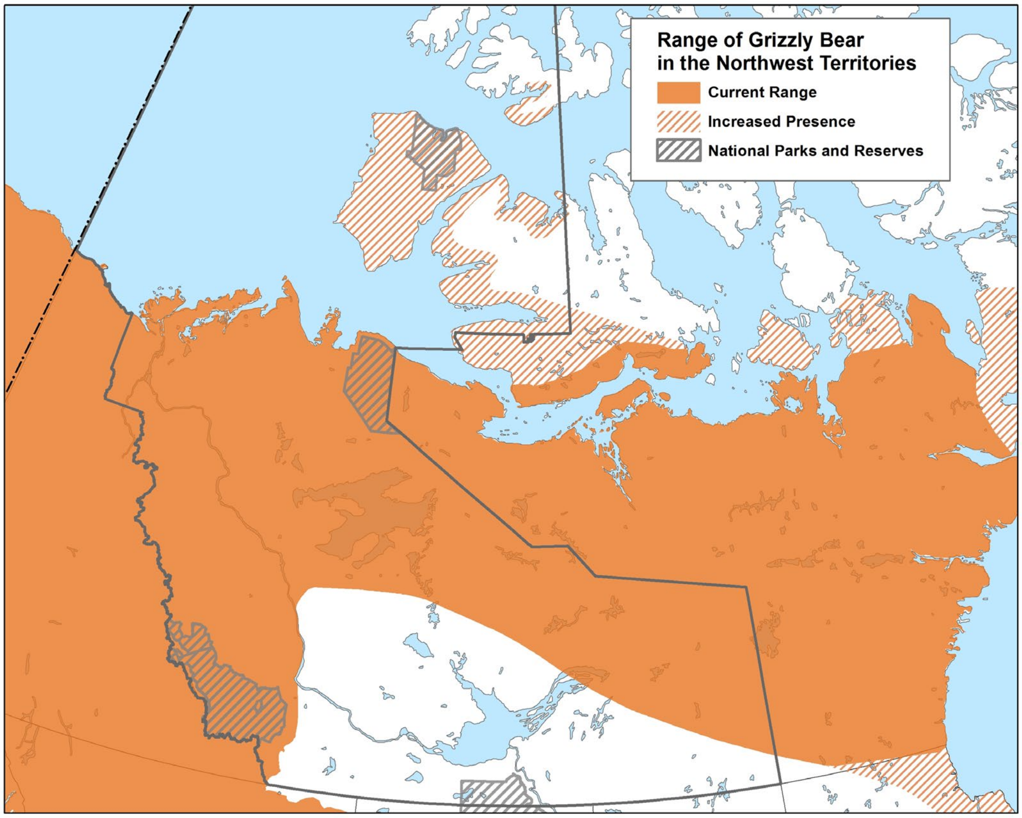

Figure 38. Range of grizzly bears in the NWT (NWT Species at Risk 2020).

Wolverines

Wolverines are found broadly across mainland NWT (Figure 39), as well as Victoria and Banks islands. Reflecting their broad range, they are considered habitat generalists. Likewise, they prey upon and scavenge a wide variety of food sources and can shift readily to alternate sources of prey when necessary, although their diet may be less varied in the central barrens compared to boreal regions, making wolverines in the central barrens more susceptible to declines linked to food availability. Wolverines have naturally low reproductive capacity (i.e., reproduce later in life, have few offspring and may not breed every year). This may make it more difficult for them to recover from population declines. Wolverines have large home ranges and occur at naturally low densities across the landscape. They also have excellent dispersal ability, moving quickly and relatively easily across most terrains and covering long distances.

Spring snow cover for denning is considered a key habitat component. In the NWT, a projected increase in snowfall overall is thought likely to offset a shorter snow season, the net effect of which may well be negligible to wolverines. Likewise, earlier springs may improve primary productivity in wolverine habitat, resulting in a possible benefit to wolverines in the northern parts of their range in North America.

Non-climate stressors, primarily harvesting, decreasing food availability and noise, are overall thought to be low to negligible at present in the NWT. However, population declines of 39-66% have been reported in the central barrens. These declines are thought to be related to significant declines in BGC herds, a key food source for wolverines in this area of the NWT (SARC 2014b).

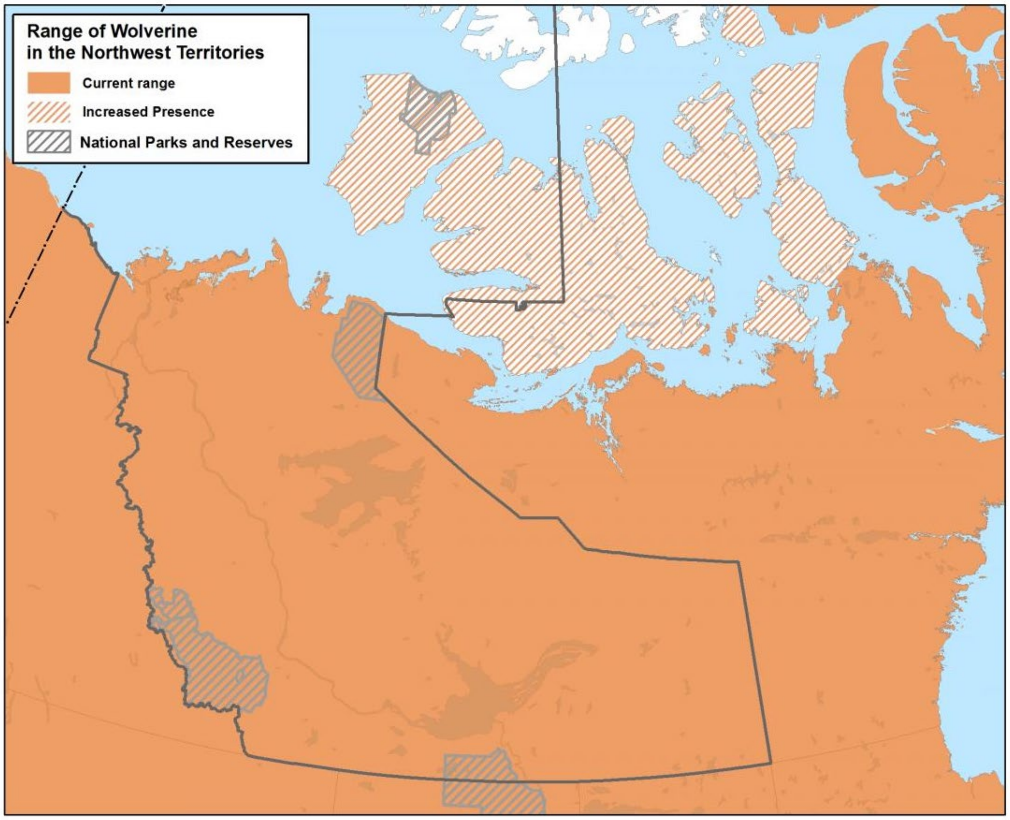

Figure 39. Range of wolverines in the NWT (NWT Species at Risk 2020).

Sea Ice/Arctic Specialists

Unsurprisingly, sea ice/Arctic specialists (Dolphin and Union caribou, Peary caribou and polar bear) are expected to be highly vulnerable to the effects of climate change. As noted above, the changes already being observed in the sea ice environment are substantial and will likely affect movements, health and survival of these species. For polar bears, marine prey availability is declining in association with changes to sea ice. While land-based hunting by polar bears does occur, terrestrial sources of food may not provide the essential nutrition that seals do. Over the long term, climate change is expected to limit survival of polar bears across most populations even though there may be short-term positive effects to high Arctic populations (more favourable ice conditions and increased prey diversity/abundance). Earlier spring green-up may favour species where spring forage availability is typically limited, but this shift may be associated with lower nutrient availability in forage plants.

Dolphin and Union Caribou

Dolphin and Union caribou occur only in the NWT and NU (Figure 40). They engage in a unique migration each year, crossing sea ice twice annually to move between Victoria Island and the mainland northern coast of the NWT and NU. The population has shown a decline of approximately 50% since 1997. Although their diet consists of a range of plants, like other caribou, they are strongly dependent on lichen. Dolphin and Union caribou generally calve every year after reaching maturity (two to three years of age). Caribou have good dispersal ability, but will typically use the easiest paths available. Soft snow, freezing rain and large bodies of water will impede their movement.

Given their twice annual migrations across the sea ice, changes in ice conditions associated with climate change are likely to be particularly problematic for Dolphin and Union caribou (e.g. later sea ice formation, changing ice thickness). These changes are already being observed; in the long term, they may affect migration, staging and direct mortality during crossings. A changing climate is also likely to impact forage availability. Observed increases in freeze-thaw cycles and freezing rain events over the last 20 years may make it more difficult for caribou to access forage and can lead to starvation. Increases in primary productivity have been documented in the western Arctic islands, which may increase forage availability. Warm weather can also benefit calf survival, but it brings with it risks of heat stress and increased insect harassment. The impacts of warmer weather are already being observed in higher warble fly indices since the 1970s.

Non-climate stressors primarily related to increased ship traffic/ice breaking activity in the Northwest Passage and harvesting, are rated as high for Dolphin and Union caribou in the NWT. Increases in shipping are projected with decreasing sea ice cover/thickness, including through the Coronation Gulf and Dolphin and Union Strait. This has the potential to disrupt the migration of Dolphin and Union caribou. A reported harvest rate of 7-11% of the population is considered unsustainable at this time (SARC 2013b).

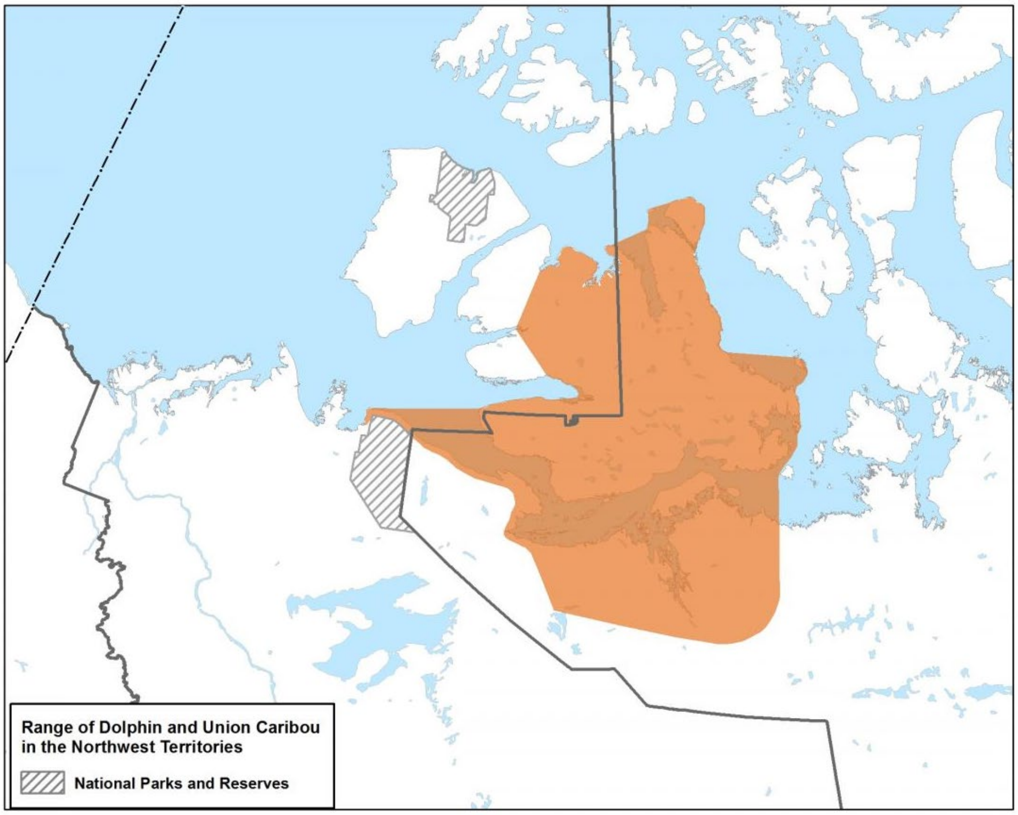

Figure 40. Range of Dolphin and Union caribou in the NWT (NWT Species at Risk 2020).

Peary Caribou

Peary caribou occur exclusively in the NWT and NU, occurring primarily in the Arctic islands and further north than any other group of caribou in North America (Figure 41). All three subpopulations of Peary caribou have experienced long-term and significant population declines. Peary caribou are long-lived and, when in good health, display relatively strong reproductive capacity. They are adapted to extreme climatic variability. Habitat and forage selection are quite broad and, unlike other types of caribou, lichen is not considered a critical habitat component given the scarcity of lichen within Peary caribou range. Stage of growth is likely as important as species in selecting forage.

Environmental factors affecting the condition and availability of forage are important to the health and survival of Peary caribou. Earlier green-up associated with climate change may be beneficial, enhancing forage access, but may also be associated with lower nutrient availability. Increases in erratic weather events are already being observed on Banks Island, which may increase instances of freezing rain. Icing events such as these can adversely impact forage availability. Warmer temperatures may increase over-winter survival, but are also tied to changing parasite and disease conditions. Changes to ice conditions may also affect movements between islands. However, overall, the effects of climate change on Peary caribou are uncertain and affected by natural population cycles, species interactions, harvesting and predation.

In addition to changing habitat conditions caused by climate change, the most important non-climate stressors for Peary caribou include shipping (impeding travel between Banks and Victoria islands), competition (muskoxen) and predation (owing to small population of Peary caribou). Seismic and coal exploration are potential future threats, in particular, licensed exploration areas that overlap with calving grounds (SARC 2012c).

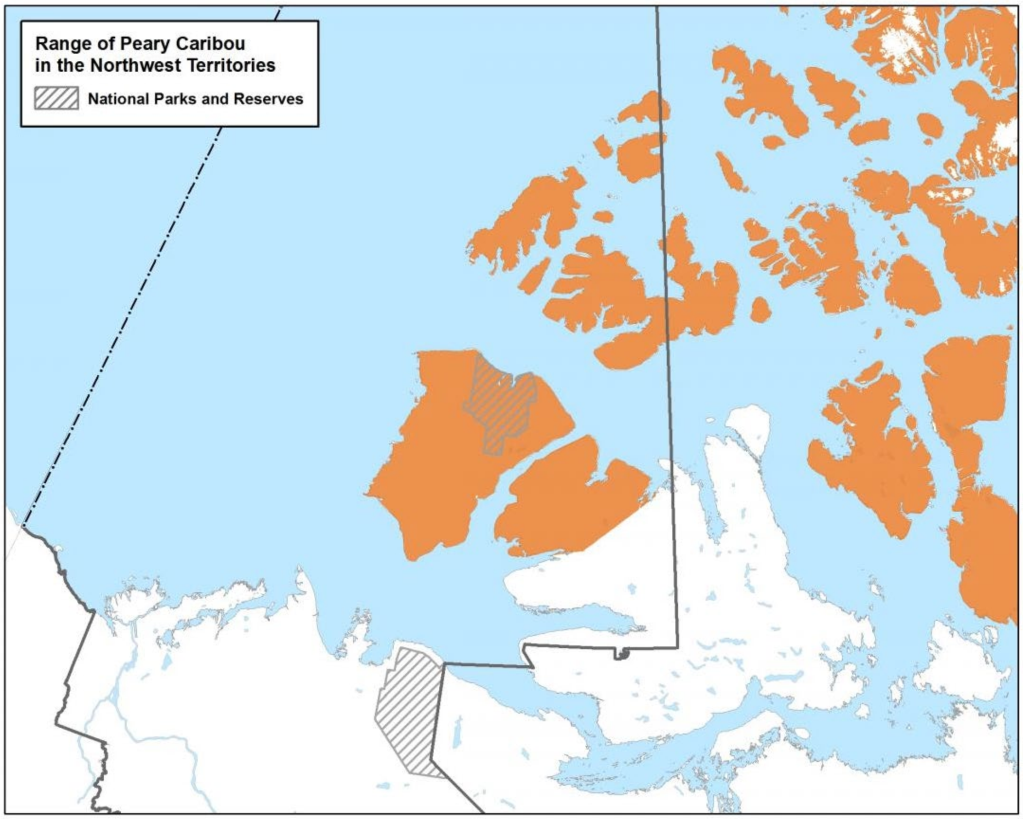

Figure 41. Range of Peary caribou in the NWT (NWT Species at Risk 2020).

Polar Bear

Polar bears occur in subpopulations throughout their circumpolar range. In the NWT (Figure 42), these subpopulations include the Northern Beaufort, Southern Beaufort, Viscount-Melville and Arctic basin subpopulations. This iconic species is well-known for its association with sea ice and, in fact, can be considered as having an obligate relationship with sea ice and seals, its primary food source. Polar bears have moderate-poor adaptive capacity, with their long generation time, low reproductive rates, late maturity and low genetic diversity, offset somewhat by excellent dispersal capacity (with home ranges that can exceed 500,000 km^2).

Given their reliance on sea ice as a platform for hunting seals, polar bears are considered highly vulnerable to the effects of climate change. The effects of climate change on ice conditions (including thinner ice, increased ice movement, declines in the number and size of pressure ridges and declines in multi-year ice) are already being observed; have been observed increasingly, in fact, since the 1980s. Seal availability is declining in association with these changes to sea ice and although polar bears are able to hunt from land (and now must, given increasingly long periods of time spent onshore as sea ice declines), the evidence suggests that terrestrial food sources, as a replacement for seals, do not provide adequate nutrition in most areas. Although these changes are largely affecting the Southern Beaufort Sea subpopulation at this time and while short-term benefits of climate change may be seen in some subpopulations (e.g. more favourable ice conditions and increasing prey diversity/abundance in some high Arctic regions), in the long term, it is expected that most polar bear subpopulations will be adversely affected by climate change. The effects may be sufficiently severe to affect the survival of the species in some areas.

Most other threats to polar bears are also tied, in some fashion, to climate change, through facilitation and/or acceleration of other, apparently 'non-climate', stressors. These threats include contaminants, offshore oil and gas exploration and development, human-bear conflicts and marine traffic. Increasing marine traffic is particularly concerning, given its potential to contribute to the decline in multi-year ice, introduce contaminants and invasive species to the Arctic marine environment and directly disturb polar bears and other species. Contaminants, including the potential for oil spills, are also concerning, owing to polar bears' tendency to bioaccumulate contaminants and to the extreme toxicity of oil to polar bears.

Overall, the potential for climate change and other threats to act cumulatively on polar bears and their habitat is highly concerning (SARC 2012d, 2020a).

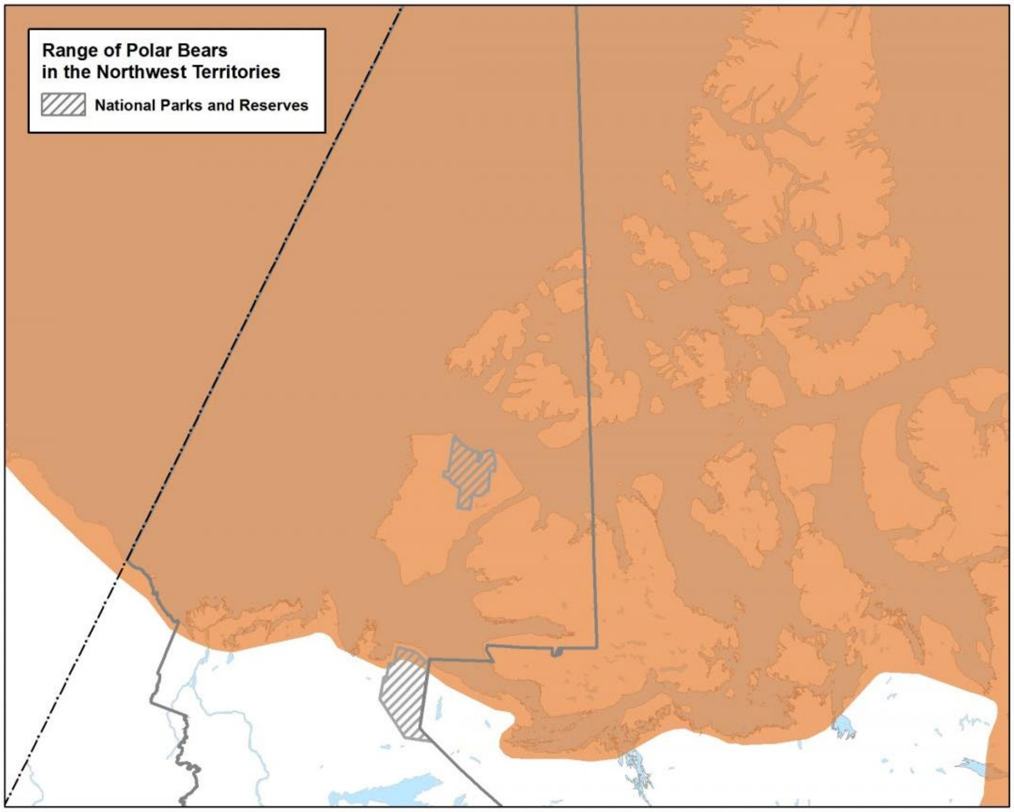

Figure 42. Range of polar bear in the NWT (NWT Species at Risk 2020).

Alpine Specialists

The two alpine specialists considered here (northern mountain caribou and collared pika) are expected to be moderately vulnerable to climate change. While these species demonstrate unique behavioural adaptations to climatic variability within their ranges (e.g. seeking shade or windy areas), they also have habitat associations (e.g. reliance on ice patch habitat) and physiological tolerances (e.g. susceptibility to heat stress) that increase their vulnerability to climate change. The changes are, overall, expected to reduce habitat availability/suitability.

Collared Pika

The collared pika is a small mammal in the rabbit family. It is a Beringian relict species that occurs only in alpine talus slopes in northwestern British Columbia (BC), YT, NWT and Alaska (Figure 43). Collared pika habitat (talus fields) provides climate microrefugia, permitting behavioural thermoregulation under adverse conditions. While they are well-adapted to cold temperatures, their high metabolic rate and low thermal conductance make them highly vulnerable to heat stress. This means that two hours of exposure to temperatures of 28°C could result in death. Without shade, prolonged exposure to temperatures of even 25.5°C may result in death. Collared pikas have a fairly short generation time (two years) and produce three to four offspring/litter. Growth rates are among the highest known in the rabbit family. Evidence suggests there is limited inbreeding within collared pika populations and that genetic diversity can be maintained despite declines in density. Collared pikas have generally poor dispersal ability.

Collared pikas are considered highly vulnerable to the effects of climate change in the NWT. Rates of change in temperature and precipitation are proceeding at a faster rate in collared pika range than in most other areas of Canada. Although there exist considerable uncertainties in terms of the extent, severity and impact of climate change to collared pikas and their habitat, impacts from increased precipitation variability, changes in vegetation communities and increasing temperatures have the potential to substantially affect collared pika populations in the long term. These changes could increase distance between habitat patches or reduce habitat suitability. Given low dispersal capacity, this is expected to impact gene flow between populations and regional population persistence. In contrast, benefits may accrue to collared pikas in the form of early spring snowmelt, which could improve forage and caching opportunities.

Collared pikas are subject to few non-climate stressors in the NWT (i.e., landslides are the primary non-climate threat) and this is not expected to change significantly in the foreseeable future. Climate change is by far the most serious threat to their long-term persistence (COSEWIC 2011b).

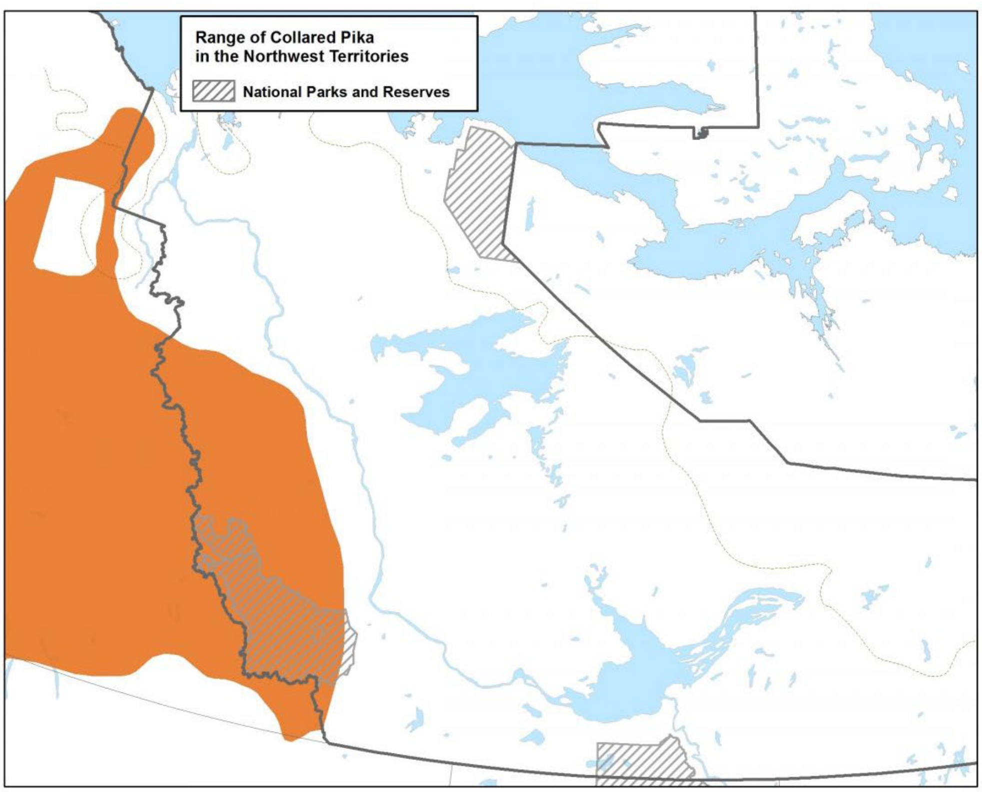

Figure 43. Range of collared pikas in the NWT (NWT Species at Risk 2020).

Northern Mountain Caribou

Northern mountain caribou range primarily occurs in northwestern Canada, including the NWT, YT and BC, as well as eastern Alaska (Figure 44). Habitat selection and use appears to be fairly flexible, although ice patch habitat is considered critical summer habitat for northern mountain caribou. As with other caribou, winter access to lichens for foraging is essential. Relative to other ungulates such as moose, caribou display late age of maturity and a low reproductive rate. With high rates of calf mortality, this could inhibit population recovery following decline. Northern mountain caribou have excellent dispersal capacity.

Northern mountain caribou are likely very sensitive to the effects of climate change. Loss of critical ice patch habitat, which is already clearly noticeable, is particularly concerning. Ice patch habitat is used primarily for cooling and escaping insect harassment in the summer and loss of this habitat component, together with potential increases in insect harassment, could adversely impact the health and condition of northern mountain caribou. Changes in vegetation composition (associated with warmer and drier summers, changes in wildfire frequency and severity and permafrost degradation) could be problematic to northern mountain caribou if they result in changes to forage availability. Likewise, changes to the depth and hardness of snow, along with increases in icing events (rain/freeze) may impede access to forage. Many of these changes are already being observed.

Climate change is one of the primary threats to northern mountain caribou in the NWT. However, while their range in the NWT is large and generally undisturbed, a number of non-climate stressors are also impacting this species in the NWT, which may exacerbate climate-related stresses. Mineral exploration and development, particularly around the South Nahanni Range Road, North Canol Road and the Macmillan Pass areas are particularly concerning. Disrespectful harvesting (increasing harvesting pressure, wounding caribou and meat wastage) and recreational access, particularly related to use of all-terrain vehicles, are tied to localized declines in the northern mountain caribou population. Direct disturbance to northern mountain caribou is associated with all these activities, but habitat destruction and disturbance are similarly important, especially given the long time required for lichen to recover from disturbance (30-80 years) and the overall harsh growing conditions in high alpine habitat (SARC 2020b).

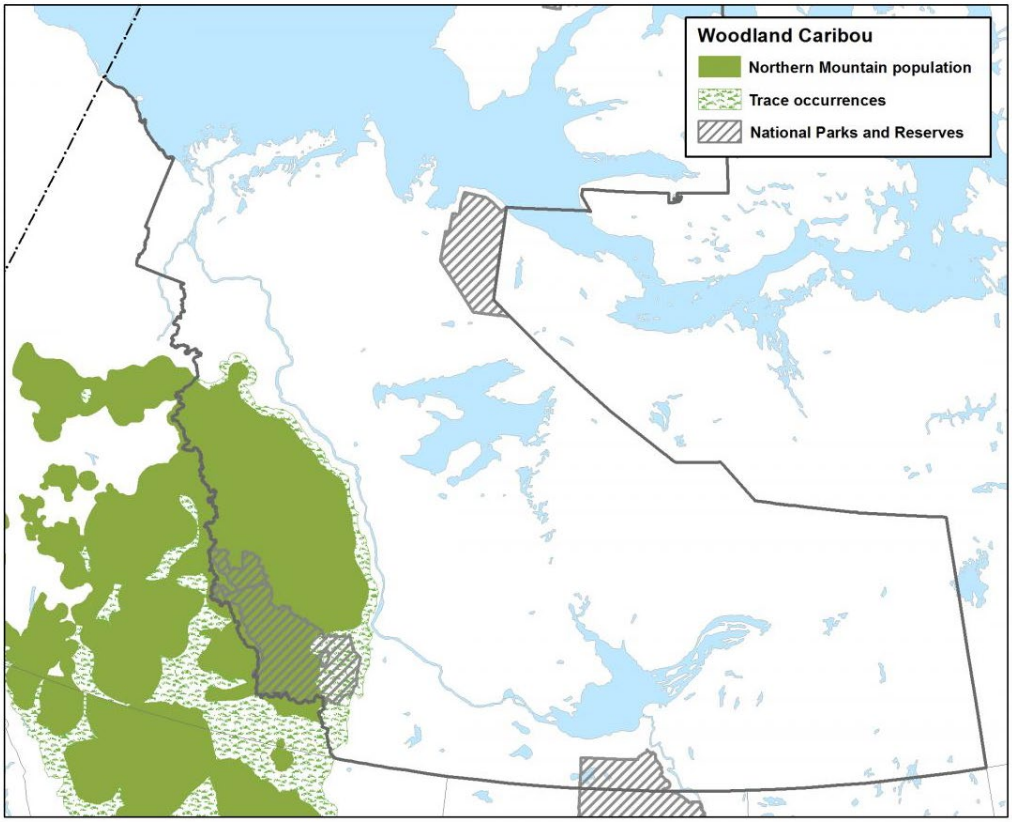

Figure 44. Range of northern mountain caribou in the NWT (NWT Species at Risk 2020).

Grassland/Meadow Specialists

Wood bison, the sole meadow/grassland specialist being considered in this report, uses wetland meadow habitats interspersed with forest stands. Compared to the other ungulates considered here, regular disturbance from fires and flooding/drawdowns are integral to building suitable habitat. If forest fire frequency increases, climate change may help increase habitat availability for this species. However, 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.

Wood Bison

Wood bison in the NWT occur in three distinct populations: the greater Wood Buffalo ecosystem population, the Mackenzie population and the Nahanni population (Figure 45). This early successional grazer occupies wetland meadow habitats interspersed with forest stands. Habitat availability is maintained by regular disturbance from flooding/drawdowns and forest fires. Adaptive capacity (low reproductive capacity and good dispersal ability) may be impacted in greater Wood Buffalo ecosystem bison by brucellosis(delayed age of first successful reproduction) and the presence of the bison control area (which functionally acts as a movement barrier to this population in order to prevent spread of disease to Mackenzie and Nahanni bison). With the possible exception of the greater Wood Buffalo ecosystem population, wood bison populations have low genetic diversity, stemming from small founding populations, which can increase vulnerability to disease and environmental changes and impair fecundity and health.

Wood bison are expected to fair reasonably well in the face of climate change, although effects may be both positive and negative. Projected increases in forest fire frequency may help maintain the mixed early successional habitat preferred by wood bison, while increased forest fire intensity may adversely impact the species (e.g. direct mortality, loss of lichen-supporting forest stands, increased predation, barriers to movement). Climatic changes, including climate variability and changes in precipitation (including snow) and seasonality, which affect growth of sedges and grasses in wood bison habitat are important to consider, especially in combination with effects from upstream hydroelectric projects (discussed below). A projected drying trend in the future may result in increases in preferred habitat for wood bison.

The most important non-climate stressors to wood bison in the NWT are disease (anthrax, tuberculosis and brucellosis in particular) and habitat loss. Tuberculosis and brucellosis are, at this time, restricted to the greater Wood Buffalo ecosystem population, with the bison control area in place to prevent spread to the other two populations. Anthrax outbreaks are infrequent but can result in high mortality during outbreaks. Future agricultural development, particularly involving livestock, is a potential future threat in the NWT given the potential for livestock to transmit disease to wood bison. There are now import, possession and export regulations. Upstream hydroelectric developments, specifically the W.A.C. Bennett Dam and Williston Reservoir, are effectively altering flooding/drawdown cycles downstream within wood bison habitat. The shift in this disturbance regime is changing riparian corridor conditions, favouring the growth of woody plants over sedges and grasses. The recent approval of the Site C dam is concerning in this context. Vehicle-bison collisions on highways is also an important concern in the NWT (SARC 2016; CMA 2019).

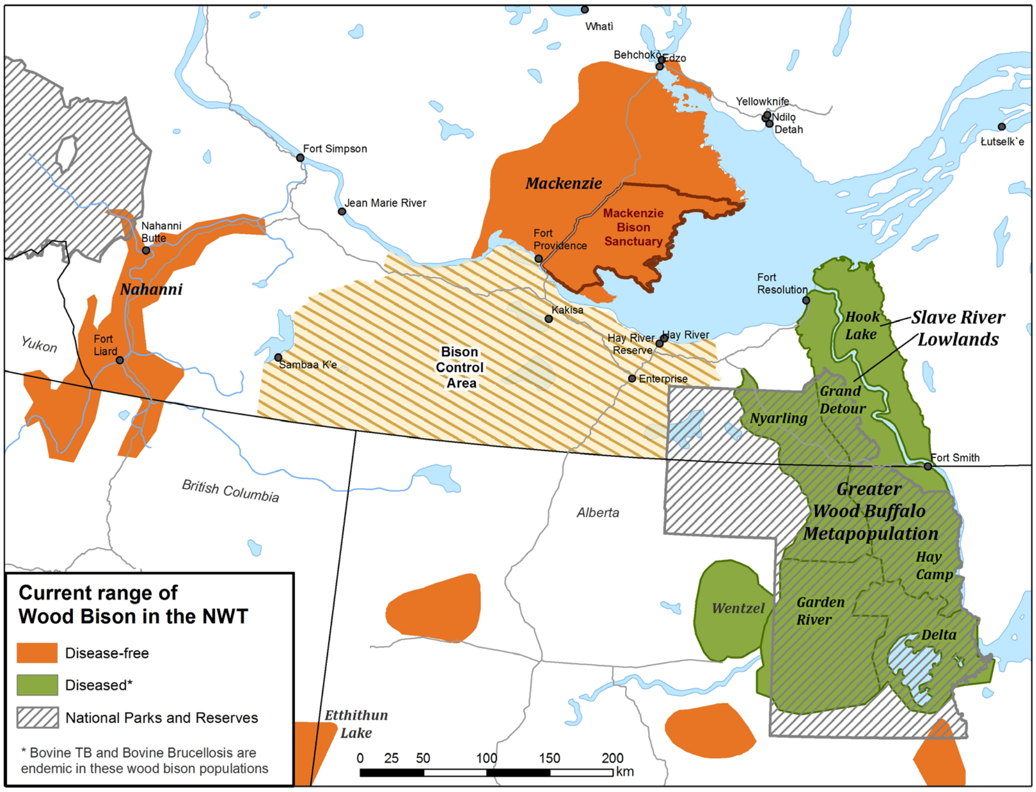

Figure 45. Range of wood bison in the NWT (NWT Species at Risk 2020).

Old Forest Specialists

Old forest specialists (barren-ground caribou and boreal caribou) show a moderate level of vulnerability to the effects of climate change. For these species, sensitivity to forage availability, fidelity to key habitats, the need for habitat connectivity, predation and insect harassment inform their high degree of vulnerability. The potential for increasing forest fire frequency and intensity is a commonly noted concern for these species, given the possibility of habitat fragmentation and removal of key winter forage, although the projections for forest fires are uncertain and dependent upon future moisture availability. Long-term fidelity to specific areas, including calving grounds, pre-calving areas, post-calving areas and water crossings, make these species vulnerable to human impacts at these sites. Over the longer-term, permafrost melt has the potential to shift lichen-supporting forest stands to wetland areas, which would reduce preferred habitat and forage availability of old forest specialists.

Barren-ground Caribou

BGC, for the purposes of this assessment, include the Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly and Qamanirjuaq herds. The Porcupine herd is considered a geographically distinct sub-population in the NWT (Figure

46). BGC migrate long distances between wintering and calving grounds each year. They are well-adapted to their environments, favouring the cold seasonal temperatures that help prevent the icing conditions that can make forage unavailable in the fall and winter and limit heat stress/insect harassment during the summer. Herds show long-term fidelity to calving grounds, pre-calving migratory routes, post-calving areas and water crossings. They rely strongly on lichen for food during the winter. Calving typically begins at three years of age, with production of a single calf each year after maturity is reached, unless females are in poor condition. Generation time is eight to nine years.

BGC are likely very sensitive to the effects of climate change. Increases in forest fire frequency/intensity are a possibility in the NWT over the long-term, although this is tied strongly to the development of warmer and drier conditions. Warmer and wetter conditions may mean there is no substantial change to the NWT's forest fire regime (Blyth et al. 2016). If forest fire frequency/intensity does increase, it is likely to impact the availability of preferred winter habitat (mature forest stands with an abundance of lichens) (ENR 2008). Bot and warble fly infestations, which are partly determined by weather, are likely to increase with increasing summer temperatures. This is already being seen in the Bathurst herd's summer range. Warmer fall and late winter air temperatures increase the probability of freeze-thaw events, which impact forage accessibility. Increases in primary productivity could be beneficial, but may not be tied to increases in forage quality. Ultimately, climate change may act in a cumulative manner on BGC, with individual impacts acting together to impact caribou.

In addition to climate change, primary non-climate stressors for BGC include development activities and predation. The combination of these stressors and climate change are reflected in an overall BGC population decline of more than 85% in the NWT since the highs seen in the late 20th century (SARC 2017b).

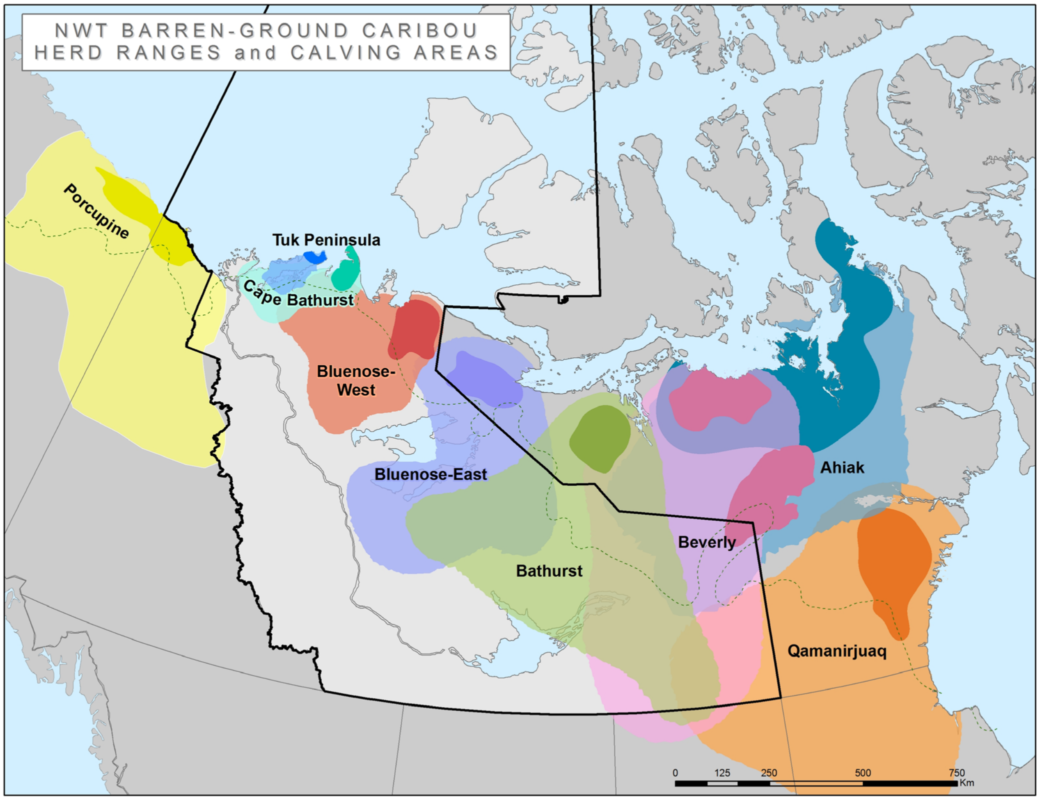

Figure 46. Range of barren-ground caribou in the NWT with calving grounds shown in darker colours (NWT Species at Risk 2020).

Boreal Caribou

Boreal caribou occur in low densities throughout the Canadian boreal forest (Figure 47). Large areas of intact habitat are required for boreal caribou to effectively minimize predation risk. Important habitat components include overwintering areas with adequate lichen supply and summering habitat for lactating females. Shade, cool forests, or open areas exposed to the wind may be important for thermal regulation and insect relief during summer.

Forest fires have been identified as an important factor influencing the availability of boreal caribou habitat in the NWT. Forest fires are thought to be increasing in many areas and impacting boreal caribou winter forage availability as a result. Increases in fire frequency/intensity are a possibility as climate changes, although recent modeling indicates that this is strongly tied to moisture availability. That is, forest fire frequency and intensity is likely to increase in warmer and drier conditions. Warmer and wetter conditions, however, may result in no substantial change to the fire regime in the NWT (Blyth et al. 2016). In the forested part of the NWT, warmer and more variable weather in all seasons is already being observed. Biting insects are most active during periods of warm temperatures, thus longer, warmer summers may lead to longer periods of insect harassment and, as a result, reduced body condition for boreal caribou. Range expansion or introduction of other diseases and parasites may also be facilitated by climate change. Higher/drier forested areas underlain by permafrost that support lichen may subside as permafrost melts. These areas may then become wetlands, which could result in tree death and subsequent loss of lichen.

The main non-climate stressors to boreal caribou are habitat loss, degradation and fragmentation from human-caused and natural disturbances that result in increased predation risk. The level of threat is considered to be high (SARC 2012a).

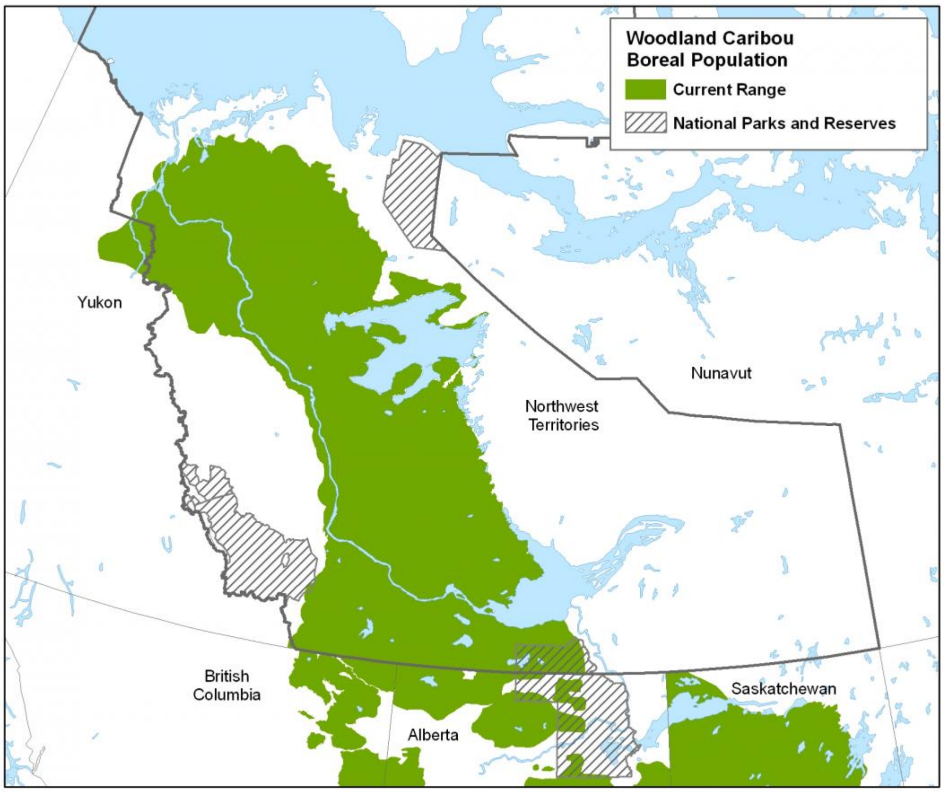

Figure 47. Range of boreal caribou in the NWT (NWT Species at Risk 2020).

Marine Mammals

The impact of climate change on the two marine mammals considered here (bowhead whale and grey whale) is less consistent. Although both species have exceedingly long generation times, low reproductive capacity, high dispersal ability and climate change will undoubtedly impact both species - grey whales are expected to benefit from climate change while bowhead whales are expected, on balance, to be adversely affected. Grey whales may see the expansion of their feeding areas and, as a result of warming waters, may be able to stay in the north year-round, avoiding the resource expenditures associated with migration. On the other hand, bowhead whales will likely see a decline in forage availability with the decline of highly productive ice edge habitat. Offshore oil and gas development, increased shipping, pollution and noise is expected to impact both species.

Bowhead Whale

Bowhead whales have a broad range, occupying marine areas throughout the circumpolar north. Only the Bering-Chukchi-Beaufort population occurs in the NWT (Figure 48). Bowhead whales are specialized filter feeders and tend to focus forage efforts at ice edge habitat, which represents an area of particular high productivity. The Bering and Beaufort Seas represent important feeding areas. Bowhead whales are very long-lived (>100 years) and do not begin reproducing until about 25 years of age. A single calf is produced every three to four years following maturity.

The impacts of climate change on bowhead whales are uncertain at this time. However, it is likely that declines/changes in sea ice will affect food availability, with less ice algae being produced and therefore less food for copepods (one of the primary food sources for bowhead whales). Changes in sea ice are already being observed and are likely to continue over the short- and long-term. Inuit knowledge holders have observed changes in the distribution of bowhead whales in the Barrow Strait, corresponding with ice edge retreat.

The population of bowhead whales has responded positively to the cessation of commercial whaling, a key factor that resulted in their earlier, significant declines. Looking forward, important non-climate stressors include offshore oil and gas development, increased shipping and noise disturbance; threats that are thought likely to increase with changes in sea ice associated with climate change. Industrial pollution associated with oil and gas development and shipping will likely also be a concern as/if these activities increase (COSEWIC 2009a).

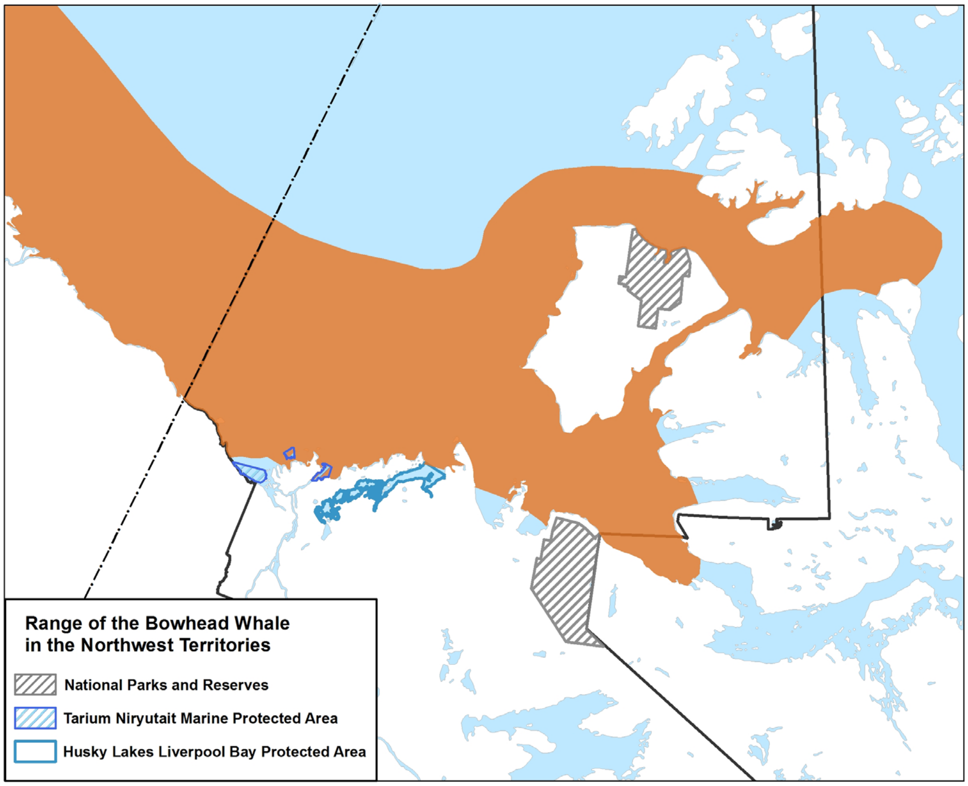

Figure 48. Range of bowhead whale in the NWT (NWT Species at Risk 2020).

Grey Whale

The northern Pacific migratory population of grey whales migrates between winter calving grounds in Mexico and summer feeding areas in northern Alaska, Russia and Canada, including the Beaufort Sea (Figure 49). Their migration totals more than 18,000 km each year. Grey whales demonstrate highly specific habitat selection in their reproductive range and strong fidelity to feeding areas. They feed on a fairly wide range of benthic organisms. Grey whales are late-maturing and produce a single calve up to every two years thereafter. Generation time is estimated at 23.3 years.

Overall, despite pronounced effects of climate change in their Arctic feeding areas, the effects of climate change are thought likely to provide a net positive effect to grey whales. Some changes in their behaviour are already being observed, including altered timing of migration, expansion of feeding areas and some individuals remaining north through the winter.

Throughout their global range, grey whales may be vulnerable to human disturbance, including habitat disturbance/destruction and noise. Harvesting, although a significant historical threat, is now considered sustainable. Threats in the NWT are considered minimal at this time (COSEWIC 2017d).

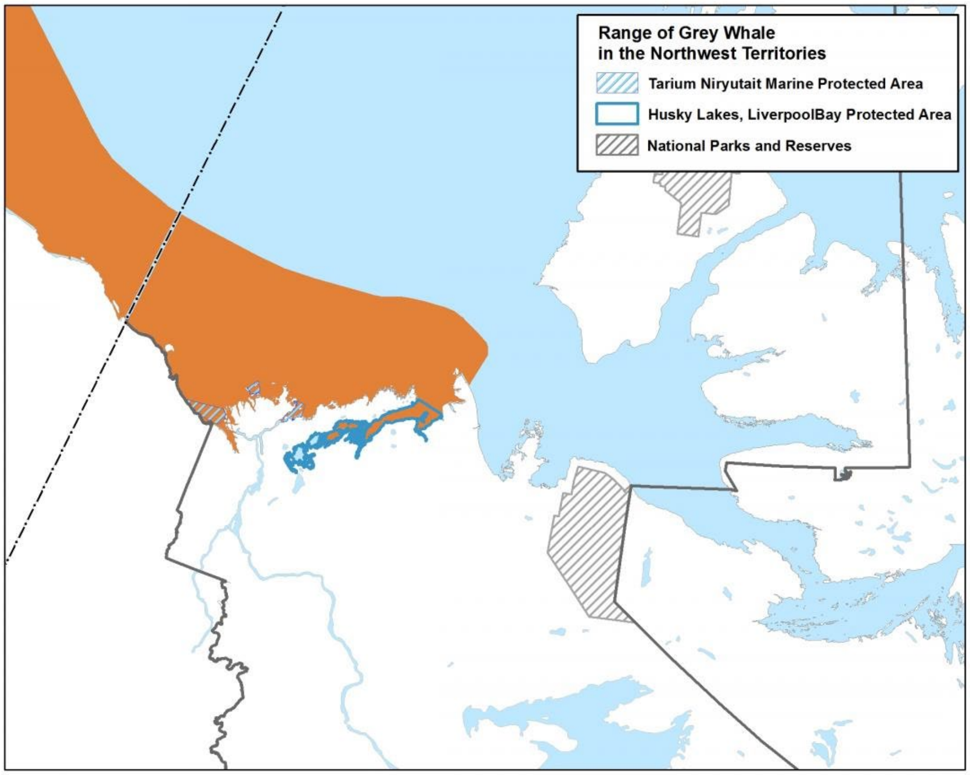

Figure 49. Range of grey whale in the NWT (NWT Species at Risk 2020).

Bats

Hibernating bats may see benefits and drawbacks as a result of climate change. While warming temperatures may increase the foraging season and decrease the duration of hibernation, changes to temperature and humidity conditions in hibernacula could prove to be problematic. Warming temperatures could facilitate northward range expansion, but this is ultimately contingent on roost availability. How climate change will impact the spread and virulence of white-nose syndrome (WNS) is uncertain. Other threats include human activities that disturb or alter hibernacula, exclusion and removal of maternity roosts, timber harvest and predation by domestic cats and mercury contamination.

Little Brown *myotis* and Northern *myotis*

In Canada, both little brown *myotis* and northern *myotis* occur in all provinces and territories except NU. The little brown *myotis* has the widest distribution of bats in North America. The northern limit of both species' ranges is likely below the treeline, related to climate and roost availability (Figures 50 and 51). Torpor and hibernation permit survival during extreme or unfavourable conditions. Important habitat requirements include suitable hibernation, roosting, mating and foraging sites. Temperature and humidity are key parameters in hibernacula. Both species are considered flexible insectivorous foragers, although northern *myotis* tends to be somewhat more specialized in their foraging approach. Females typically produce one pup per year, although reproduction may not occur in years with poor resource availability. Evidence suggests that reproduction in little brown *myotis* may decline as latitude increases. Both species are long-lived (max. 34 years and five to 16-year generation time in little brown *myotis*; max. 19 years and 6.8-8.5-year generation time in northern *myotis*). Dispersal capacity is strong.

Warming temperatures associated with climate change may reduce hibernation times and increase the functional season for reproduction and foraging. Whether this results in range expansion is more uncertain, given dependence on roost availability. Interactions between climate change and WNS, the most serious threat to little brown *myotis* and northern *myotis* in the NWT are unclear.

Both little brown *myotis* and northern *myotis* are considered highly vulnerable to WNS. At current expansion rates, it is expected to reach NWT bat populations within one to two decades. Additional non-climate stressors include human activities that change hibernacula conditions (accessibility, temperature, humidity, airflow, and hydrology), exclusion and removal of maternity roosts (non-lethal exclusion during the breeding season or lethal extermination), timber harvest, predation by house cats and mercury contamination (SARC 2017c).

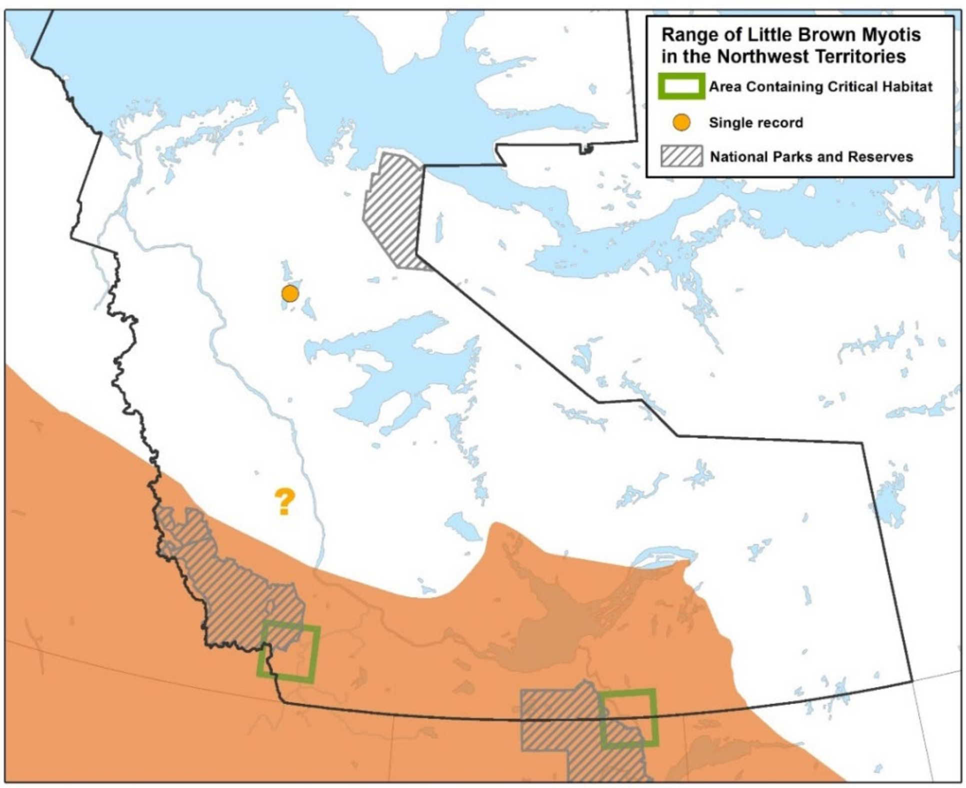

Figure 50. Range of little brown *myotis* in the NWT. Question marks indicates uncertainty with respect to the northern extent of the range (NWT Species at Risk 2020).

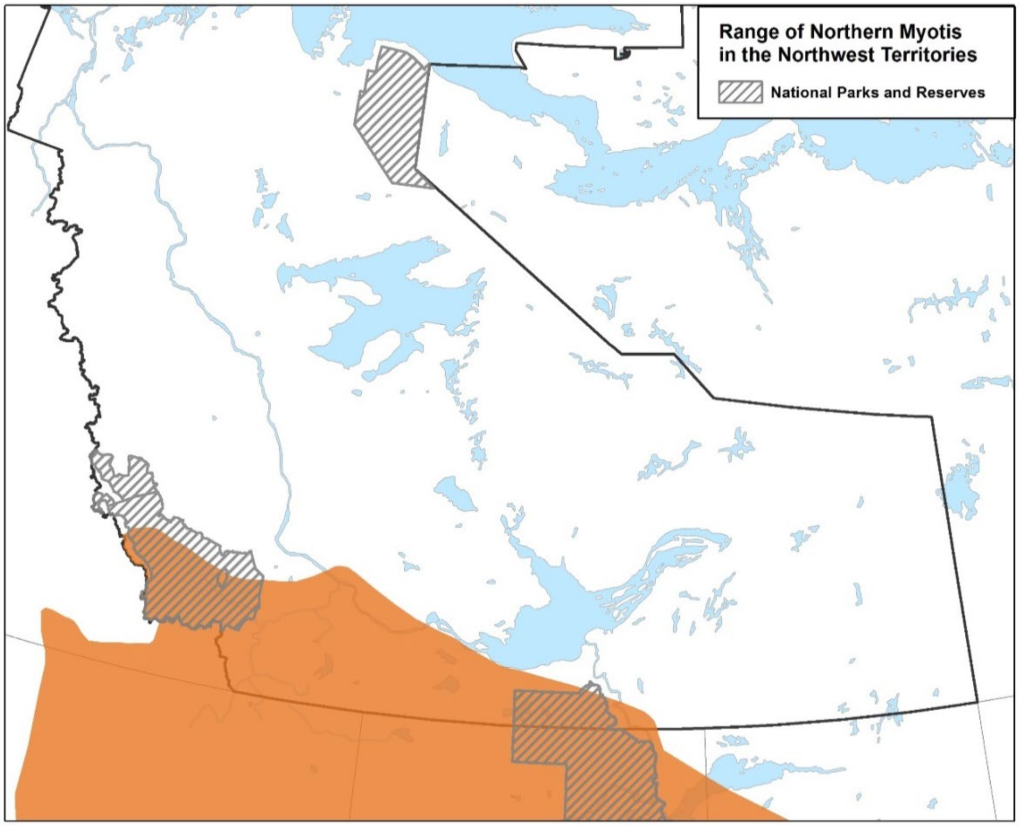

Figure 51. Range of northern *myotis* in the NWT (NWT Species at Risk 2020).

Birds

Of the 283 species of birds that inhabit the NWT, only about 6% reside in the NWT year-round. The birds of the NWT perform important ecological roles, including as keystone species, ecosystem engineers, indicators of ecological change and as predators of insect/pest species (ENR 2010b). The GNWT manages only those bird species that do not fall under the federal *Migratory Birds Convention Act* (administered by Environment and Climate Change Canada (ECCC)). In this context, focused cooperation of management authorities throughout their global ranges is necessary to ensure their long-term conservation.

Nineteen bird species at risk were included in this Phase 1 vulnerability assessment, including aerial insectivores, forest birds, marine birds, raptors, waterfowl and other water birds.

Data can be limited in areas of the NWT, compared to the south, given the geographic scale of the territory, sometimes widely-spaced communities and limited reach of conventional measures such as Christmas bird counts and the North American breeding bird survey (Ecosystem Classification Group 2013). Overall, they range from not particularly vulnerable (i.e., short-eared owl, peregrine falcon) to moderately to highly vulnerable to the effects of climate change (i.e., ivory gull and red knot (*rufa*)). Most fall somewhere in the middle. Although these species vary in terms of range and habitat preferences, declines in insect prey availability and the potential for phenological mismatch (between timing of insect emergence and bird breeding seasons), among other stressors, are likely to affect a number of these birds. Those that are migratory are more vulnerable to potential mismatches, given the accelerated rate at which climate change is progressing in their breeding range versus their wintering grounds.

As can be seen in the table below (Table 11) and as detailed in the more expansive species summaries that follow, there are few non-climate stressors affecting these birds in the NWT at this time. That does not, however, imply that the birds are not subject to significant non-climate pressures elsewhere in their ranges, or that the impacts elsewhere do no impact the abundance and health of the birds throughout their life cycles, including while in the NWT. This underscores why cooperative management of species that move among different jurisdictions is necessary. Commonly noted non-climate threats across their ranges include: agricultural conversion/simplification/intensification, deforestation, wetland loss, collisions (both with buildings and along roads), pesticides (particularly salient for insectivorous birds), contaminants and house cat predation.

Regarding threats in the NWT, it should be noted that mercury is a commonly cited non-climate stressor to these birds. Mercury represents a contaminant spread via long-distance atmospheric dispersal from industrial operations. However, boreal mercury concentrations are also increasing as a result of permafrost melt (released as methylmercury). In sufficient concentrations, mercury can result in reproductive, behavioural and physiological impairments in a number of bird species.

Table 11. Summary of vulnerability assessment results for birds at risk.

Assessed species	Climate change sensitivity[29]	Non-climate stressors[30]	Adaptive capacity[31]
Aerial insectivores			
Bank Swallow	2	1	1
Barn Swallow	1.7	1	2.5
Common Nighthawk	2	1	2
Olive-sided Flycatcher	2	1	2
Forest birds			
Canada Warbler	2.3	1	1.5
Evening Grosbeak	2.5	1	1
Harris' Sparrow	1.7	1	1
Rusty Blackbird	2.5	1	1
Marine birds			
Ivory Gull	3	1	2.5
Raptors			
Peregrine Falcon	1.3	1	2.5
Short-eared Owl	1	1	1
Waterfowl			
Horned Grebe	2.3	1	1.5
Red-necked Phalarope	2.7	1	1.5
Other water birds			
Buff-breasted Sandpiper	1.7	1	1
Eskimo Curlew	2.5	1	2
Red Knot (*islandica*)	3	1	1.5
Red Knot (*rufa*)	3.5	1	1.5
Whooping Crane	2.3	1	3
Yellow Rail	2	1	1

Aerial Insectivores

Aerial insectivores (bank swallow, barn swallow, common nighthawk and olive-sided flycatcher) are declining globally, in concert with documented declines in flying insect populations. It is unclear at this time whether insect populations in the NWT are experiencing a similar decline. The possibility of phenological mismatch is also concerning and could have important implications for these species given different rates and magnitude of climate change between their breeding and wintering ranges (environmental cues for migration may shift apart from cues for insect emergence at key times). Other impacts of climate change that have the potential to affect these species include adverse weather events (cold snaps, increases in precipitation and storms), flooding, river bank collapse, increasing forest fire frequency/intensity, heat stress and changes to insect abundance/community composition. Shifts in nesting/reproduction, altered reproductive

[29] The average of habitat, abiotic and biotic factors.

[30] Scored based on threats in the NWT only. This does not imply that there are not significant threats elsewhere in the range.

[31] Based primarily on reproductive and dispersal capacity.

success and range shifts are possible responses. Hydroelectric development is the only non-climate threat noted in the NWT (for common nighthawk), given its potential to flood breeding habitat and alter hydrological regimes and thus insect abundance.

The aerial insectivores considered in this report all have moderate-good adaptive capacity, with the exception of barn swallow, although long-distance annual migrations can expose them to various threats throughout their life cycles and, in combination with relatively short periods of time spent on the breeding grounds, may make them particularly sensitive to changes in insect emergence/availability. The NWT constitutes a portion of the breeding habitat for these species (the larger breeding habitat includes portions of Canada, the United States and Central America, depending on the species). Wintering occurs in South and/or Central America.

Bank Swallow

Bank swallows are aerial-foraging insectivores with a range that extends across most of the globe. Breeding occurs in the northern two-thirds of the United States and across most of Canada (Figure 52). Wintering takes place primarily in South America. Although a long-distance migrant, home ranges during the nesting season are typically <1 km. Bank swallows can breed as early as one year of age, with breeding attempted annually thereafter. Clutch size averages five eggs with relatively high nest success. Severe long-term declines (98%) have been documented in the Canadian population over the last 40 years, likely the result of multiple interacting stressors.

Survival rates can be substantially impacted by weather events, particularly rainfall, river flooding, bank collapse and insect availability. An increase in precipitation in all seasons has been projected for the NWT (Zhang et al. 2019). Climate change may impact the timing of insect emergence, which has the potential to adversely impact food availability for insectivorous birds such as bank swallow. Increased coastal erosion and sea level rise in coastal areas, which is already being documented along the coast of the Arctic Ocean, may reduce breeding habitat. River flooding and bank collapse often result in nestling mortality in breeding areas.

Loss of breeding and foraging habitat, nest destruction, vehicle collisions and reduced prey abundance are apparent in other areas of bank swallow range, accompanied by substantial population declines. However, there are no serious non-climate stressors to bank swallows in the NWT (COSEWIC 2013).

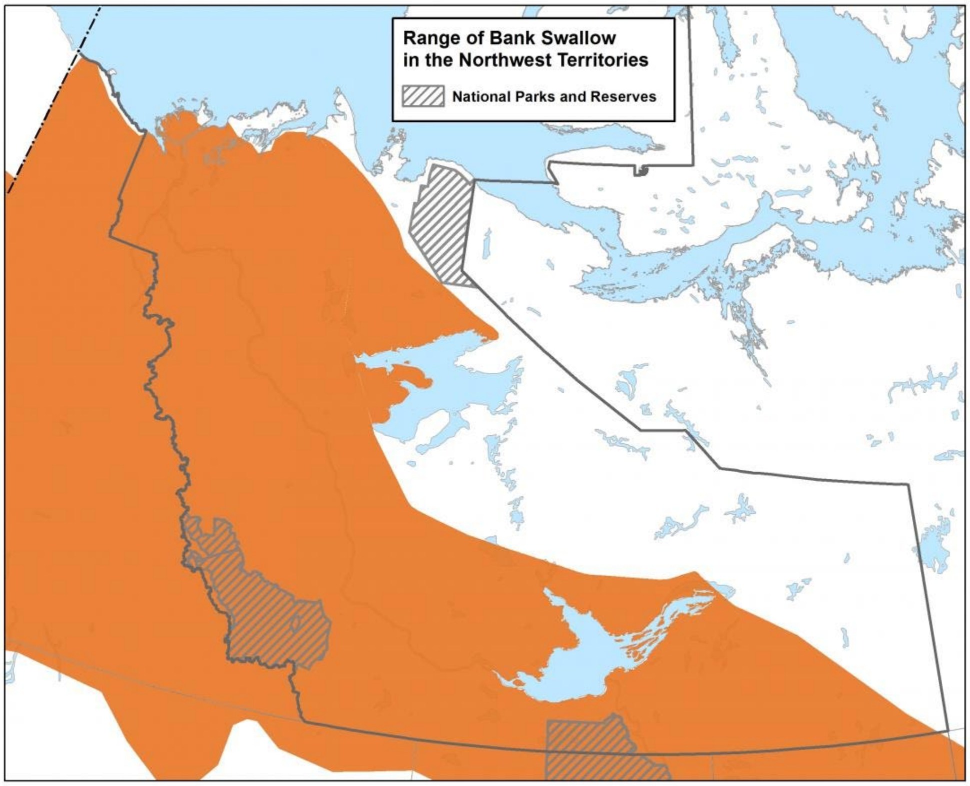

Figure 52. Range of bank swallows in the NWT (NWT Species at Risk 2020).

Barn Swallow

The barn swallow is the most widespread species of swallow in the world. In Canada, it is known to breed in all provinces and territories (Figure 53). Although the species has experienced declines in Canada since the 1980s (concurrent with declines seen in many aerial insectivores), the population may still be greater than it was prior to European settlement, given how well it adapted to nesting in human-made structures. This high degree of adaptability makes barn swallows broad habitat generalists, although wet sites with a nearby source of mud are required for nest construction and sensitivity to cold snaps is apparent during spring and nesting. Reproductive capacity is moderate and they show fairly strong nesting site fidelity.

Unlike many other species in the NWT, the barn swallow's response to climate change has been extensively studied, although these studies have been based primarily in Europe. Here, nesting and reproductions times are shifting earlier in response to warmer spring temperatures. Enhanced reproductive success has also been documented. In North America, however, these adaptive responses could make barn swallows vulnerable to cold snaps in the spring and may impact prey availability during the breeding season (COSEWIC 2011a).

The influence of non-climate stressors is unclear and minimal in the NWT. Ectoparasites and changes in insect prey abundance are threats of low magnitude in the NWT at this time.

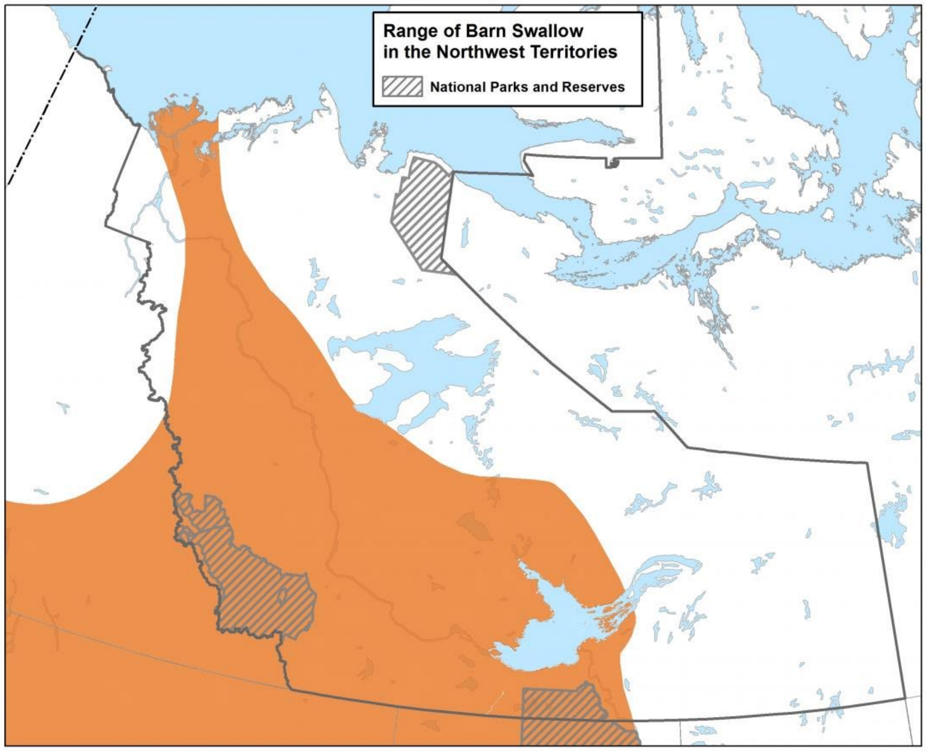

Figure 53. Range of barn swallows in the NWT (NWT Species at Risk 2020).

Common Nighthawk

The NWT is part of the breeding range of the common nighthawk. This breeding range extends throughout much of the Canadian provinces, as well as the southeastern YT and southwestern NWT (Figure 54) and into the United States and parts of Central America. Wintering occurs in South America for this migratory species. Habitat selection is quite broad, including open and partially open habitats, post-fire habitats and disturbed/developed areas. Fidelity to certain roosting sites suggests that although selection is broad, site characteristics such as shade and camouflage are likely important. Foraging site selection for this aerial insectivore is opportunistic; focusing on areas that attract a large number of flying insects, including waterways and well-lit areas. Migration paths may reflect features that enhance flight efficiency or foraging.

Adaptive capacity is considered moderate to good. One to two eggs are laid in one brood per year. Compared to other land birds, the common nighthawk has a short breeding season. Combined with long incubation and nestling periods, annual productivity and population recovery is limited.

Declines or changes in insect populations likely represent the most important widespread threat associated with climate change for the common nighthawk. Its fall migration is currently synchronized with the emergence of flying ants, suggesting some degree of dependence on that food source and vulnerability to phenological mismatch. Impacts of mismatch may also be felt during key periods such as nest-laying, moult and chick-rearing. Climate change has also been associated with declines in the overall availability of flying insects (in addition to other factors affecting insect populations). Increases in extreme weather (temperature, precipitation, storms) may have severe impacts on populations locally, by increasing mortality and reducing reproductive success (e.g. overheating, changes to abundance of flying insects). Increasing frequency of forest fires in the boreal forest may have both positive and negative impacts to the common nighthawk. Forest fires may, initially, increase suitable habitat availability (i.e., open/partially open post-fire habitat) and contribute to temporary increases in the local availability of insect prey (e.g. beetles); they may also destroy nests.

Threats are poorly understood, but the most serious threats in the NWT likely include changes in aerial insect abundance, availability and community composition and changes in weather regimes, including precipitation and temperature extremes. Non-climate stressors within the NWT are likely limited to hydroelectric projects (flooding of common nighthawk habitat and changes to local insect populations) (COSEWIC 2018b).

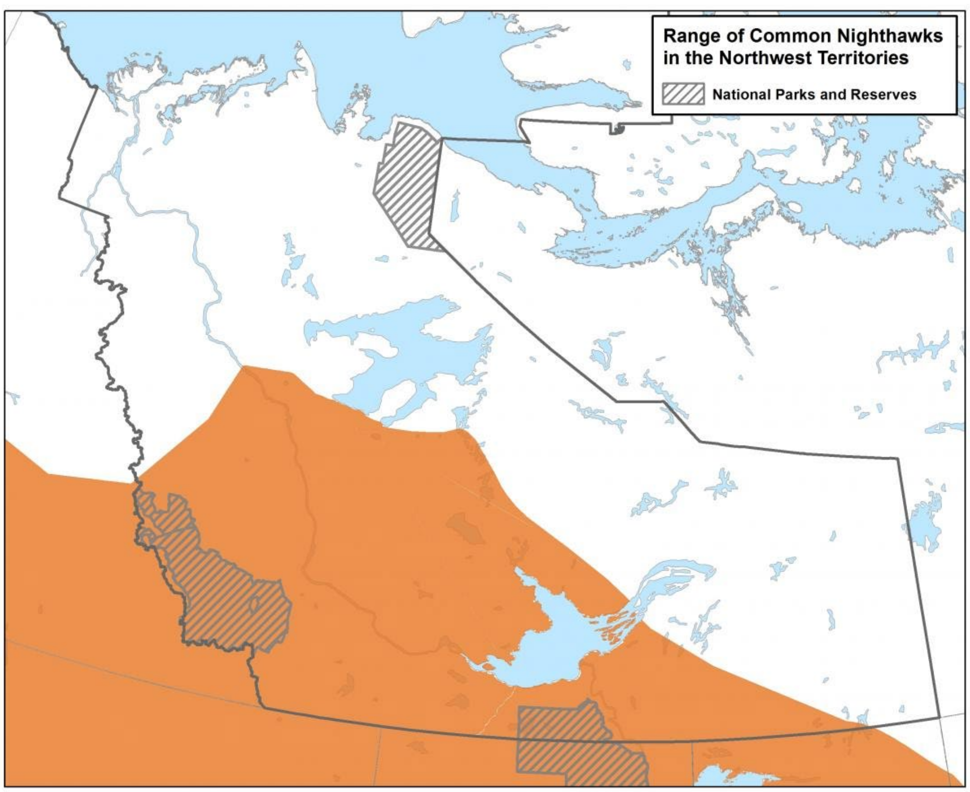

Figure 54. Range of common nighthawks in the NWT (NWT Species at Risk 2020).

Olive-sided Flycatcher

The olive-sided flycatcher is an insectivorous, migratory songbird with one of the longest migrations of any North American flycatcher, flying up to 8,000 km between their breeding grounds in Canada (Figure 55) and the United States and wintering grounds in Central and South America. Preferred breeding habitat is often semi-open mature forests. Olive-sided flycatchers demonstrate fidelity to both breeding and wintering grounds. An average of three eggs/clutch are laid, with a single brood each year. Olive-sided flycatchers have a relatively long nesting period, coupled with a short period on the breeding grounds.

How climate change will impact olive-sided flycatcher is uncertain, but it is likely to have an effect through changes to the forest fire regime, insect availability, changing moisture conditions and increased adverse weather events. Forest fire frequency and severity is expected to increase with climate change, which may remove areas of breeding habitat and affect insect availability (either increase or decrease availability, depending on intensity, location and time since the burn). Insect availability may also change in response to changing moisture conditions and the potential for mismatch between insect availability and chick hatch is a risk. Extreme weather events such as storms and hurricanes have been known to cause mortalities during migration and of nestlings. As a result of these effects, olive-sided flycatcher distribution may shift northwards.

Global threats to olive-sided flycatcher include habitat loss in the wintering range, reductions in insect availability and pesticide use. In the NWT, threats are few, although declines in insects could be potentially important in the future. Significant declines in many insect species are already been observed across many regions of the world (COSEWIC 2007a).

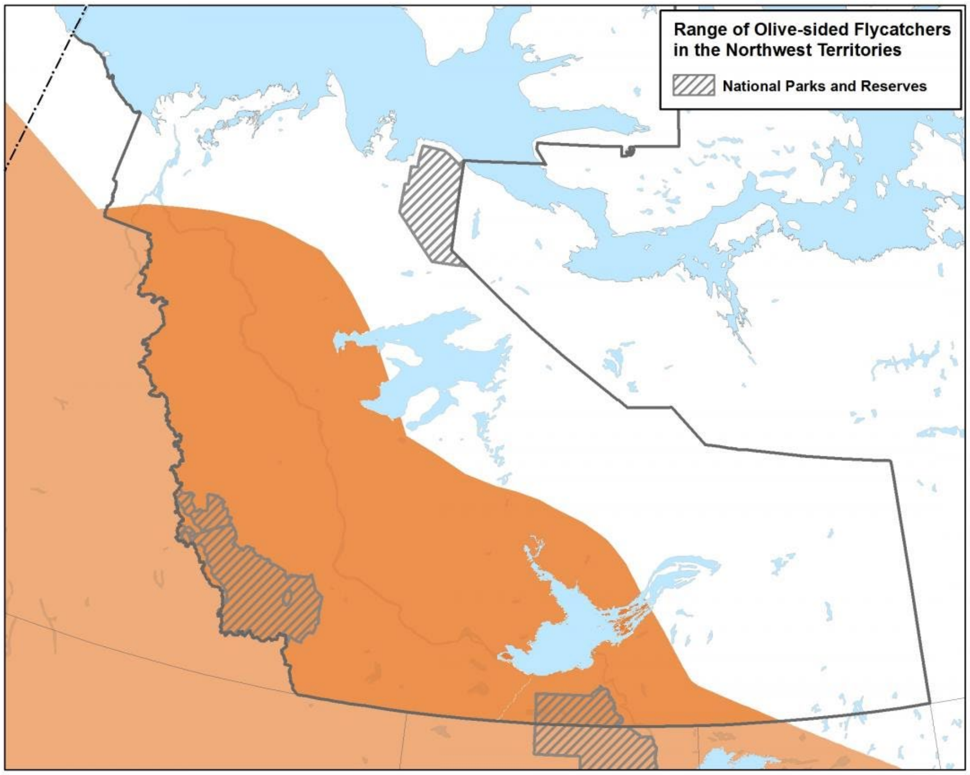

Figure 55. Range of olive-sided flycatchers in the NWT (NWT Species at Risk 2020).

Forest Birds

As with aerial insectivores, the possibility of a mismatch developing between breeding times and insect/invertebrate emergence is concerning for some of the forest birds discussed here (Canada warbler, evening grosbeak, Harris' sparrow and rusty blackbird). Likewise, the long migration undertaken by the Canada warbler makes the development of mismatches more likely for this species. Overall, the bird species considered here can be considered moderately sensitive to the effects of climate change. Beyond the possibility of phenological mismatches, other impacts of climate change that have the potential to affect these species include heavy rain, extreme temperatures, droughts, slumping/erosion near nesting sites, declines in forage/prey species, forest fires, wind storms, changing distribution of predator/pest species and earlier availability of snow-free nest sites. Changes in distribution (shifting northward or range contractions), nest failures, mortality, heat stress, disrupted migration and earlier breeding are possible responses that vary depending on the species and its sensitivity and exposure to climate change.

As noted earlier, non-climate stressors are less severe in the NWT compared to other areas of the ranges and for these particular species, are expected to be low to negligible at this time. Threats across their ranges can be substantial though and include habitat degradation/loss (e.g. agricultural conversion/intensification), collisions, pesticides and contaminants (lead, mercury, organophosphorus compounds, brominated flame retardants and polybrominated diphenyl ethers (PBDEs)) and house cat predation.

The forest birds considered here all have good adaptive capacity, with reasonably strong reproductive capabilities and good dispersal capacity. This is expected to assist their response to both climate and non-climate stressors, but it must be noted that some of these species have lifecycle characteristics, like limited time on the breeding grounds, that could hinder a highly adaptive response to these pressures.

Canada Warbler

The Canada warbler is a small, migratory song bird, with a breeding range that includes all Canadian provinces and territories except NU and Newfoundland (NL) and Labrador (as well as the northeastern United States) (Figure 56). Migratory range includes the United States and Central America, while wintering range is found in South America. Habitat selection during the breeding season and migration is fairly diverse, but a well-developed shrub layer is essential. On the wintering range, mature cloud rainforests at an altitude of 500-2,500 m are used primarily, as well as second-growth forests, forest edges, coffee plantations, agricultural field edges and semi-open areas. Adaptive capacity is reasonably strong, although limited to some degree by a shorter time on the breeding grounds relative to other warblers, a single clutch being laid each year and low adult survival.

As a long-distance migrant that uses seasonal habitats, Canada warbler is considered particularly sensitive to the effects of climate change and distributional shifts are thought to be a likely possibility. Given that warming is more severe in the breeding range than in the wintering grounds, mismatches between migration cues and insect availability on the breeding grounds are likely. Climatic changes such as heavy rain, extreme temperatures, droughts and intense wind storms could result in higher nest failure, mortality, issues with thermoregulation, disrupted migration and habitat damage.

Deforestation, often intensive, associated with agriculture, forestry, development and urbanization is an important threat in large areas of the range. Declines in insect prey populations are occurring across much of the globe and have been associated with declines in aerial insectivores. The Canada warbler, as an insectivore (although not an aerial insectivore), is expected to be similarly affected by insect declines. Collisions with buildings and communications towers, pesticide use and domestic cat mortality are also concerning. However, these threats have not been seen in a significant manner in the NWT to date (COSEWIC 2008a; Environment Canada 2016).

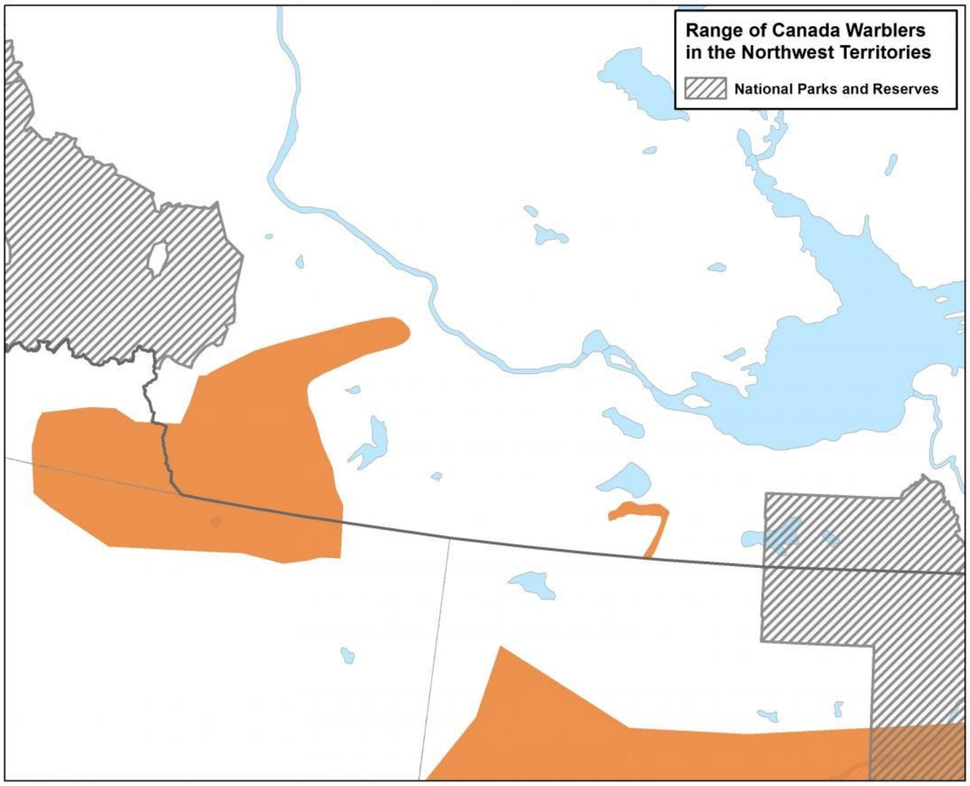

Figure 56. Range of Canada warblers in the NWT (NWT Species at Risk 2020).

Evening Grosbeak

The evening grosbeak is a long-distance migrant that breeds throughout much of North America. The area around Fort Liard, NWT, represents part of the known northern limit of this species (Figure 57). Evening grosbeak has good reproductive capacity, laying three to four eggs/clutch and showing little breeding site fidelity.

Adverse effects of climate change are likely to be felt most substantially in northeastern Canada and the United States, where a warmer and drier breeding season are expected to result in a contraction of balsam fir forest habitat and a reduction in spruce budworm, a key forage species. Mismatch between spring spruce growth and budworm feeding is a possibility (potentially adversely affecting the spruce budworm population) and increases in forest fire frequency in central and western Canada could reduce the amount of available suitable habitat. In contrast, potentially significant density and habitat suitability increases are projected for evening grosbeak in northern Canada in the long term, although these projections do not account for changes in forest distribution associated with climate change. Threats associated with habitat availability, window collisions and road-associated mortality are potentially important throughout their North American range, but there are no known non-climate threats to evening grosbeak in the NWT (COSEWIC 2016b).

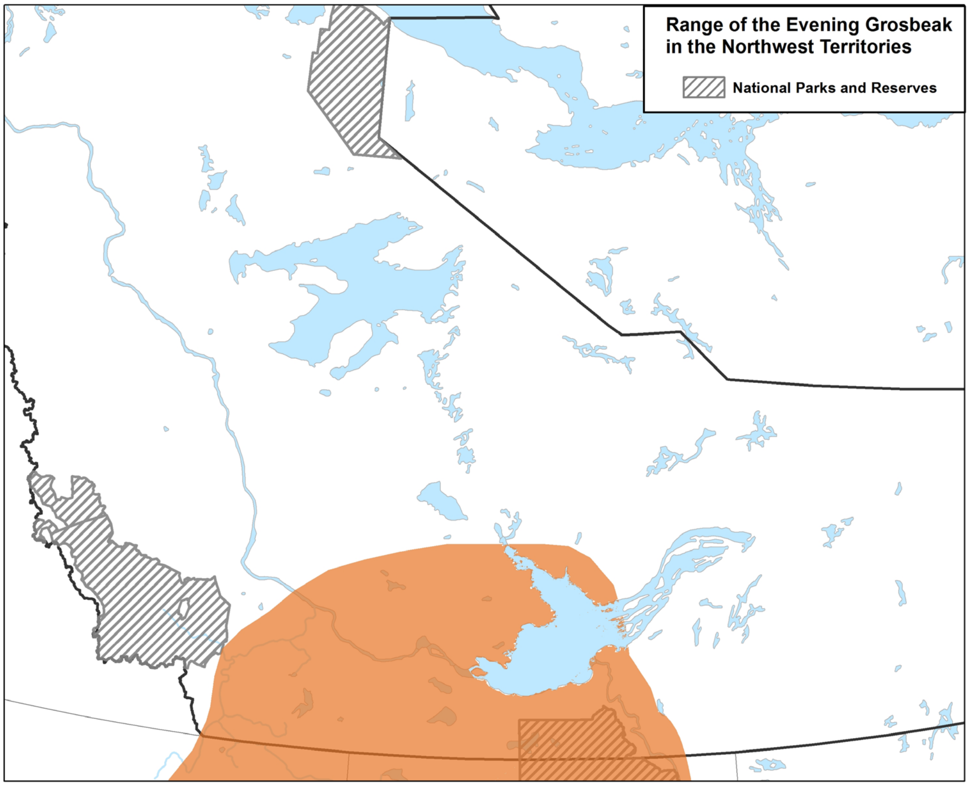

Figure 57. Range of evening grosbeaks in the NWT (NWT Species at Risk 2020).

Harris' Sparrow

This migratory species winters in the central midwest United States and breeds along the treeline in northern Canada (Figure 58). Breeding habitat is typically in spruce or tamarack dominant forests while wintering and migration habitat varies. The diet consists of a variety of plant species, but berries may be particularly important in the spring before insects emerge. This ground-nesting songbird has strong adaptive capacity.

Climate change is likely to impact Harris' sparrow and its habitat, although the scope and severity is unclear. High temperatures (20-30°C) may cause heat stress for young in the nest and increased parental attention as a result; likewise, for temperatures below -10°C. Storms may cause adults to abandon breeding areas, which can result in nest fatality if egg-laying has already occurred. Changes to habitat associated with climate change (e.g. changing distribution of pest/predator ranges, temperature extremes, vegetation changes) may reduce habitat availability in the southern portion of the Harris' sparrow's breeding range, but may facilitate a northward shift in range.

Overall, habitat loss (agricultural conversion/intensification), pesticide use, road mortality and predation by feral cats are the most significant threats throughout the range of Harris' sparrow. In the NWT however, threats are primarily related to climate change. Other factors (e.g. mining) are considered to be negligible at this time in the NWT (COSEWIC 2017c).

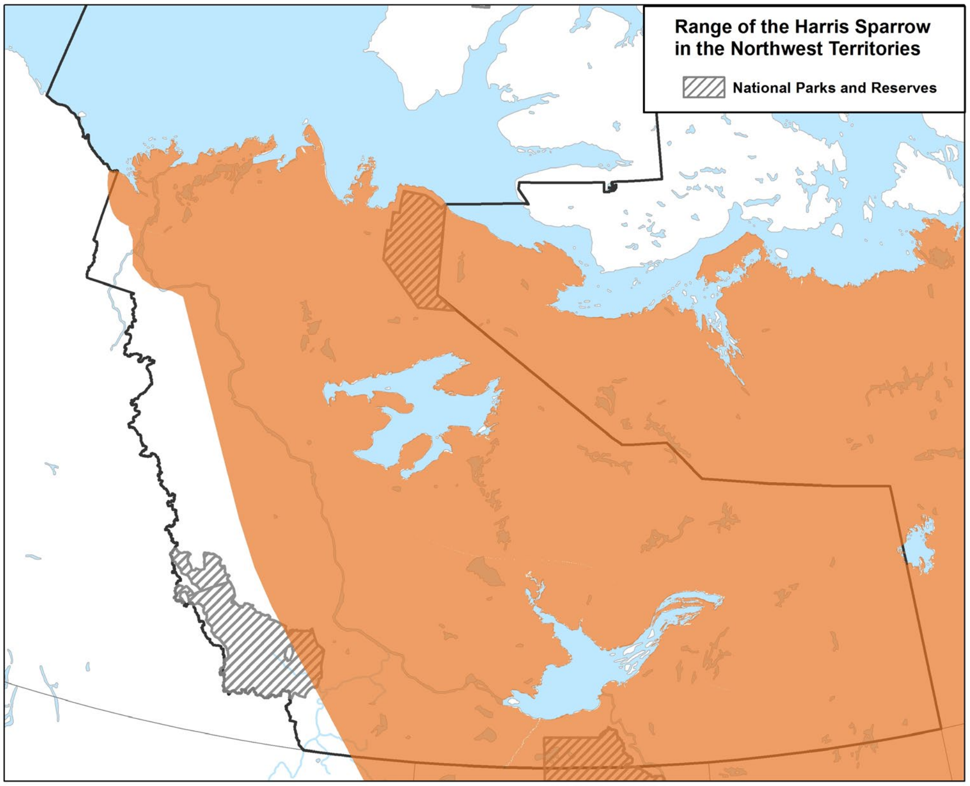

Figure 58. Range of Harris' sparrows in the NWT (NWT Species at Risk 2020).

Rusty Blackbird

This North American species breeds in Canada and migrates to wintering grounds in the central and eastern United States. Breeding range is primarily within the boreal forest (Figure 59), in areas regularly disturbed by events such as fire, flooding and insects. Abundance appears to be associated with the North Atlantic Oscillation. Beavers may play an important role in the creation of habitats suitable for rusty blackbirds. Adaptive capacity is good, with three to seven eggs laid in each clutch and higher nest success than seen in other blackbird species.

The rusty blackbird is likely very sensitive to climate change. Although its use of habitats that experience regular, natural sources of disturbance may prove beneficial in a changing climate (e.g. increased forest fire frequency), the changes expected in the boreal forest are, overall, expected to result in a core breeding range contraction of 64-90%. Some degree of contraction has already been observed along the southern limits of its breeding range. A decline in boreal wetlands has also been documented, tied to melting of the underlying permafrost. This decline directly affects aquatic invertebrate availability and community composition; key forage for rusty blackbirds. Loss of boreal wetland invertebrate habitat could also impact emergence timing, potentially moving it out of phase with rusty blackbird breeding. As noted above, beavers, through their dam-building activities, may have some influence on wetland habitat creation, which could help buffer the effects of drought and drying.

Looking beyond the effects of climate change, important threats to the species across its range include loss of wetland habitat (from land conversion activities and dam construction), blackbird control programs (primarily in the eastern United States) and pesticides. Threats in the NWT are less severe in general, particularly from non-climate losses of wetlands, although mercury contamination is a concern. Mercury is deposited at long-distances from industrial activities, but its concentration in the boreal forest is also increasing as a result of permafrost melt (methylmercury). Mercury, in sufficient concentrations, has the potential to affect health of rusty blackbirds (e.g. reduced reproductive success, behavioural/physiological impairments) (COSEWIC 2017b).

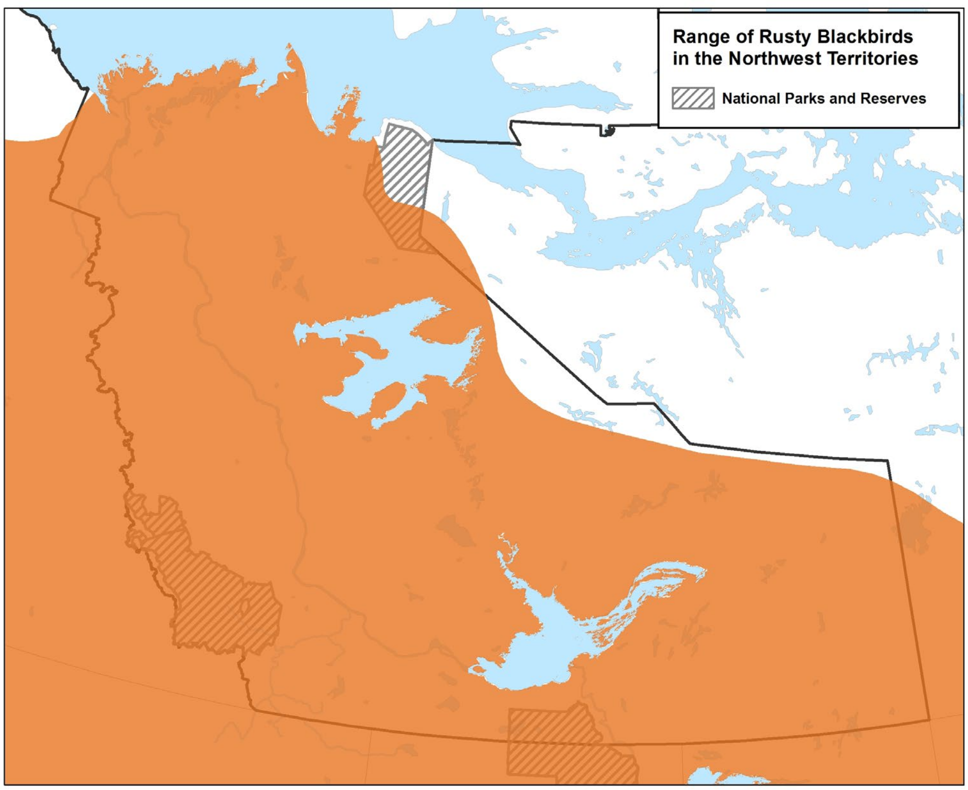

Figure 59. Range of rusty blackbirds in the NWT (NWT Species at Risk 2020).

Marine Birds

Only one marine bird is currently considered a species at risk in the NWT. The ivory gull, given its year-round dependence on high Arctic habitats, narrow parameters for habitat suitability and relatively low adaptive capacity, is expected to be highly vulnerable to the effects of climate change.

Ivory Gull

Ivory gulls are pack ice-dependent Arctic seabirds that spend their whole life cycle in high Arctic and ice-edge/polynya/lead (ice fracture) habitats. In Canada, they currently only nest in NU; a previously used nesting site on the NWT's Prince Patrick Island has been abandoned (Figure 60). Currently, ivory gulls rarely occur in the NWT's Beaufort Sea. Nesting sites must have access to open water early in the spring and be free of predators, which restricts the number of suitable available breeding locations. Ivory gulls feed largely opportunistically, foraging on small fish, zooplankton, small mammals and carrion. High metabolic and energetic requirements make them vulnerable to contaminant bioaccumulation. Ivory gulls have moderate-poor adaptive capacity, with delayed sexual maturity, low reproductive rate and the possibility of intermittent breeding.

Climate change may have a substantial impact on the ivory gull given its year-round use of ice edge habitat and need for early season open water. Changes to Arctic and sea ice environments are already observable and impacts to ivory gull habitat may already be occurring; however, a causative link, either positive or negative, has not been established to date.

Throughout their range, non-climate stressors include contaminants (particularly mercury), harvesting in Greenland and possible disturbance from mineral exploration projects in portions of the breeding range (COSEWIC 2006).

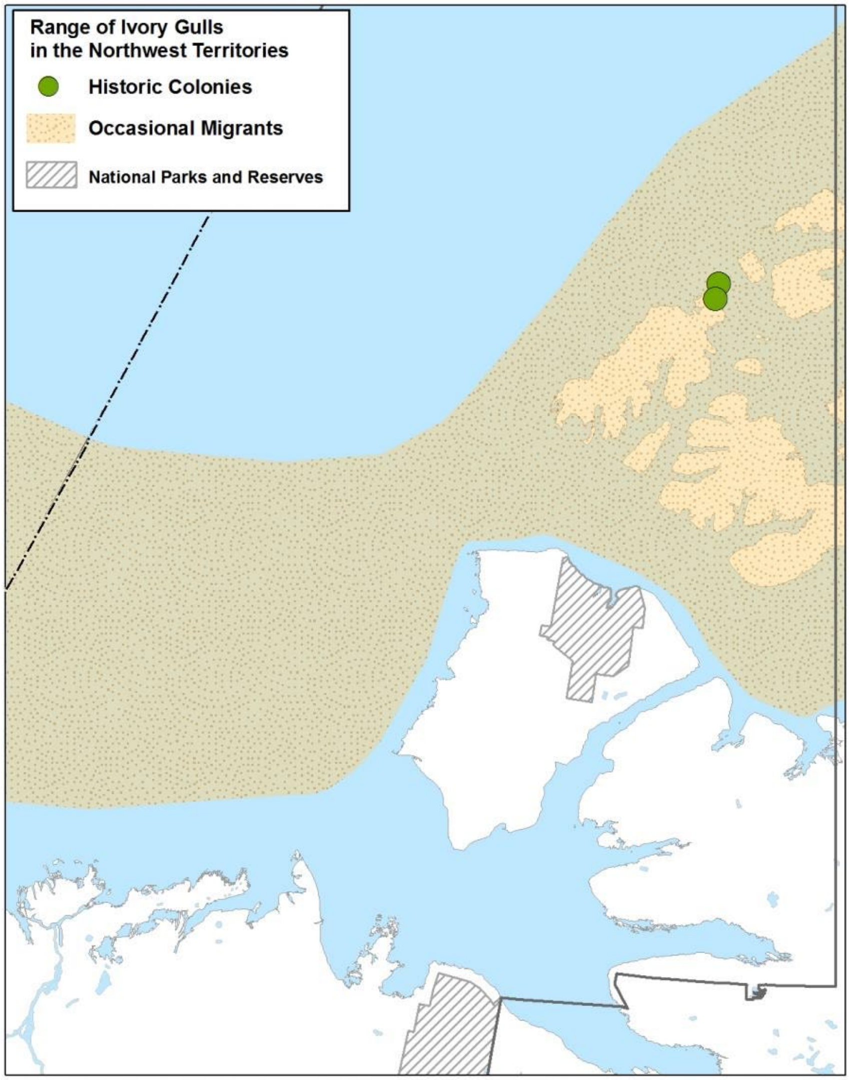

Figure 60. Range of ivory gulls in the NWT (NWT Species at Risk 2020).

Raptors

The two raptors considered in this report (peregrine falcon and short-eared owl) are not considered to be strongly vulnerable to climate change, particularly short-eared owl. Both species are generalists with wide ranges, which substantially reduces their sensitivity overall. However, peregrine falcon reproduction and survival may be adversely affected in cases of extreme events (i.e., temperature, storms), by the expanding ranges of pest species and if prey availability declines. Threats in the NWT are expected to be low to negligible at this time for both species.

Peregrine Falcon

Peregrine falcons range widely in Canada, occurring in most provinces and all territories (Figure 61). Those that occur in the NWT breed in in the Arctic and migrate annually to wintering grounds in coastal and inland wetland areas in Central and South America. Peregrine falcons are considered habitat generalists, although they do require open/partially open habitats and higher densities are often found in Arctic and coastal habitats. Peregrine falcons are territorial and show fidelity to roosting sites. Prey selection is fairly flexible and peregrine falcons are known to cache excess food for later consumption. One brood is raised annually and while average clutch size is three to four eggs, clutch size in the Arctic is typically smaller.

Climate change is expected to result in environmental changes that may have both positive and negative effects on peregrine falcons; however, on balance, the effects appear to be largely negative. With respect to potential positive influences, climate change may have already facilitated some Arctic range expansion. It may also enhance access to snow-free nest sites for early season arrivals, which may allow for earlier breeding/hatching and increase time available for young to gain important hunting skills prior to fall migration. Conversely, peregrine falcons may be adversely affected by extreme temperature events (heat stress and dehydration of nestlings), storms and precipitation (potential increasing frequency of heavy rain events, which can result in nestling mortality and heavy late spring snowfalls, which can result in nest abandonment), nest site loss (from permafrost melt, slumping and erosion of riverbanks and forest fires), ornithophilic black flies (northward range expansion of this pest species is tied to climate change) and declines in prey availability (tied to declines in wetland/shorebird habitat). Overall, peregrine falcons may be somewhat, or possibly very, sensitive to the effects of climate change.

Peregrine falcons have undeniably benefitted from long-term targeted recovery efforts in response to significant earlier declines in population. In this context, non-climate stressors are generally thought to be minimal for peregrine falcons when considered at the population level. However, at somewhat more local scales, contaminants (including lead, mercury and organophosphorus compounds) and habitat loss (wetland loss and conversion/simplification of agricultural areas) may have an impact. Brominated flame retardants and PBDEs represent an emerging threat with the potential for bioaccumulation and reproductive effects. In the NWT, long-range transport of mercury is likely the most important non-climate stressor to peregrine falcons; however, the impact of this threat is thought to be negligible at this time (COSEWIC 2017a).

Figure 61. Range of peregrine falcons in the NWT (NWT Species at Risk 2020).

Short-eared Owl

Short-eared owls are considered broad generalists for the most part. They have a wide range (Figure 62) and utilize many different unforested habitat types. They depend on small mammal populations for prey, but are skilled at finding local food sources and will shift habitats based on prey availability. Adaptive capacity is good, with four to seven eggs per clutch, the capacity to lay a replacement clutch if necessary and relatively high chick survival. Dispersal capacity is quite strong.

The species is not expected to be particularly vulnerable to the effects of climate change. The most important non-climate stressor is habitat loss and degradation; a result of agriculture and grazing in the prairies of Canada and the United States. There are no known threats to short-eared owls in the NWT (COSEWIC 2008b).

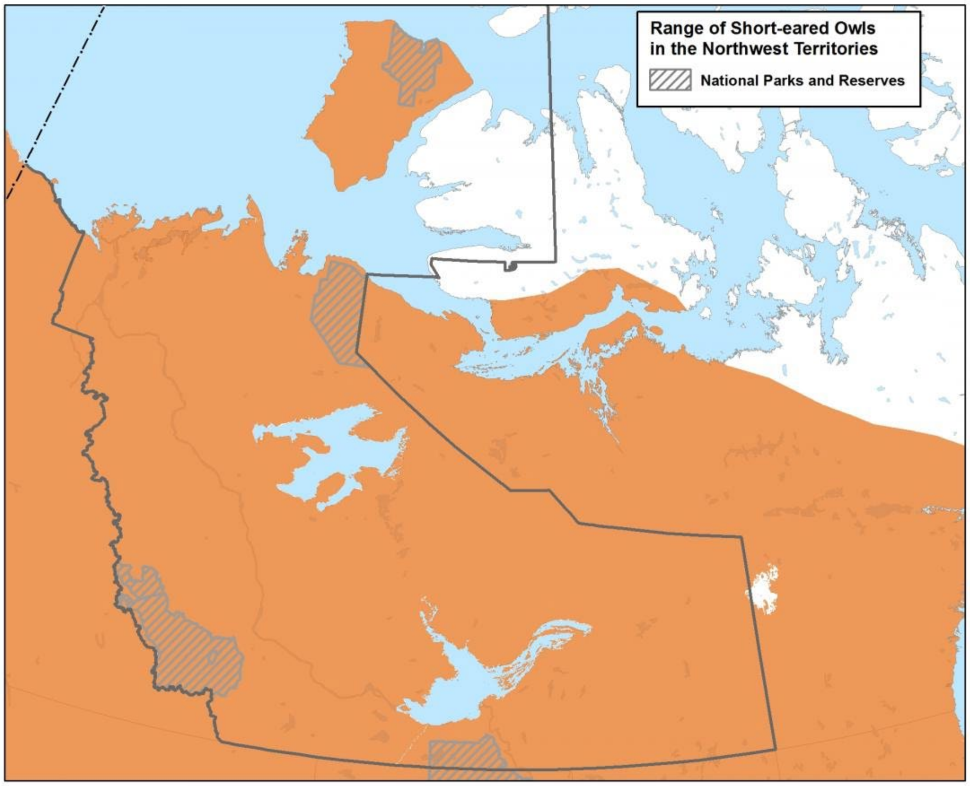

Figure 62. Range of short-eared owls in the NWT (NWT Species at Risk 2020).

Waterfowl

Horned grebes and red-necked phalaropes, the two species at risk considered here, are both strongly water-associated, with water-based habitats (wetlands, coastal areas and oceans) essential throughout their life cycles. Given the sensitivity of these habitats to climate change (e.g. drying trends, permafrost melt, changes to hydrological/nutrient cycles, etc.), they are both considered to be likely very sensitive to the effects of climate change.

Horned Grebe

All stages of the horned grebe lifecycle depend on water; breeding takes place primarily in freshwater with vegetation for nesting materials and concealment while wintering takes place in marine habitats. The NWT likely hosts a good proportion of the western population, although at lower densities than other areas (Figure 63). Adaptive capacity is good, with breeding beginning in the first year, a clutch size of over five eggs on average and the capacity to rebuild/lay up to four replacement clutches if needed. Site/mate fidelity have been observed.

Horned grebe is vulnerable to changes in its habitat, including changes to water quality, drainage, or desiccation of the waterbodies it uses for breeding, or disruption/destruction of nests. Higher temperatures, more frequent and intensive droughts, increasing intensity and frequency of forest fires, changes in vegetation, sediment run-off, changes to nutrient cycles and hydrological process and melting permafrost can all contribute to these habitat changes. If storms increase in frequency or intensity, nests could become vulnerable to flooding or affect the birds during migration.

Throughout their global range, the primary non-climate stressors to horned grebe include loss and degradation of wetland habitat from agriculture and development, increasing numbers of predators (common raven, black-billed magpie and raccoons), oil spills (within the wintering grounds) and contaminants (noted in BC and Manitoba). Non-climate threats in the NWT are less well-described, although increasing populations of magpies near Yellowknife may represent a local threat (COSEWIC 2009c; ECCC 2020).

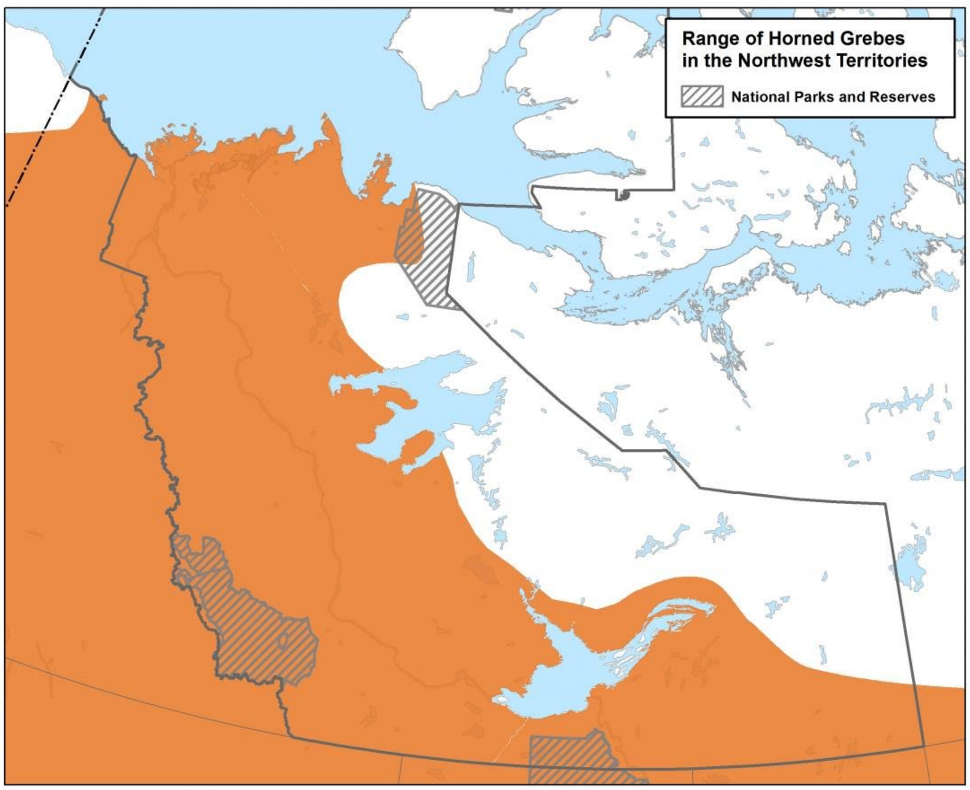

Figure 63. Range of horned grebes in the NWT (NWT Species at Risk 2020).

Red-necked Phalarope

The red-necked phalarope is a New World species that breeds in subarctic and Arctic regions of Canada (Figure 64) in wetlands and near sources of freshwater, migrate annually along both the west and east coasts and winters largely in the open ocean, where it gathers in large foraging groups. Aquatic habitats are important at all life stages for this species. Females will breed and lay multiple clutches each year if possible, leaving rearing to the males. Nest success varies widely by location.

Climate change is likely to result in environmental changes that impact the breeding habitat of red-necked phalaropes, including drying, shrinking, or loss of preferred wetland habitat, possible declines in food availability and localized flooding. Drought and conditions favourable to drying are projected for areas of the breeding range, along with permafrost melt beneath the small waterbodies preferred by red-necked phalaropes, which may result in water drainage. An expected shift in habitat composition from wetlands to shrub/tree-dominant ecosystems would reduce availability of breeding habitat. The possibility of a mismatch developing between peak insect abundance and chick hatch would have a significant impact if it occurred. Changes to insect abundance or composition would also be concerning. Coastal breeding habitat may be vulnerable to flooding and salinization, the risks of which are expected to increase with rising sea levels, loss of multi-year sea ice and increasing storm frequency. These changes may be offset somewhat by the potential for a longer breeding season, but on balance, the effects are expected to be negative. Climate change may also affect red-necked phalaropes along their migratory and wintering ranges, through impacts to oceans (temperature, salinity and currents) and ocean food availability.

During winter, reflecting their habit of congregating together in ocean upwellings, red-necked phalaropes are vulnerable to the effects of oil spills (hypothermia, organ damage and damage to prey species). This is certainly true of event-specific oil spills, but risks may also accrue from less noticeable exposure to oil (e.g. boat leakage, runoff, etc.). In the breeding grounds, climate change is the most serious threat, although impacts from development activities and contaminants may also have an impact on red-necked phalaropes. Development activities can involve the removal of breeding habitat or alter vegetation community composition. Slow growth rates in the north can limit recovery of habitat from disturbance/destruction. Long-distance atmospheric transport of contaminants like mercury is being increasingly documented in northern regions and levels of these contaminants in some other Arctic-nesting shorebirds are approaching concentrations that can result in physiological effects. Evidence of dichlorodiphenyltrichloroethane (DDT) and polychlorinated biphenyl (PCB) accumulation in Arctic-nesting shorebirds has also been noted (COSEWIC 2014b).

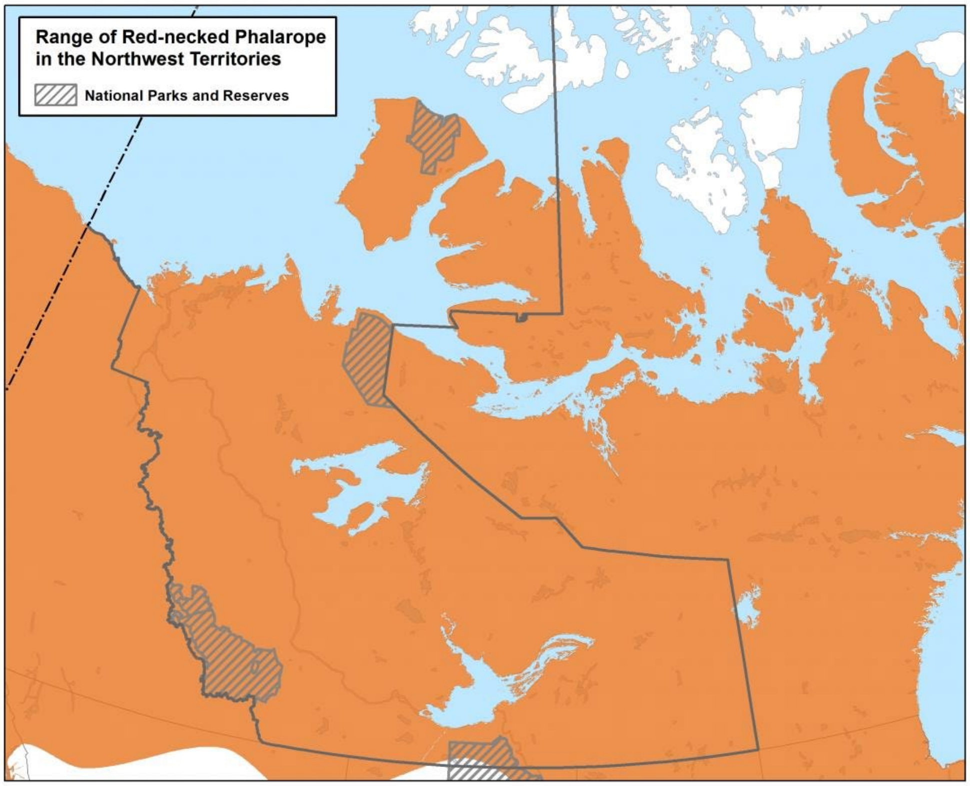

Figure 64. Range of red-necked phalaropes in the NWT (NWT Species at Risk 2020).

Other Water Birds

As a group, these birds are more vulnerable to climate change than other bird groups considered in this report. With the exception of the yellow rail, this group of birds shows a degree of habitat and/or forage specificity that raises their overall vulnerability score. They can also be subjected to significant levels of stress from a variety of sources, both climate and non-climate related.

Buff-breasted Sandpiper

In the NWT, during the breeding season, the buff-breasted sandpiper on Banks and Victoria Islands (Figure 65). In fact, breeding habitat for this species is found exclusively on the tundra. Habitat selection during breeding is flexible, reflecting high natural environmental variability. During migration and wintering, the species specializes on heavily-grazed grasslands (short-grass); a habitat type that is currently declining. The buff-breasted sandpiper winters in South America. Relative to other bird species, Arctic-breeding shorebirds have low reproductive rates.

The buff-breasted sandpiper's Arctic breeding habitat is expected to be affected by climate change, but the overall impact to the species is not clear. Tundra drying, changes to snowmelt patterns, rising sea levels, increased rainfall, increases in the frequency and intensity of storms and the possibility of mismatches developing between periods of food availability and chick hatch are all factors of potential concern for this species. Significant and observable changes to buff-breasted sandpiper habitat related to climate change are already being observed, including in the Arctic.

The species has recovered somewhat from intensive historical commercial harvesting, although numbers have not recovered to historical levels. Currently, the most significant non-climate stressor affecting the buff-breasted sandpiper is the loss and degradation of grassland (short-grass) habitat on its wintering grounds and along migration routes. Changes to agricultural practices, including shifts to no-till farming and growth of biofuel crops, represent threats to this species. Wind energy developments along the migration corridor are concerning. In the NWT, non-climate stressors are associated primarily with mining on the breeding grounds; the overall threat level is likely low, however. Garbage that accumulates around development sites and Arctic communities likely attracts increased numbers of predators that prey on the eggs and young of buff-breasted sandpipers (COSEWIC 2012a).

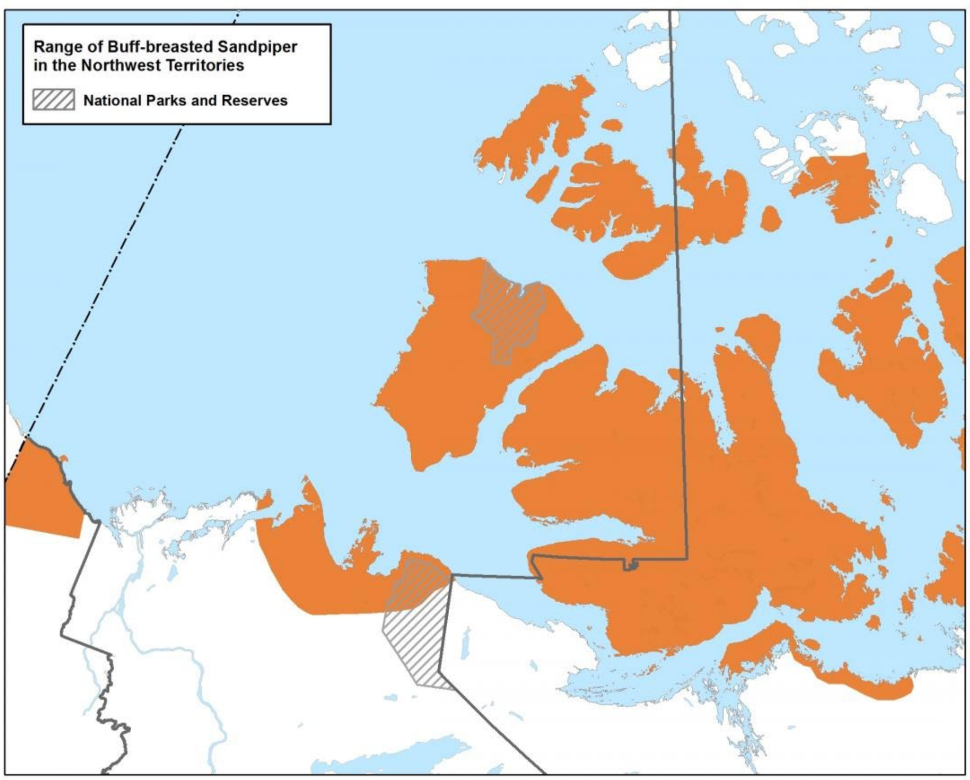

Figure 65. Range of buff-breasted sandpipers in the NWT (NWT Species at Risk 2020).

Eskimo Curlew

The eskimo curlew is a long-distance migrant with 100% of its known breeding range in Arctic Canada (Figure 66). Despite a few unconfirmed sightings over the last several decades, it is presumed extinct following a population collapse. The collapse was primarily due to dramatic habitat loss and degradation in Canada, the United States and Argentina and extensive commercial harvesting. This has likely permanently affected any chance of species recovery regardless of impacts from climate change (COSEWIC 2009b, Borstad et al. 2008).

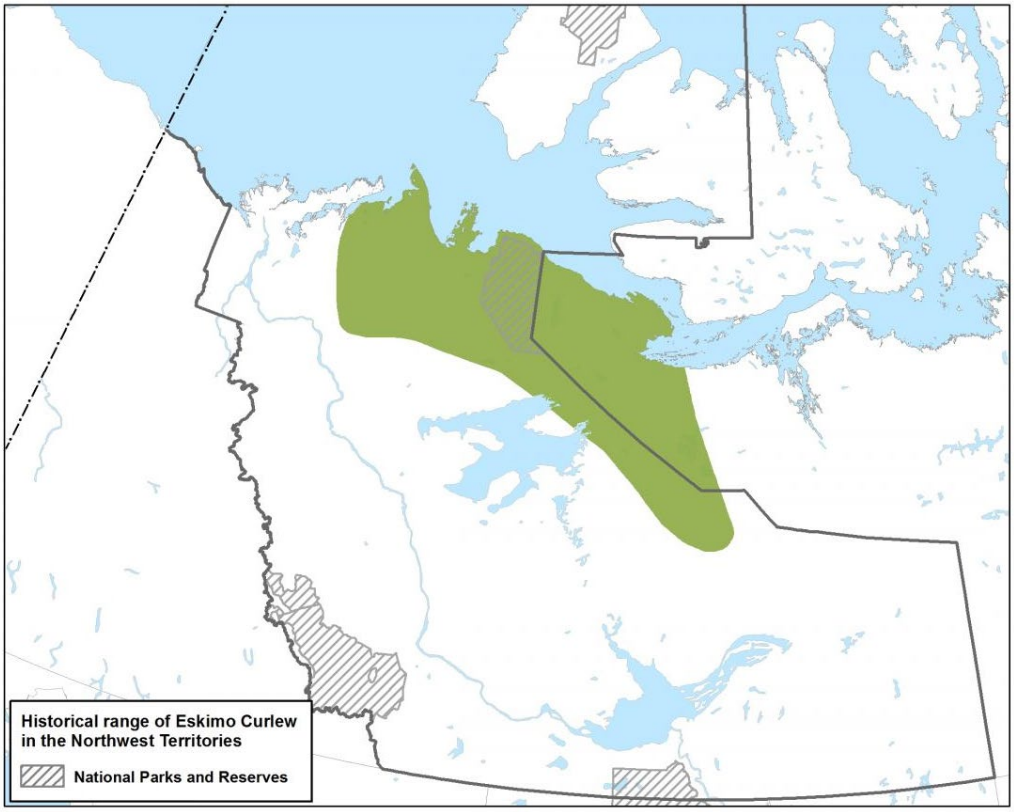

Figure 66. Range of eskimo curlews in the NWT (NWT Species at Risk 2020).

Red Knot (*rufa* and *islandica* subspecies)

The red knot has two subspecies that occur in the NWT: *rufa* and *islandica*. All of *rufa*'s breeding range occurs within the central Canadian Arctic (Figure 68), while the breeding range of *islandica* is somewhat broader (40% within the northeastern Canadian Arctic) (Figure 67). Nesting habitat in the Arctic for both subspecies is in relatively barren areas with little vegetation cover and near wetlands or lake edges. Coastal areas with sand or mudflats are used during wintering and migration. The *rufa* subspecies migrate annually between their Arctic breeding grounds and wintering grounds on the tip of South America, while *islandica* winters in Europe. Roosting areas that provide safety from predators are necessary. Red knots show fidelity to breeding, wintering and migration grounds and display several limiting biological characteristics that affect their adaptive capacity and potential recovery in the event of a decline, including delayed maturity and relatively low reproductive capacity. Unlike other bird species considered in this report, red knot egg formation is dependent upon local food sources at the breeding grounds, rather than on body stores built up during migration. Generation time is estimated at four to five years.

Climate change is expected to have important implications to red knot's habitat and biological interactions. With respect to breeding habitat, projections suggest ecological shifts northwards, which are likely to have implications for these high Arctic breeders. This is expected to be particularly concerning for *rufa*, which breeds in the southern portion of the high Arctic ecoregion. Along the migratory corridor, loss of 20-70% of intertidal habitat is projected over the next century at a number of sites in the United States, including at Delaware Bay, Delaware (DE), USA, a key stopover and foraging site during *rufa* migration. Fidelity to breeding, migratory and wintering grounds makes the likelihood of adaptation in this species uncertain. The possibility of a mismatch developing between the timing of peak insect abundance and chick hatch is concerning in the species' Arctic breeding habitat, which may have implications for chick survival. Further to these serious considerations, the potential for increasing frequency and severity of storms and severe weather during migration is a potential threat associated with climate change that is projected to increase over time.

The most pressing concern for the *rufa* subspecies is the decline in horseshoe crab eggs, which is their most important food source during migration. Horseshoe crabs are harvested for their blood by the medical industry as a means of testing for contaminants in medical devices, vaccines, etc. Unfortunately, the overexploitation of this invaluable resource has resulted in declines in horseshoe crabs and their eggs. This, in turn, affects red knots, in such a way that in some years they are unable to achieve adequate body mass prior to migration. Declines in the crabs have been primarily noted in Delaware Bay, DE, USA, but large declines have also been observed elsewhere. Although other foods are consumed by red knots, they may not provide a suitable substitute to horseshoe crab eggs, nutritionally. Combined with the previously noted projected declines in intertidal habitat and marsh/wetland losses in the United States, the potential cumulative effects to *rufa* and their habitat are important. Additional non-climate threats to *rufa* include oil spills, industrial development and ports/shipping in their wintering range. For *islandica*, the most serious threats include shellfish overharvest and dredging in their European wintering grounds, which has implications for food availability. Tidal power development in the Bay of Fundy, NL is a potential threat in their migratory corridor. For both species, disturbance by people in their migratory and wintering habitats is a concern. There are no known non-climate threats to red knots in the NWT (COSEWIC 2007b).

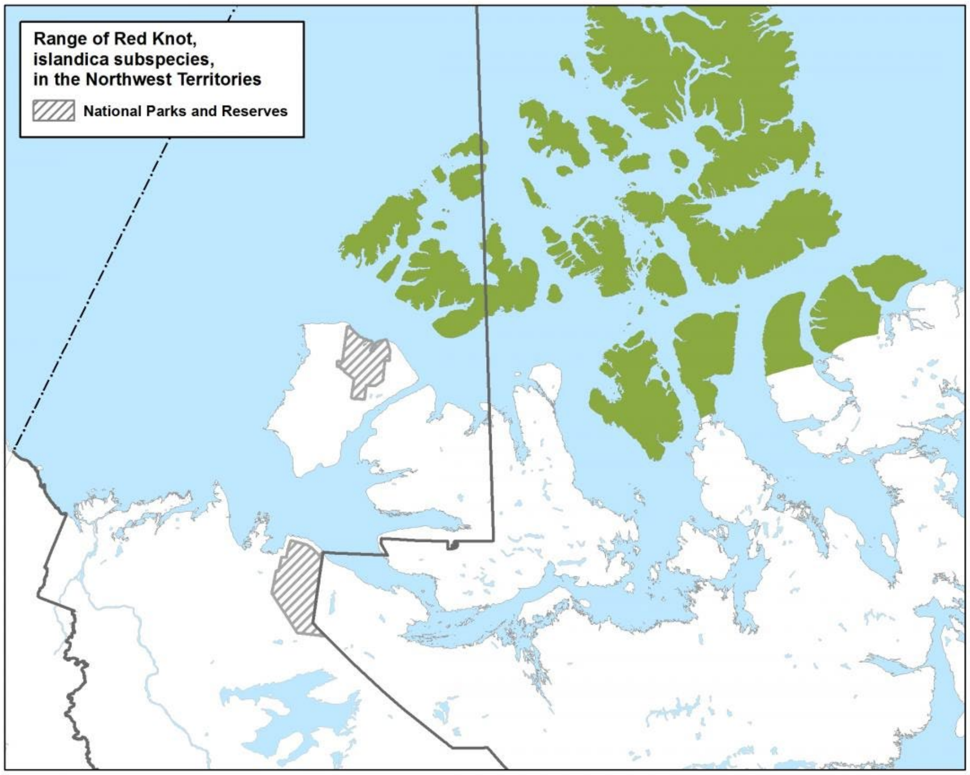

Figure 67. Range of red knots (*islandica* subspecies) in the NWT (NWT Species at Risk 2020).

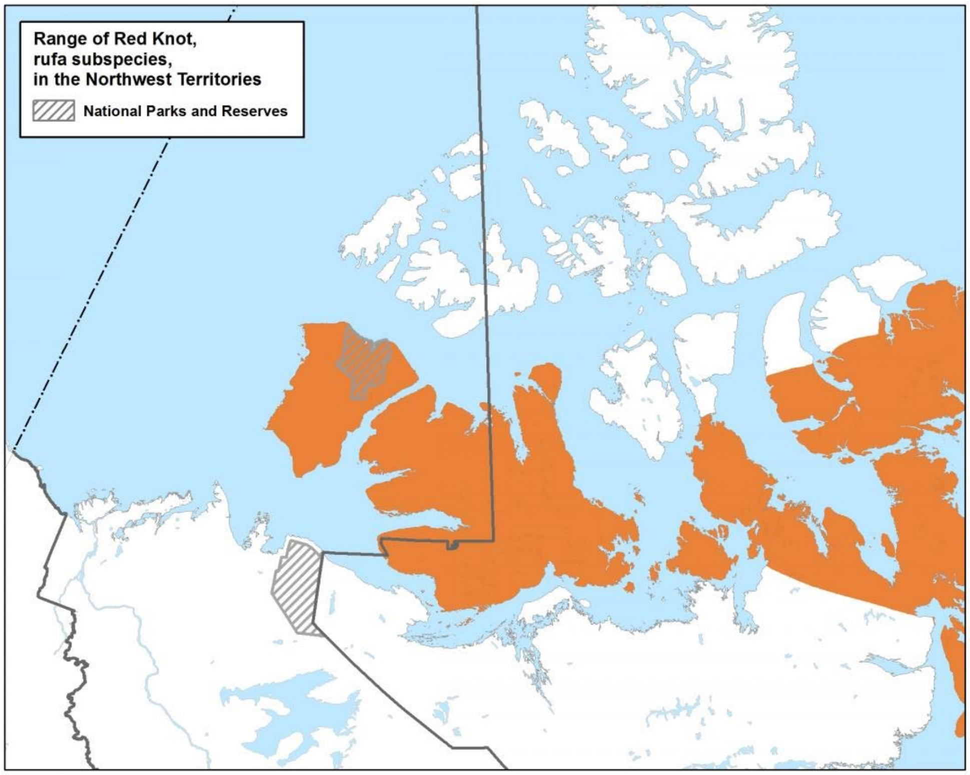

Figure 68. Range of red knots (*rufa* subspecies) in the NWT (NWT Species at Risk 2020).

Whooping Crane

The NWT's whooping cranes constitute part of the only self-sustaining wild whooping crane population in the world (Figure 69). They migrate annually between their breeding grounds in Wood Buffalo National Park and wintering grounds on the Texas Gulf Coast. This population is very small and, coupled with specific and limited habitat requirements, delayed sexual maturity, low fecundity, low genetic diversity and long generation time, is highly vulnerable to threats and stressors. Whooping cranes are omnivorous, but rely strongly on blue crabs and clams in their wintering range.

Whooping cranes are likely vulnerable to drought effects in their breeding grounds and to storms and precipitation, both immediately after hatching occurs, but also on their wintering grounds (i.e., hurricanes). However, anthropogenic threats on the wintering grounds (e.g. habitat degradation and loss, oil spills and declines in blue crab population) likely represent a more significant and immediate threat. Collisions with tall structures and power lines along their migration path is also concerning and represents an increasing threat. There are no known significant non-climate stressors in the NWT (COSEWIC 2010b).

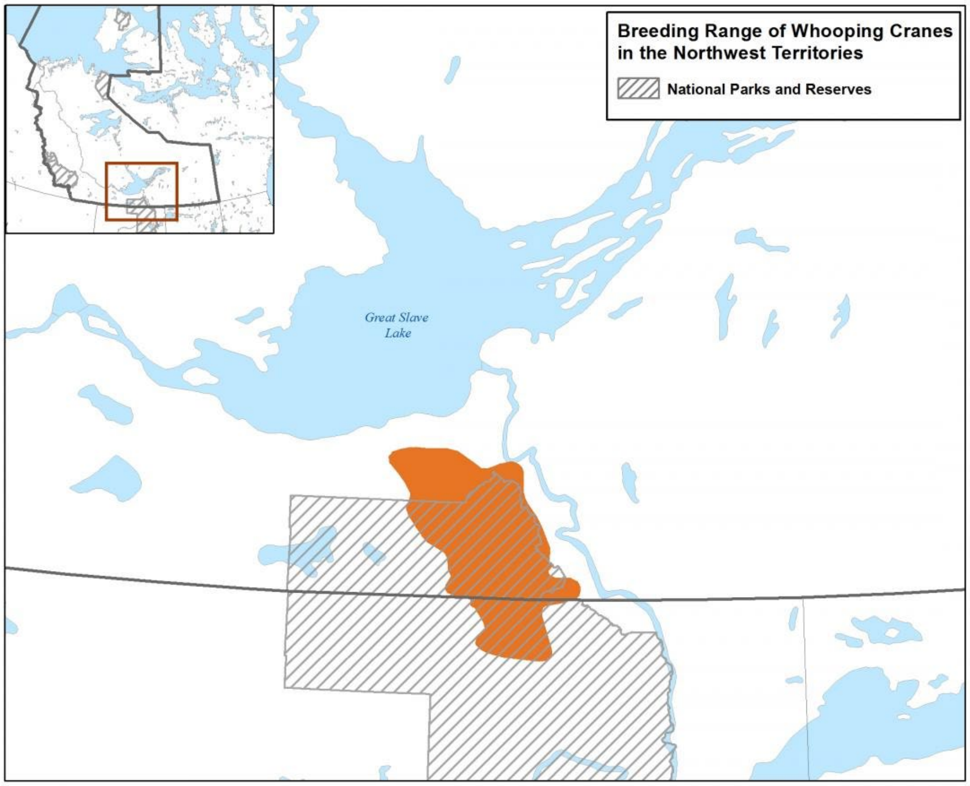

Figure 69. Range of whooping cranes in the NWT (NWT Species at Risk 2020).

Yellow Rail

The yellow rail occurs in a variety of ranges that offer grassy (primarily sedge) marsh habitat. The habitat must remain wet throughout the breeding season, but can have no more than 15 cm standing water. Tolerance for water levels and different vegetation characteristics are somewhat broader outside the breeding season. Most of the breeding habitat occurs in Canada, including a portion in the NWT (Figure 70), while wintering for this migratory species occurs from Texas to the Carolinas. Yellow rails are relatively uncommon overall, and have a fairly small population. Reproductive capacity is reasonably good, with about eight eggs produced per clutch. Dispersal capacity is generally strong, although yellow rails undergo a flightless period during moult, following breeding (two weeks).

The species' associations with wetland habitats throughout its lifecycle and high water-level specificity during breeding make it vulnerable to changes in hydrologic regimes, drought/drying conditions and precipitation/extreme weather events. Drought conditions are expected to increase in parts of the range, which will undoubtedly impact habitat availability. Sea level rise and increasing frequency of storms (including hurricanes) are affecting coastal wetlands and are therefore likely to impact the species in its wintering range.

Loss of wetland habitats (as a result of industrial and municipal development activities and changing hydrological regimes) likely represent the most important non-climate threat to this species. Other threats across the range include agricultural run-off (e.g. pesticides), disturbance by livestock and accidental deaths/disturbance caused by people. There are no significant non-climate stressors in the NWT at this time (COSEWIC 2009c).

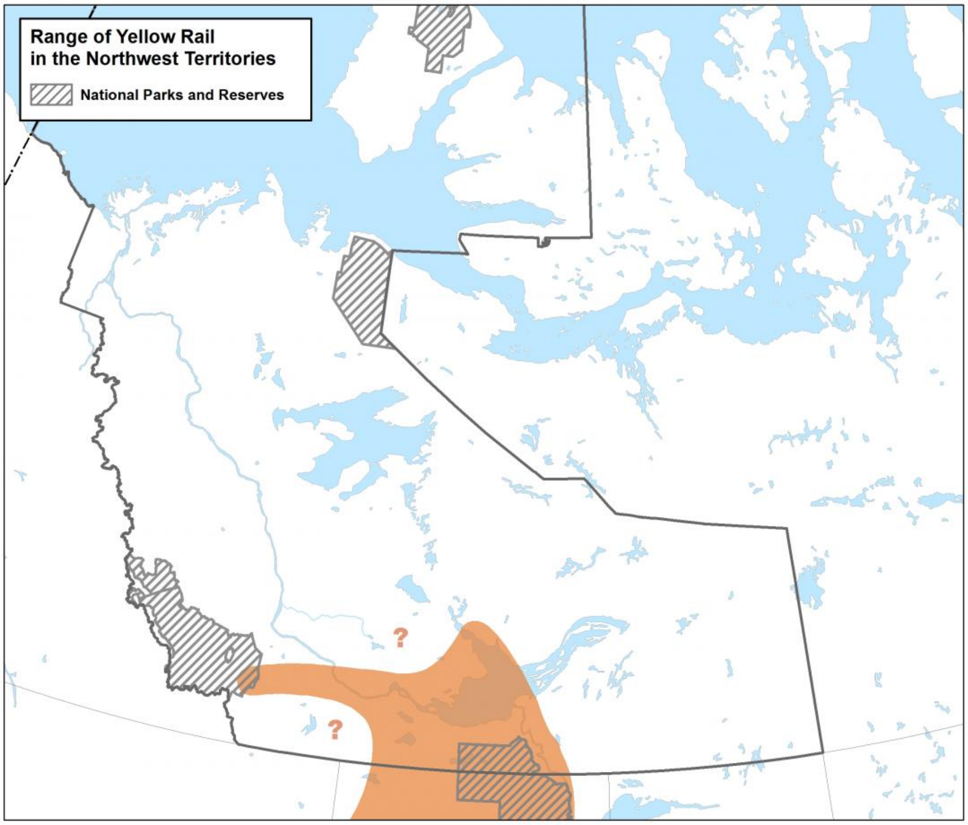

Figure 70. Range of yellow rails in the NWT (NWT Species at Risk 2020).

Fish

Four fish species at risk were included in this Phase 1 vulnerability assessment, including fish that occupy lakes, streams, rivers and oceans. In the NWT, fish fall under the federal *Fisheries Act* (administered by the Department of Fisheries and Oceans). These fish are late-maturing, slow-growing, long-lived and range-restricted, which renders their adaptive capacity as a group quite low. High habitat specificity and sensitivity to temperature changes increases the vulnerability rating for these species, particularly dolly varden and bull trout, for which suitable habitat is also very limited. Significant range contraction is expected for both dolly varden and bull trout as temperatures increase and drying conditions prevail in some areas. Given the high degree of habitat specialization seen in both species, their ability to expand northwards is doubtful. Beyond climate change, habitat disturbance, destruction, or fragmentation represent a threat to all but shortjaw cisco. Harvesting/by-catch mortality is a concern for dolly varden (given their propensity to congregate in relatively concentrated areas) and northern wolffish. The spread of alien/invasive species is a clear threat to both bull trout and shortjaw cisco, although the potential spread of whirling disease is likely the most pressing threat in the NWT.

Table 12. Summary of vulnerability assessment results for fish species at risk.

Assessed species	Climate change sensitivity[32]	Non-climate stressors[33]	Adaptive capacity[34]
Anadromous			
Dolly Varden	3	2	3
Marine			
Northern wolffish	1.7	1	2.5
Lake/stream residents			
Bull trout	3.3	2	2.5
Shortjaw cisco	1.7	1	2.5

Anadromous Fish[35]

Dolly Varden

Globally, dolly varden occur in fresh and marine waters in northeastern Eurasia and North America. In the NWT, they can be found in the coastal estuarine waters of the Beaufort Sea and in the freshwater streams and rivers that drain into the Beaufort Sea (Figure 71). Suitable spawning and overwintering sites, characterized by year-round groundwater upwellings that provide adequate oxygen and temperature requirements and do not freeze to the bottom in the winter, are limited in number (<1.0 km^2 for the western Arctic population). Connected habitats for migration, smoltification and feeding are also required. This degree of habitat specialization, coupled with its small range, makes dolly varden particularly vulnerable to events that disturb or degrade habitat. Average age at maturity is five to ten years and five to seven years for anadromous males and females, respectively. Spawning is every year or every second year following maturity, depending on the location and typically occurs only twice during the lifetime of a dolly varden. Dolly varden are primarily opportunistic feeders.

Climate change is unlikely to result in an increase in suitable spawning/overwintering sites, which suggests that a northward range expansion is also unlikely. However, warming temperatures and declines in precipitation could result in drying of habitat; perhaps resulting in as much as a 29-90% reduction in distribution for the western Arctic population of dolly varden. Declining water levels in some areas may also increase

[32] The average of habitat, abiotic and biotic factors.
[33] Scored based on threats in the NWT only. This does not imply that there are not significant threats elsewhere in the range.
[34] Based on reproductive and dispersal capacity.
[35] The term 'anadromous' means that the fish occupy both freshwater and marine habitats at different points in their lifecycles.

vulnerability to predation. Conversely, earlier sea ice retreat and warmer waters may enhance growth and digestion in some areas.

Non-climate stressors in the NWT are primarily limited to overharvesting and industrial development. Overharvesting is a particularly important threat at spawning and overwintering sites (where fish are concentrated in a relatively small area) that, if not appropriately managed, could result in local extirpations. Industrial development, including proposed development on the Gayna River and quarrying activities along the Dempster Highway, could impact dolly varden habitat through water drawing, diversion, or direct damage to waterways. Other potential threats are tied to climate change, including increasing marine traffic (i.e. contaminants and alien species) (COSEWIC 2010a).

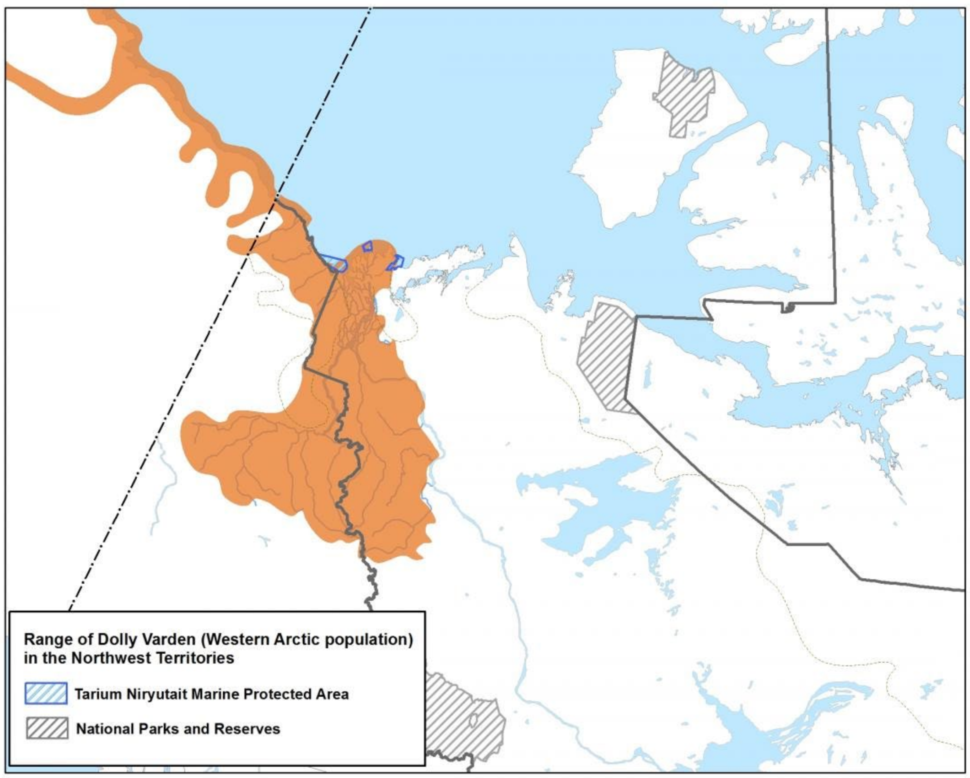

Figure 71. Range of dolly varden in the NWT (NWT Species at Risk 2020).

Marine

Northern Wolffish

The northern wolffish is only known to occur occasionally in the NWT (Figure 72). It occurs primarily in cool and cold deep ocean waters between Norway and NL. Adaptive capacity of this large, slow-growing, long-lived, range-restricted, relatively sedentary species is poor and makes it vulnerable to local threats. Threats include by-catch mortality and habitat disturbance from bottom trawling, dredging and aggregate extraction. Climate change has the potential to affect the species' distribution and abundance, most likely related to expected increases in temperature in its preferred marine habitats. Impacts of all threats in the NWT are likely negligible at this time, given its only occasional occurrence in NWT waters, although could become more important in the future if range shifts occur (COSEWIC 2001, 2012c).

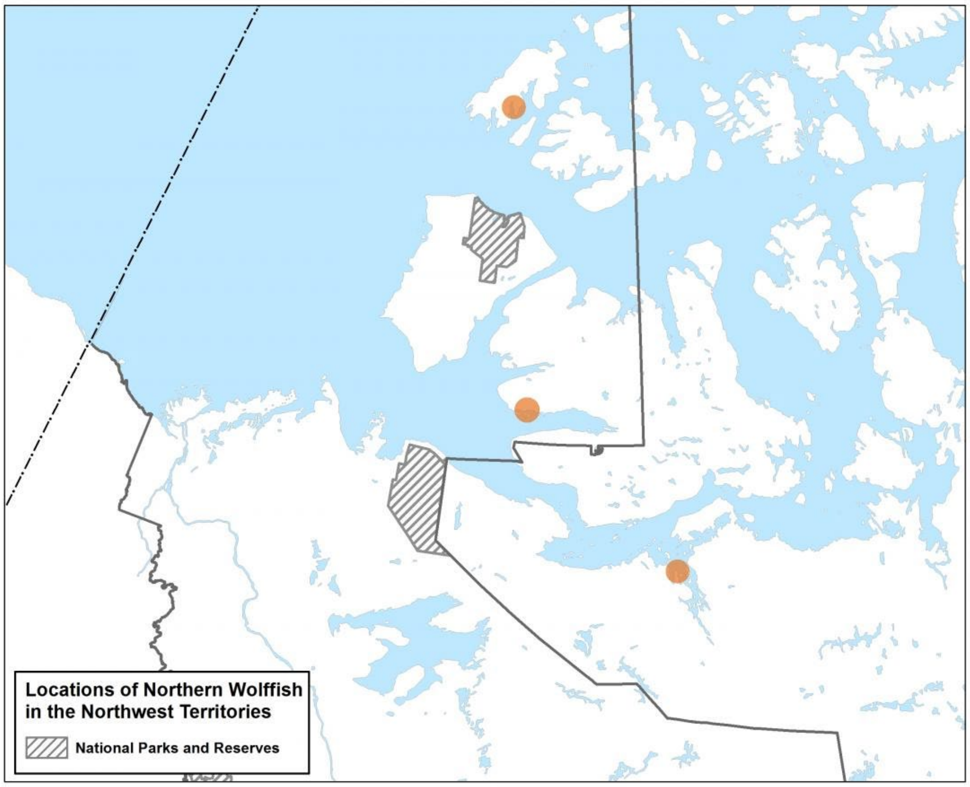

Figure 72. Range of northern wolffish in the NWT (NWT Species at Risk 2020).

Lake and/or Stream Residents

Bull Trout

Bull trout populations occur in western Canada; YT, NWT, BC and AB specifically, although distribution in AB is no longer considered wide (Figure 73). Population density is naturally low. Bull trout are habitat specialists, thriving in cold, pristine and unfragmented waters. They show strong fidelity to spawning and overwintering sites. Sites with a perennial groundwater supply are important for spawning and rearing in northern populations, although these sites are considered to be relatively rare (Mochnacz pers. comm. 2020). Given less productive habitat, northern populations of bull trout may have smaller populations than more southerly populations. Northern population also demonstrate slower growth and less frequent mating, which may impede recovery in the event of a decline. This has been noted for bull trout of the upper Liard River basin in particular. Bull trout have a narrow tolerance of environmental conditions, including factors such as temperature. Bull trout are a long-lived species that matures late and grows slowly. They are a top aquatic predator and opportunistic forager. Genetic diversity is fairly low and rescue effect is unlikely, except for between populations that have strong habitat connectivity. They demonstrate extensive phenotypic plasticity.

Bull trout are expected to be highly sensitive to the effects of climate change, reflecting specific habitat requirements and narrow physiological tolerance limits. Populations are vulnerable to changes in temperature and other abiotic factors and can be affected by ice accumulations, scouring and low stream flows. Availability of suitable cold-water habitats and habitat connectivity, are likely to be affected by climate change. Populations in the south are particularly susceptible to the effects of climate change.

Given its specific habitat requirements and relatively narrow environmental tolerances, the bull trout is likely to be adversely impacted by activities that disturb or fragment its habitat, or alter environmental parameters like stream temperatures, including development activities and dams. In the NWT, the potential spread of whirling disease to northern populations is likely the most concerning non-climate threat (COSEWIC 2012b).

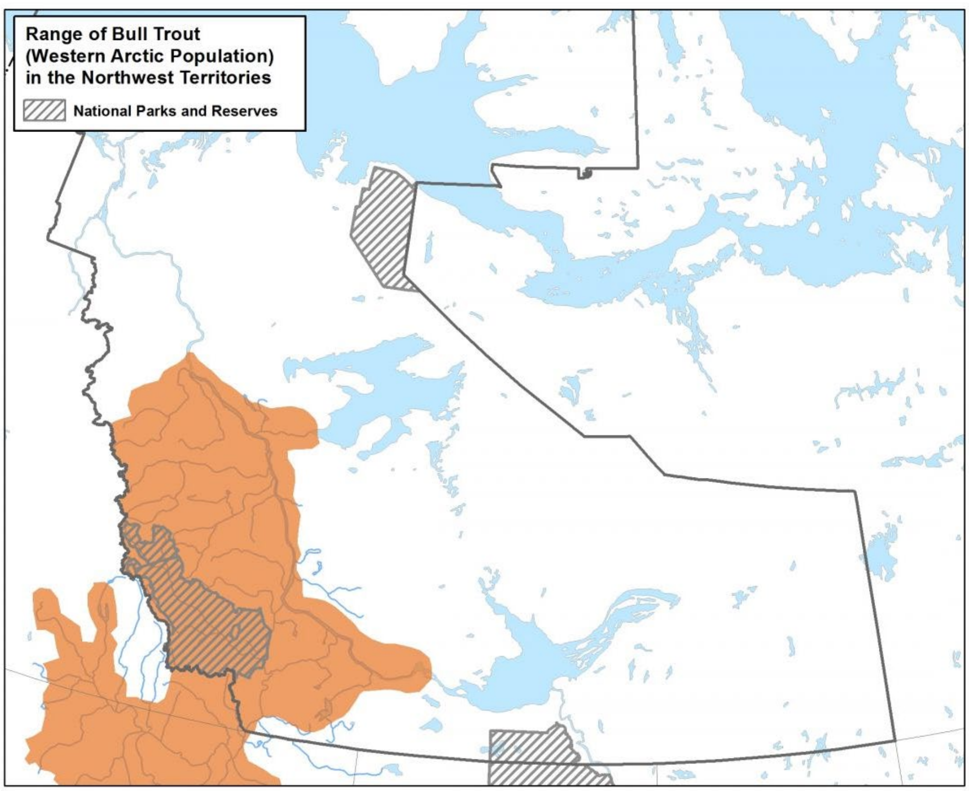

Figure 73. Range of bull trout in the NWT (NWT Species at Risk 2020).

Shortjaw Cisco

The taxonomic status of shortjaw cisco is in question, the results of which may have an impact on the species' definition and therefore assessment of vulnerability. However, until a decision on it's taxonomic and therefore species at risk, status has been made, it has been included in this document given continued occurrence in NWT waters (Figure 74) and current status as a species at risk.

The shortjaw cisco is generally found in lake waters of medium depth, although depth selection can vary by location. Lake temperature influences the time required for egg development. Prey availability is important. Adaptive capacity is likely moderate-poor, with late maturity, a long generation time, but high fecundity.

Habitat change and introduced/invasive species likely represent the most serious effects of climate change to shortjaw cisco. Shifts of lake conditions associated with increasing temperatures can alter habitat suitability for species, resulting in species displacement. Introduced sea lamprey, a predator of shortjaw cisco and other fish, has also resulted in changes in lake fish communities. Fecundity of sea lamprey is expected to increase under a warming climate (Cline et al. 2014).

Competition and displacement from introduced species are likely the most significant non-climate stressors to shortjaw cisco (although, as noted above, the competitive ability of these species can be worsened by climate change). Introduced species of concern include sea lamprey (noted above), rainbow trout and rainbow smelt. There are no significant non-climate stressors in the NWT at this time, however (COSEWIC 2003).

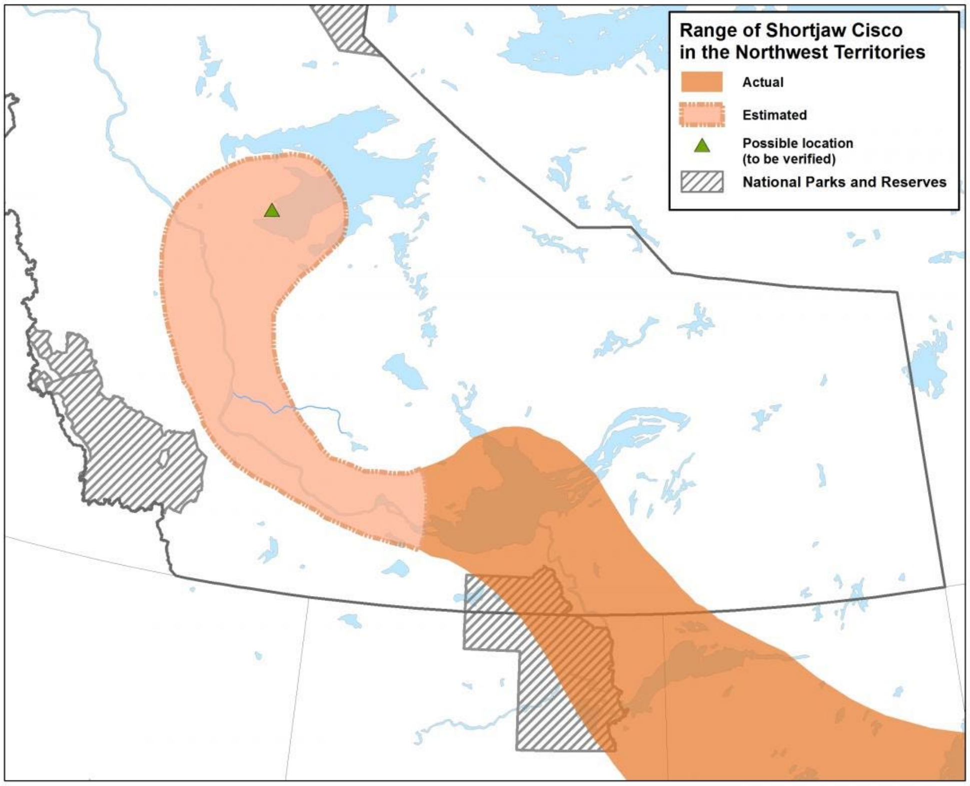

Figure 74. Range of shortjaw ciscos in the NWT (NWT Species at Risk 2020).

Insects

Four insect species were included in this vulnerability assessment, representing identified species at risk in the NWT: gypsy cuckoo bumble bee, transverse lady beetle, western bumble bee and yellow-banded bumble bee. Of these species, western bumble bee is expected to be the most vulnerable to climate change, linked to its body size and limited northern distribution and declines in this species are expected in the long term related to increasing temperatures and heat waves in the NWT. The potential for phenological mismatches tied to climate change could impact all three bumble bee species and could result in severe population declines.

Table 13. Summary of vulnerability assessment results for insect species at risk.

Assessed species	Climate change sensitivity[36]	Non-climate stressors[37]	Adaptive capacity[38]
Gypsy cuckoo bumble bee	1.7	2	1.5
Transverse lady beetle	1	1	1
Western bumble bee	2.3	2	1.5
Yellow-banded bumble bee	1.7	2	1.5

Gypsy Cuckoo Bumble Bee, Western Bumble Bee, Yellow-banded Bumble Bee

Gypsy cuckoo bumble bee occurs broadly throughout the world and Canada (Figure 75). The yellow-banded bumble bee is a North American species with a broad range in Canada (Figure 77). Western bumble bee, specifically the *mckayi* subspecies (the subspecies that occurs in the NWT), occurs only in northwestern Canada and Alaska (Figure 76). All three are considered forage and habitat generalists, with nesting sites, overwintering sites and adequate floral resources constituting required habitat. Western bumble bee and yellow-banded bumble bee are both ground-nesting species. The gypsy cuckoo bumble bee is considered an obligate nest parasite of other bumble bee species, including western bumble bee. Bumble bees in general are considered to be cold-adapted species. Colonies in the north can be relatively large, likely given early spring emergence and reproductive activity into the fall. Dispersal ability can likely be up to a few kilometers, but day-to-day foraging is often more limited. Bumble bees are highly vulnerable to extinction when reduced to low population numbers given haplodiploid sex determination.

Cold adaptations in bumble bees are expected to make them somewhat vulnerable to climate change. Gypsy cuckoo bumble bees and yellow-banded bumble bees, with their large North American distributions, are expected to be fairly resilient to temperature increases in the NWT, but western bumble bees, with their more restricted northern distribution and larger body size, are expected to decline in response to temperature increases and heat waves. Mismatches between timing of forage availability and spring emergence has the potential for devastating population-level impacts to bumble bees in the NWT. It is not known if emergence timing of gypsy cuckoo bumble bees and their host species will be affected by climate change. Permafrost melt and increases in drought and/or flooding conditions could also have an adverse impact on these three species.

Nationally, non-climate stressors for these species include pathogens, pesticide use, habitat changes/loss and, for gypsy cuckoo bumble bee, declines in host bee populations. In the NWT, climate change is considered the most serious plausible threat to western bumble

[36] The average of habitat, abiotic and biotic factors.
[37] Scored based on threats in the NWT only. This does not imply that there are not significant threats elsewhere in the range.
[38] Based on reproductive and dispersal capacity.

bee and yellow-banded bumble bee at this time, and potential declines in host populations being the most concerning threat to gypsy cuckoo bumble bees. Increasing interest in honey production and pollinator imports is possibly concerning, given the potential for forage competition and pathogen spillover (SARC 2019).

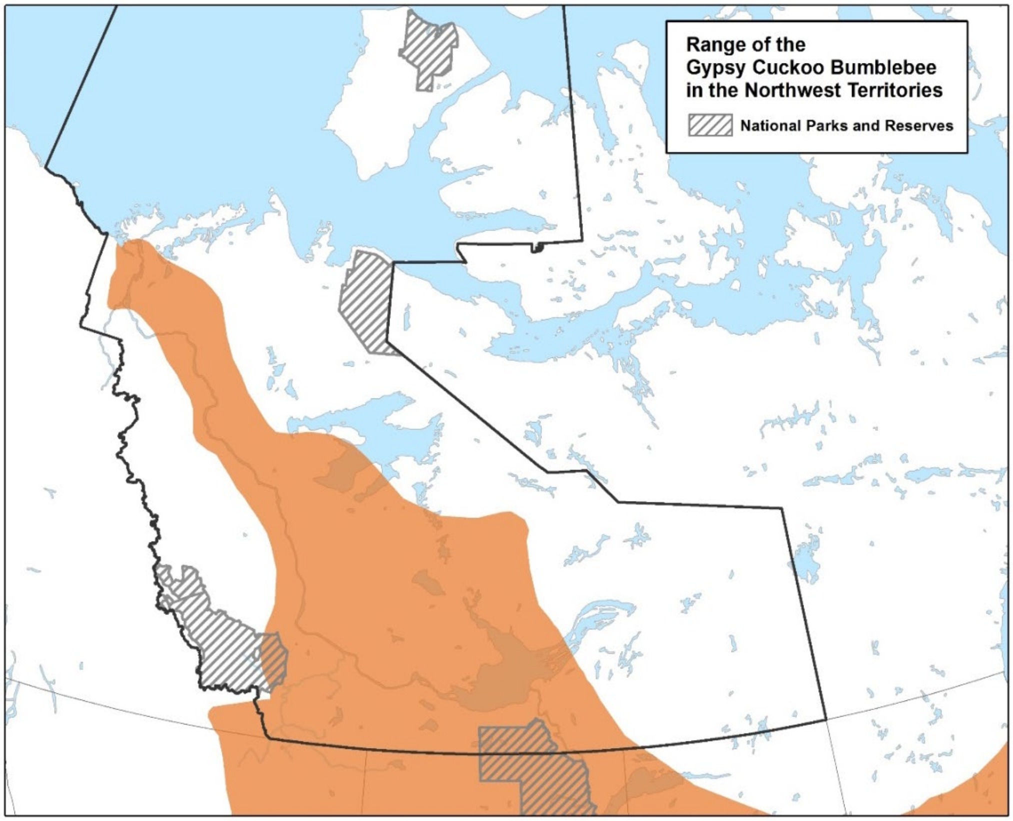

Figure 75. Range of gypsy cuckoo bumble bees in the NWT (NWT Species at Risk 2020).

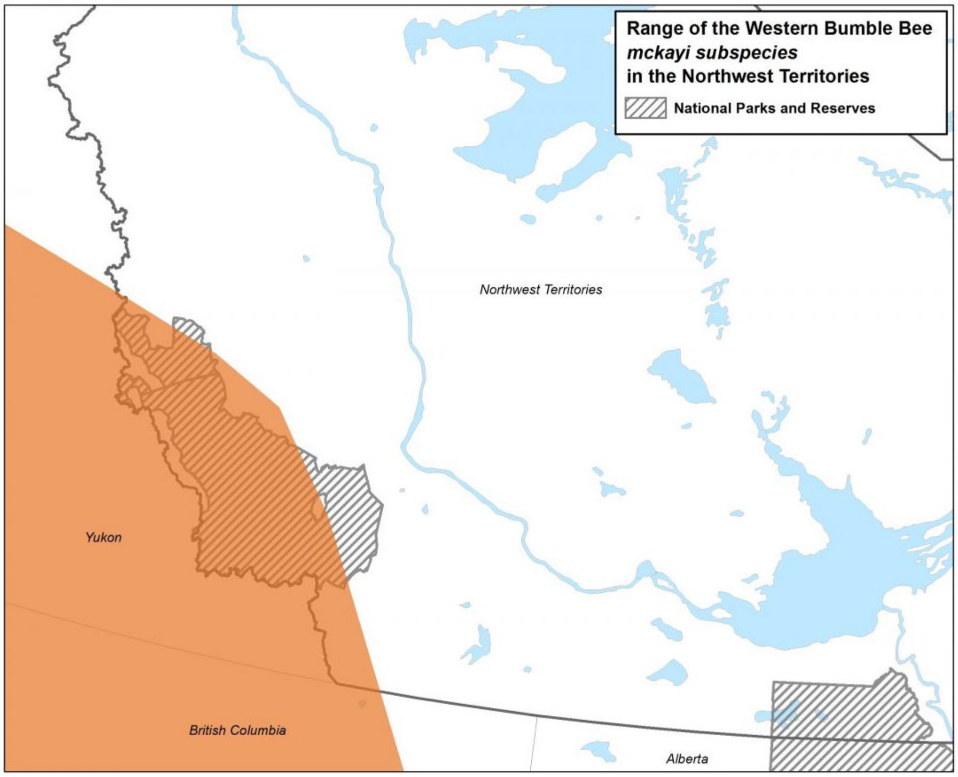

Figure 76. Range of western bumble bees in the NWT (NWT Species at Risk 2020).

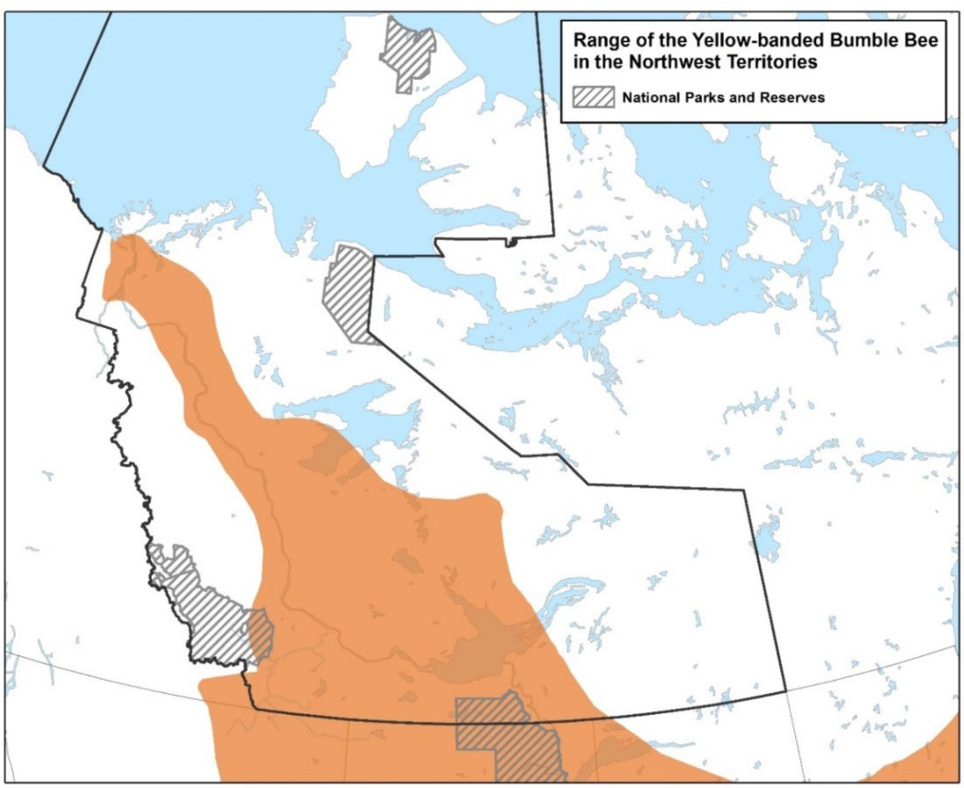

Figure 77. Range of yellow-banded bumble bees in the NWT (NWT Species at Risk 2020).

Transverse Lady Beetle

Transverse lady beetles are not likely particularly vulnerable to climate change. They have a broad range that includes most of Canada and areas of the United States (Figure 78). Summer dormancy, overwintering behaviour and cold tolerance allow them to survive in a wide variety of habitats and conditions. Transverse lady beetles produce two generations per year and a female can lay over 250 eggs in a two-week period. Development and size are linked to prey availability and temperature. Lady beetle dispersal ability is very good, with individuals able to undertake both short- and long-distance movements. Significant declines in this once-abundant species have been documented in central and eastern Canada since the 1970s. These declines may be related to invasion by non-native beetles, but this species is subject to a number of threats throughout its North American range. However, threats in the NWT are considered to be negligible at this time (COSEWIC 2016a).

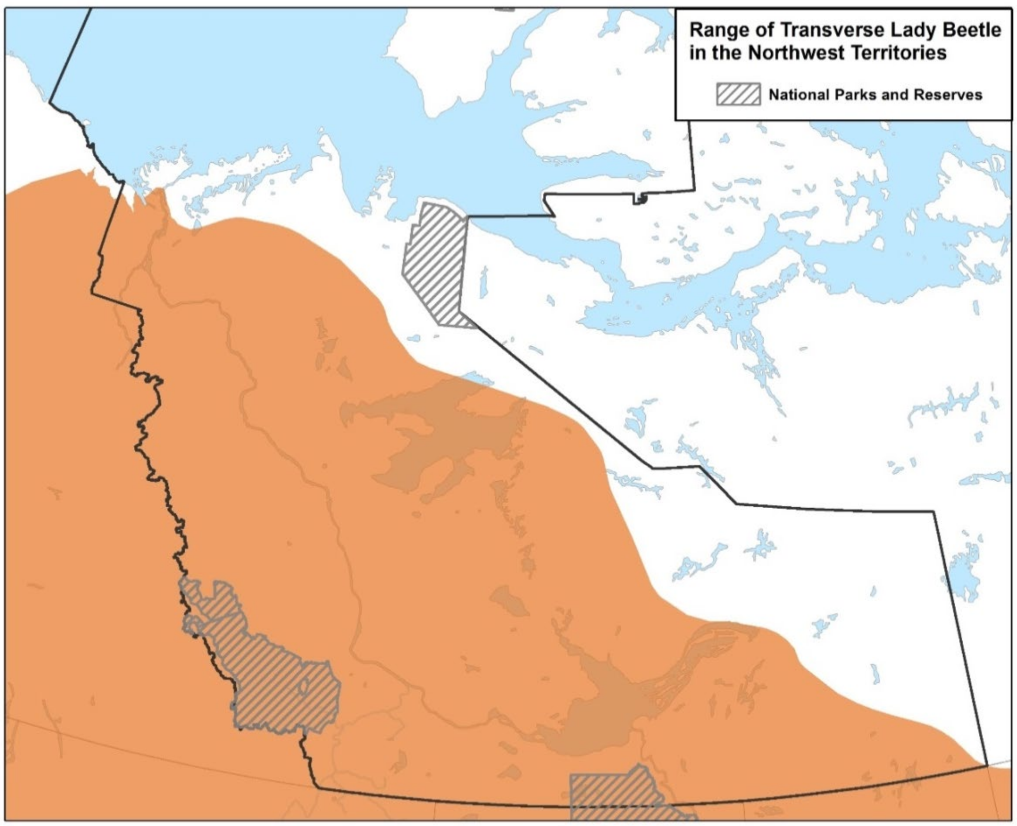

Figure 78. Range of transverse lady beetles in the NWT (NWT Species at Risk 2020).

Plants

Three plant species were included in this vulnerability assessment: hairy braya, Nahanni aster and Mackenzie hairgrass. All three species are endemic to Canada and are considered moderately to highly vulnerable to the effects of climate change, reflecting small distributions, small populations and habitat specializations. The effectiveness of their dispersal abilities is likely limited by the availability of habitat.

Table 14. Summary of vulnerability assessment results for plant species at risk.

Assessed species	**Climate change sensitivity**[39]	**Non-climate stressors**[40]	**Adaptive capacity**[41]
Hairy braya	3	1	3.5
Mackenzie hairgrass	3	1	1.5
Nahanni aster	2	1	1.5

Hairy Braya

Hairy braya is a small plant in the mustard family. Its range is limited to the Cape Bathurst peninsula and Baillie Islands in the NWT (Figure 79); an area that remained ice-free during the last glaciation. It requires bare soil for establishment and has poor competitive abilities. Hairy braya is a long-lived perennial that reproduces through cross-pollination. Dispersal ability is unknown, but the fruits and seeds are not suited to long-distance dispersal. Climate change is the most significant threat to this species. Coastal erosion in some parts of hairy braya range is progressing at a rate of 9-10 m/year. With continuing sea ice decline, increases in storm surge duration and severity and rising sea levels, coastal erosion is expected to continue. Salinization, tied to storm surges, is another factor negatively impacting hairy braya habitat and populations. Given the remote distribution of hairy braya, non-climate stressors are considered negligible at this time (SARC 2012b).

[39] The average of habitat, abiotic and biotic factors.
[40] Scored based on threats in the NWT only. This does not imply that there are not significant threats elsewhere in the range.
[41] Based on reproductive and dispersal capacity.

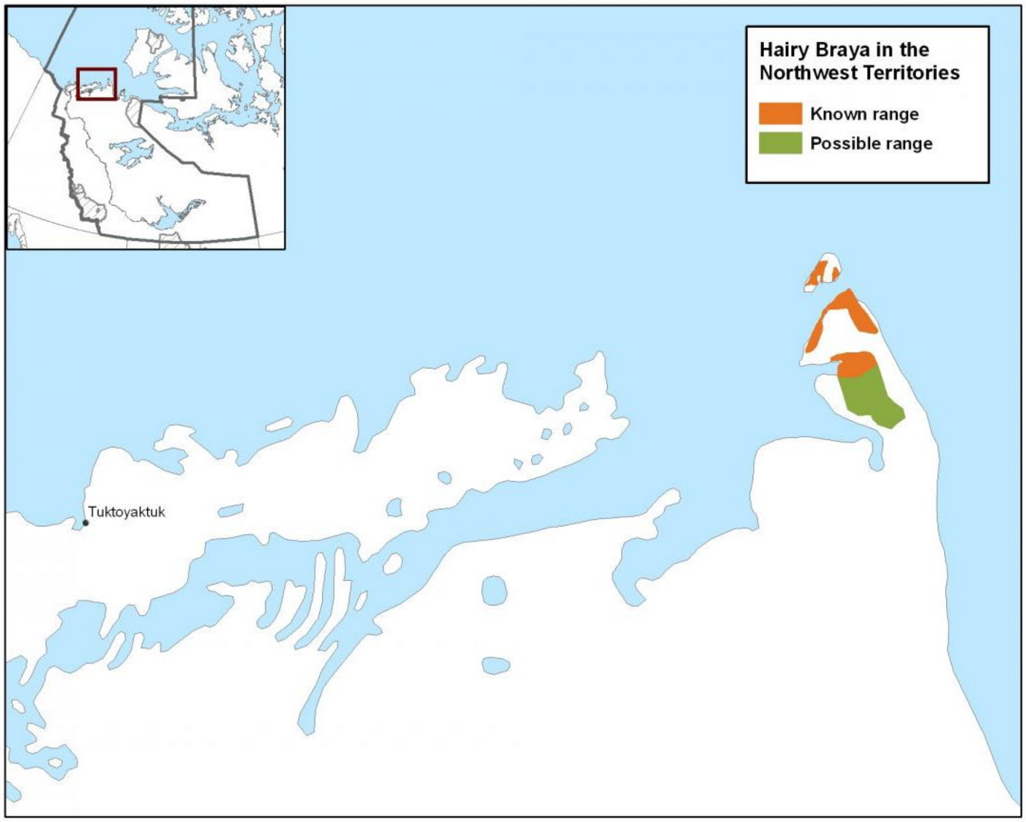

Figure 79. Range of hairy braya in the NWT (NWT Species at Risk 2020).

Nahanni Aster

The Nahanni aster occurs only in hot springs in the Nahanni National Park Reserve in the NWT (Figure 80). Their association with hot springs likely offers relatively stable temperatures and a good water and nutrient supply. However, Nahanni asters remain in areas where hot spring conditions have changed over time, suggesting that it can survive a broader range of temperature and nutrient conditions. Nahanni aster is perennial and while lifespan and generation time are unknown, they may live as long as ten years based on longevity in other species of this genus. Seed production is unknown, but each individual has the potential to produce several hundred seeds each year. Successful germination appears to be related to cold stratification and moisture. Seed dispersal is likely wind-based, but limited by available habitat.

Changes in hot spring conditions are the most significant threat to Nahanni aster. Changes in precipitation associated with climate change may alter groundwater discharge, but this is largely speculative and could result in either an increase or decrease in available habitat depending on the response of the system. Changes to hot spring conditions can also result from seismic activity and permafrost melt. This area is one of the most seismically active areas in Canada and a shift could shift, reduce, or stop groundwater flows to hot springs. Slumping associated with permafrost melt has already been observed in some areas of the

Nahanni National Park Reserve, but no Nahanni aster populations are found in the high-risk slide zones.

Given its presence in a protected area, non-climate stressors are considered to be negligible (COSEWIC 2014a).

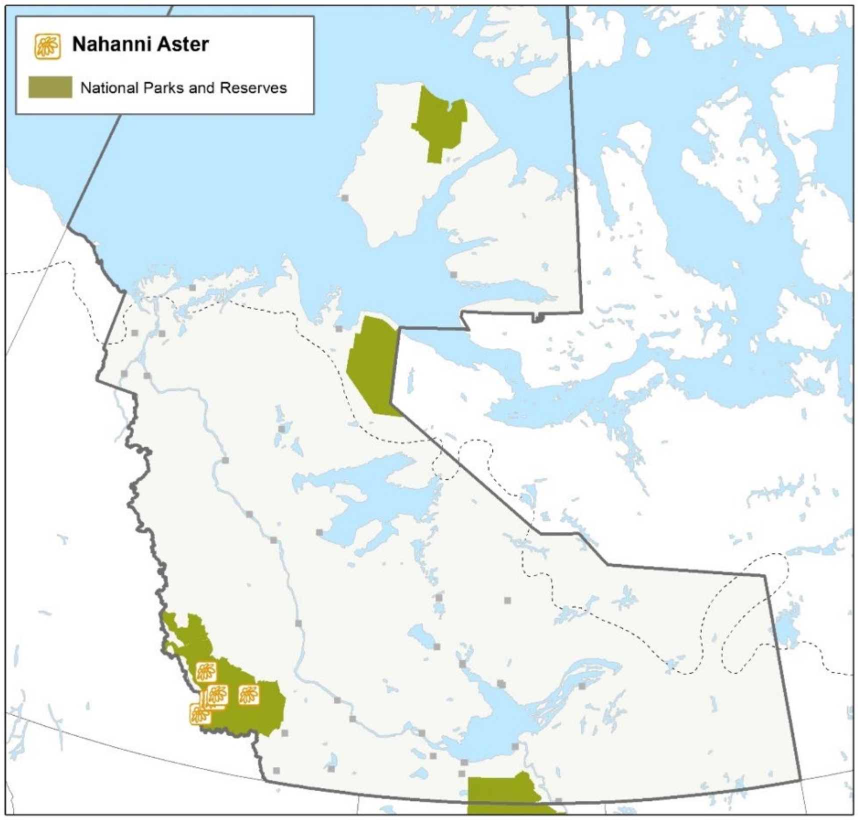

Figure 80. Range of Nahanni aster in the NWT (NWT Species at Risk 2020).

Mackenzie Hairgrass

The Mackenzie hairgrass is only known to occur in the Athabascan sand dunes in northern SK. One historical observation was also recorded near the NWT's Great Slave Lake (Figure 81). Reflecting its sand dune habitat, Mackenzie hairgrass is adapted to high temperatures and sand blasting. This species is a long-lived perennial that is wind-pollinated. It has lower than expected genetic diversity, possibly the result of an earlier bottleneck and limited gene flow.

Species in this sand dune environment are adapted to the highly dynamic nature of shifting sand dunes. The most important threat to Mackenzie hairgrass at this time relates to stabilization of the sand dunes. Stabilization may be the result of forest encroachment or invasive species establishment. Forest encroachment may be facilitated by changing wind patterns associated with climate change and forest fire suppression activities, which may increase if development activities and therefore human presence, increase in the area.

Invasive species such as smooth brome (*Bromus inermis*) and white sweet clover (*Melilotus alba*), with their ability to establish quickly in this environment, may also accelerate sand stabilization. Droughts are projected to increase with climate change and while this may impact the success of seed germination and establishment, the plants are well-adapted to this already arid environment, so the overall impact is unclear.

There are no known non-climate stressors to Mackenzie hairgrass in the NWT. In SK, the primary non-climate threats include the development of linear features associated with development activities and associated increased human access and activities. However, the Athabascan sand dunes area is currently quite remote and difficult to access (COSEWIC 2018a).

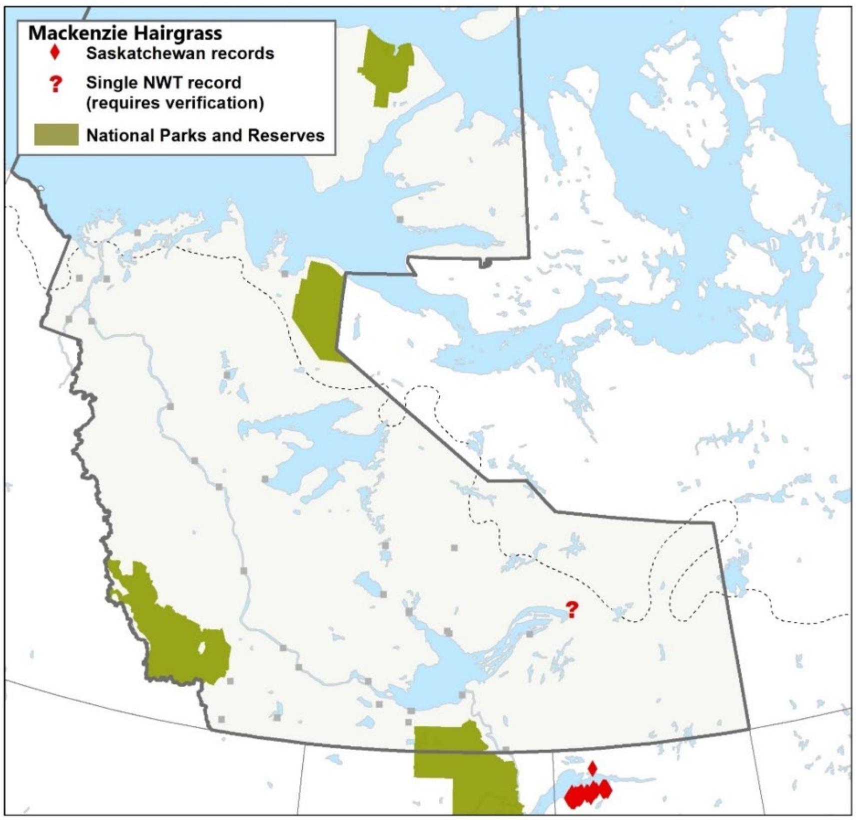

Figure 81. Range of Mackenzie hairgrass in the NWT (NWT Species at Risk 2020).

MANAGEMENT AND ADAPTATION

Climate change is an important threat to the species considered in this Phase 1 assessment. Future projections of change, coupled with high uncertainty, can discourage and overwhelm wildlife managers. In order to begin moving the conversation forward, this chapter looks beyond the assessment of vulnerability considered in previous chapters and towards the use and interpretation of these assessment results. Specifically, the following subsections will address the uses to which vulnerability assessments can be put, adaptation planning/prioritization, institutional capacity and dealing with uncertainty.

As noted previously, a detailed *Wildlife Climate Change Adaptation Plan* is currently under development by ENR. As such, detailed, species-specific management actions have not been proposed in this Phase 1 assessment.

Uses for Vulnerability Assessment Results

As noted earlier (*Climate Change Vulnerability Assessments*, pg. 38), CCVAs are often used to rank relative vulnerability, but they are also helpful in gaining a better understanding of the source(s) of vulnerability and, therefore, for developing and prioritizing targeted adaptation strategies and appropriate monitoring and evaluation (Young et al. 2012, 2015; Stein et al. 2014, Gross et al. 2016). Vulnerability assessments can also aid in informing communications with partners and the public (Stein et al. 2014, Young et al. 2015).

Adaptation Planning/Prioritization

Vulnerability assessments raise a broad range of concerns that must somehow be prioritized, alongside the multitude of other management concerns decision-makers already face. Indeed, successful management and conservation will likely be contingent on the appropriate allocation of scarce resources (Bagne et al. 2011).

Preparing for climate change as wildlife managers does not necessarily involve having to start from scratch. Adaptation planning can and should, start with a purposeful and open-minded evaluation of existing goals and objectives. Some of the goals may continue to be valid, but those whose achievability is likely to be adversely affected by climate change should be re-examined and revised (Stein et al. 2014, Gross et al. 2016). These latter goals may include maintaining the historical distribution of a highly climate-vulnerable species, or maintaining the full suite of historical biodiversity in a localized area – these types of goals are likely to be compromised by climate change. When evaluating existing goals and objectives, a number of important factors should be considered. Goals and objectives should, for example:

- Look forward, towards future climate/ecological conditions and potential range shifts, rather than relying on historical conditions as a benchmark (Stein et al. 2014, Gross et al. 2016).

- Where considering transboundary species, or species whose ranges are likely to shift in response to climate change, be coordinated across jurisdictional borders (Young et al. 2015).
- Not undermine the conservation of other species (Stein et al. 2014).
- Provide benefits under multiple climate futures (Stein et al. 2014).

Using the results of the vulnerability assessment as a starting point, new or revised adaptation strategies should aim to reduce exposure, reduce sensitivity, or enhance adaptive capacity (Stein et al. 2014, Daviet 2018). These strategies may be based on resistance/preservation/persistence (RPP), resilience, or facilitation/realignment. Actions in the first category (RPP) involve work to maintain the current system. As noted above, this approach is becoming increasingly difficult to do effectively, but may still be appropriate if success is likely in the long-term (e.g. a species residing in a climatic refugium), or to buy time to prepare for longer-term actions, or if not taking this kind of action means the loss of a species entirely (Stein et al. 2014, Gross et al. 2016). Resilience implies actions taken to maintain ecological functions and services while allowing changes to specific species communities (Gross et al. 2016). Facilitation/realignment involves making decisions towards a desirable future state. This last approach is particularly appropriate where change becomes unavoidable or imminent. Approaches here can be passive (allowing change to happen) or active (actively facilitating shifts) (Stein et al. 2014, Gross et al. 2016). It is important to consider options under all these categories/approaches to management to ensure paths forward are articulated and available when they become necessary (Stein et al. 2014). Examples of possible broad adaptation strategies are included in Table 15.

One particularly important component of building a climate change adaptation strategy is to focus on those vulnerabilities that are most important for conservation purposes. Using the vulnerability assessment as a starting point, consider which specific vulnerabilities will most impact existing conservation goals and objectives. Identify or develop a suite of adaptation options to address those vulnerabilities. Then, to narrow those options down to those that will form part of your adaptation strategy, consider:

- Is the action practical/realistic/feasible?
- What influence will the proposed action have on conservation goals/objectives?
- What is the ecological importance of the species being considered?
- How severe could the impact be? Could it impact more than one species?
- How likely are the impacts? Can they be reversed? When are they likely to occur?
- Will the action provide benefits under multiple future climate scenarios?
- Is the adaptation action likely to be successful?
- What are the consequences of not pursuing the action?
- What trade-offs are being accepted if this action is pursued?

- Are monitoring/evaluation of the species/adaptation action possible?
- Can the action accommodate flexibility (i.e., can it be altered as new information emerges) (Stein et al. 2014, Gross et al. 2016)?

Adaptation strategies do not necessarily need to be focused on the species with the highest vulnerability scores. A species with a key ecological role but moderate vulnerability may be more important to focus on than a highly vulnerable species with no known ecological role. Ultimately, it involves clearly defining conservation goals and making management and adaptation decisions that support those goals (Stein et al. 2014).

Table 15. Broad adaptation examples/options (not exhaustive).

Example/option	Considerations	Reference
Reduce non-climate threats	This approach has the potential to reduce cumulative stressors to species, but as part of climate change adaptation, it must be done strategically, to ensure that the threats, if managed, will decrease species/system vulnerability to climate change (e.g. minimize/reverse habitat fragmentation and enhance connectivity). Those threats with negative synergistic relationships with climate change are particularly important to address.	Meltofte et al. (2013), Stein et al. (2014), Price and Daust (2016), Gross et al. (2016)
Consider conservation goals at larger spatial scales	Increasing consideration will need to be given to minimizing species extinctions at the global scale, while making allowances for shifts at more local scales.	Stein et al. (2014), Gross et al. (2016)
Protect important features, climatic refugia, important habitat components and biodiversity hotspots (e.g. polynyas, perennial sea ice, etc.).	Features and refugia are areas that are likely to either remain fairly constant through climate change, or respond more slowly. They can facilitate connectivity or be destinations for species shifting to new ranges. Important habitat components and biodiversity hotspots may help maintain biodiversity over the long term.	Meltofte et al. (2013), Stein et al. (2014), Gross et al. (2016), Price and Daust (2016), Littlefield et al. (2019)
Protect/restore connectivity	This allows species and resources to move freely; that is, adapt/respond appropriately to climate change (improving adaptive capacity). Consider not only existing or historical routes, but routes to areas that may become suitable in the future.	Meltofte et al. (2013, Stein et al. (2014), Gross et al. (2016), Price and Daust (2016), Littlefield et al. (2019)
Protect alternate/future habitat	Minimizing global extinctions will mean allowing, at least to some degree, shifts in species/ecoregions. It is important to ensure these species/assemblages have somewhere to go.	Meltofte et al. (2013), Gross et al. (2016)

Consider flexible methods of protection that can shift over time	This recognizes the potential for range/ecoregion shifts.	Meltofte et al. (2013), Littlefield et al. (2019)
Conserve a diversity of ecosystems, species and distinct populations	This improves overall ecological resilience, ability to recover and evolutionary potential.	Stein et al. (2014), Price and Daust (2016)
Conserve processes (e.g. decomposition, gene flow, disturbance regimes, pollination, etc.)	This will help ensure ecosystems continue to function and may help facilitate natural adaptation.	Gross et al. (2016)
Develop a method of detecting and preparing for alien/invasive species	This may also involve determining when response is necessary, given that range shifts represent a normal adaptive response to changing climate conditions. However, detection and response to species whose impact may be particularly severe (e.g. vector-borne diseases) is still important.	Meltofte et al. (2013), CCH (2019)
Monitoring, evaluation and research	Simply monitoring populations and associated life history parameters is no longer likely to be sufficient. Monitoring should be designed to detect and test the effects of limiting factors, threats, interactions and interventions. Design of monitoring programs may need to account for shifting species ranges. Indicator species will be important to track, including representatives from multiple taxa, both above- and belowground.	Meltofte et al. (2013), Stein et al. (2014)
Building climate literacy	Putting effort into communication and education, both with external partners and the public and internally (i.e., staff), can help improve support for adaptation initiatives and when staff are given appropriate education/resources, can help increase the adaptive capacity of the organization to respond to rapid environmental changes.	Parker 2017a and b

Institutional Capacity

Institutional capacity can have a direct effect on the development of appropriate adaptation strategies and their effective and timely implementation. Factors that may limit institutional capacity include limited financial and human resources, other competing priorities, leadership vision, communication of priorities to staff, presence or absence of clear goals and objectives, understanding of vulnerability, available professional development opportunities for staff related to climate change, access to required data/resources and flexibility/responsiveness of processes. Factors such as these impact an organization's ability to prepare for and detect change and then respond in a timely and appropriate manner (Gross et al. 2016).

Lack of institutional capacity has the potential to facilitate success or derail climate adaptation efforts. Methods of evaluating and improving institutional capacity are available (e.g. Edwards et al. 2015) but are not discussed in detail here.

Dealing with Uncertainty

Uncertainty is a clear barrier to climate change adaptation. Projections, although useful, particularly for defining climate trajectory, do not purport to provide exact predictions of the future. Contained within them are of assumptions that make them subject to change and interpretation. Unpredictable responses of species/systems also add to this uncertainty (Young et al. 2012, Price and Daust 2016).

However, uncertainty can no longer be used as a reason to delay action on climate change adaptation, particularly given that it is clearly understand the direction in which climate change is proceeding. In this context, actions can be pursued while acknowledging and accommodating uncertainty. For instance, the strategies pursued should provide benefit under multiple future scenarios. This provides a no-lose situation for managers. Explain why certain strategies were chosen for implementation and how the system may respond. This helps communicate rationale, but also facilitates evaluation and adaptive management as information improves in the future (Stein et al. 2014, Gross et al. 2016).

Most importantly, it is important to recognize that we will never have all the information we want. Start anyway, with the knowledge and resources already available (Stein et al. 2014). As information improves and adaptation strategies are tested, approaches can be altered over time in response.

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The methods used in this assessment largely replicate those described in Price and Daust (2016), with some modifications put forward by Dr. Chris Shank. This method permitted relatively rapid assessment of multiple species at low cost, while allowing presentation of results in a simple, readable layout and, recognizing uncertainties, in a manner that avoids perception of high precision.

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Appendix A: Instructions to Reviewers and Methods

NWT Species at Risk

Climate Change Vulnerability Assessment and Threat Trends Assessment

Instructions for Expert Reviewers

Thank you for participating in this review. This work will contribute to two projects being undertaken by the Government of the Northwest Territories (GNWT): (1) a wildlife climate change vulnerability assessment and (2) updating the species at risk indicators in the territory's State of the Environment Report.

The wildlife climate change vulnerability assessment is being undertaken following a review of the GNWT's climate change programs by the Office of the Auditor General in 2017. This first phase will focus on species at risk only.

Simply, we are asking species experts to review the attached species summary pages for completeness. The content of these was based on species at risk status reports. NWT status reports were used where possible; COSEWIC status reports were used otherwise. Some of these status reports are becoming dated or may not have considered threats from an NWT perspective. Thus, our desire to bring in species experts to ensure that the information we're using is as up-to-date as possible. When adding information to the summaries or flagging missing information, please include references for the new information.

Reviewers are also encouraged to submit suggested scores for the climate change vulnerability assessment and the threats calculator. Detailed instructions for participating in the scoring are on the following pages.

If you have any questions, or require clarification regarding the instructions, please contact the NWT Species at Risk Secretariat:

Claire Singer, Species at Risk Implementation Supervisor
Ph: (867) 767-9237, extension 53216
Toll-free: (855) 783-4301

Detailed Scoring Instructions - Climate Change Vulnerability Assessment:

Sensitivity and adaptive capacity are scored using a method developed for British Columbia's wildlife climate change vulnerability assessment (Price and Daust 2016). This provides an estimate of intrinsic vulnerability to climate change. This simple method of scoring vulnerability is appropriate given the uncertainty associated with climate change. Scores are therefore not finely divided.

Sensitivity

Two aspects of a species' sensitivity are evaluated: sensitivity to climate-related factors and exposure to potentially interacting non-climate pressures.

Sensitivity to climate-related factors

Three factors are taken into account when assessing a species' sensitivity to climate-related factors: (1) dependence on habitats that are sensitive to climate change, (2) sensitivity to climate-relevant abiotic factors and (3) sensitivity to climate-relevant biotic factors. An overall score for sensitivity to climate change reflects the highest value of the three factors.

Dependence on habitats that are sensitive to climate change – For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regimes. Includes specialists defined with a climate change lens.

1 – Broad generalist.
2 – Generalist, but some sensitive habitats are important.
3 – Depends on sensitive habitats that are not rare.
4 – Depends on sensitive habitats that are rare.

Sensitivity to climate-relevant abiotic factors – For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

1 – Not sensitive.
2 – Somewhat sensitive or possibly very sensitive.
3 – Likely very sensitive.
4 – Known very sensitive.

Sensitivity to climate-relevant biotic factors – Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology and disease).

1 – Not sensitive.
2 – Somewhat sensitive or possibly very sensitive.
3 – Likely very sensitive.
4 – Known very sensitive.

Exposure to potentially interacting non-climate pressures

Potentially interacting non-climate pressures – Sensitivity to climate change may be affected by the extent to which other factors, such as habitat loss, invasive species, or pollution pose threats.

1 – No pressures.
2 – Moderate pressures or possibly major pressures.
3 – Likely major pressures.
4 – Known major pressures.

Adaptive capacity

Overall adaptive capacity is calculated as the mean of reproductive capacity and dispersal ability, modified by genetic diversity or plasticity if known. Data for genetic diversity and phenotypic plasticity are scarce; they are therefore not explicitly scored, simply noted. Adaptive capacity is scored as: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.

Reproductive capacity – Based on averages provided in sources.

1 – Fast generation time, many offspring.
2 – Fast generation time, few offspring.
3 – Long generation time, many offspring.
4 – Long generation time, few offspring.

Dispersal capacity – Taken from maxima noted in sources. If this information is not available, extrapolate from species of similar size. Barriers to effective dispersal should be noted and factored into the score.

1 - >100 km.
2 – 10-100 km.
3 – 1-10 km.
4 - <1 km.

Genetic diversity – Include notes where information is available. High genetic diversity likely provides a better foundation for climate-based selection provided that the diversity exists in climate-relevant traits.

Phenotypic plasticity – Include notes where information is available. Plasticity allows individuals to respond physiologically or behaviourally to changes over the short term.

Threat Trends Assessment

Threats should be scored based on the assessment unit as a whole (species, subspecies, or distinct population, as defined on the first page of the species summary pages), insofar as those threats may be directly relevant to the status of the population in the NWT. It's key to remember that this is a jurisdictional review of threats. Notes can be included about threats in other jurisdictions (e.g. mining in South America for a migratory bird species), but unless the NWT has some measure of responsibility or control over that threat, please score as N/A (not applicable).

The approach to threats assessment noted below 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*. This approach is considered easier to use and understand. This modified scoring protocol was adopted as the standard threat assessment method by both the Species at Risk Committee and Conference of Management Authorities for Species at Risk in 2019.

Parameter	Description	Scoring Categories
Extent (i.e., scope)	Indicates the spatial extent of the threat (based on percentage of population area affected).	Widespread (>50%) Localized (<50%)
Severity	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
Timing (i.e., immediacy)	Indicates if the threat is presently happening, expected to happen 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	Indicates the likelihood of the threat to occur over approximately the next 10 years.	High Medium Low
Certainty	Indicates the level of confidence that the threat will have an impact on the population.	High Medium Low
Overall level of concern	**Indicates the overall threat to the population (considering the above).**	**High** **Medium** **Low** **N/A (not applicable)** **Negligible**

Threat categories are as defined by the IUCN unified threats classification scheme. Descriptions/definitions of each category may be found here: https://nc.iucnredlist.org/redlist/content/attachment_files/dec_2012_guidance_threats_classification_scheme.pdf.

Appendix B: Detailed Scores by Species

Species: Bank Swallow (*Riparia riparia riparia*) (subspecies)
Populations (if applicable): A clear distinction between populations is not apparent.
Percentage of North American population NWT is responsible for: Extensive distribution, occurring on every continent except Antarctica and Australia. In North America, it breeds widely across the northern two thirds of the United States, north to the treeline. It breeds in all Canadian provinces and territories, except perhaps NU. It winters primarily in South America. The NWT hosts approximately 3% of the Canadian population of bank swallows.
NWT General Status Ranks: At Risk
NatureServe Conservation Rank (NWT): S3S4B
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Threatened
Reasons for assessment or population trends: This widespread species has shown a severe long-term decline amounting to a loss of 98% of its Canadian population over the last 40 years. As with many other aerial insectivores, the decline continues, albeit at a slower rate since the 1980s. Breeding bird survey data from 2001-2011 indicate a potential loss of 31% of the population during that ten-year time period. The reasons for these declines are not well understood, but are likely driven by the cumulative effects of several threats. These include loss of breeding and foraging habitat, destruction of nests during aggregate excavation, collision with vehicles, widespread pesticide use affecting prey abundance and impacts of climate change, which may reduce survival or reproductive potential.
Sources used for assessments: COSEWIC (2013)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[42] = 2		
Dependence on habitats that are sensitive to climate change[43]	Perhaps the most limiting habitat requirement for nesting bank swallows is the availability of eroding, vertical banks composed of unconsolidated substrates (e.g. silty fine sands). Bank swallows excavate nesting burrows in eroding vertical banks. These can include a wide variety of low-elevation (<900 m), natural and artificial sites with vertical banks, including riverbanks, lake and ocean bluffs, aggregate pits, road cuts and	2 – Generalist, but some sensitive habitats are important.

[42] Overall sensitivity score derived from the average of habitat, abioticand biotic factor scores.
[43] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	stock piles of soil. Breeding sites tend to be somewhat ephemeral due to the dynamic nature of bank erosion. Breeding sites are often situated near open terrestrial habitat used for aerial foraging (e.g. grasslands, meadows, pastures and agricultural cropland). Nest burrows are nearly always in a vertical or near-vertical bank (range: 76-105° slope). During migration, a wide variety of lowland habitats and open areas are used (prairies, marshes, agricultural areas, seashores, savannas, reed beds). Existing information regarding bank swallow habitat requirements during winter is relatively scant. In general, wintering birds are observed over grasslands, savannas, open agricultural terrain and freshwater and brackish wetlands, reservoirs and beaches. Winter nocturnal roosts occur in large wetlands or reed beds, as they do during migration.	
Sensitivity to climate-relevant abiotic factors[44]	Since the 1990s, the increased rate of erosion caused by climate change, increases in coastal development and increases in erosion control measures have almost certainly resulted in further habitat loss in the Maritimes. Survival rates fluctuate annually and may be most influenced by rainfall on the wintering or breeding grounds. Most nestling mortality is apparently caused by starvation and is associated with periods of inclement weather and reduced aerial insect availability. River flooding and bank collapse often result in nestling mortality.	2 – Somewhat sensitive or possibly very sensitive.
Sensitivity to climate-relevant biotic factors[45]	Aerial-foraging insectivorous bird species, consuming mostly flying insects. Changes in the timing of emergent insects may be occurring as a result of climate change, such that there is a mismatch between the availability and demand in food supply for birds (i.e., for provisioning young, post-fledging, migration or during winter).	2 – Somewhat sensitive or possibly very sensitive.
Non-climate stressors = 1		
Sensitivity to potentially	Loss of breeding and foraging habitat is apparent in other areas of its range, accompanied by substantial	1 – No pressures.

[44] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

[45] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

interacting non-climate pressures	population declines; however, there are no serious non-climate stressors to bank swallow in the NWT.	
Adaptive capacity[46] (mean = 1)		
Reproductive capacity[47]	In North America, the bank swallow is single-brooded and nest success is often relatively high (often 70% of eggs laid result in fledged birds). Generation time is likely 1.7 to two years old. Both males and females can breed in their first year (i.e., 10-11 months of age), with annual breeding attempts thereafter. Clutch size is typically three to six eggs, but averages five eggs. The longevity record for this species is an adult that was at least eight years and 11 months old. There is no available information on annual reproductive success, or average annual female fecundity, because it is unknown what proportion of the population breeds annually.	1 – Early reproduction/many offspring.
Dispersal capacity[48]	Traditional colony sites are used. Maximum juvenile dispersal recorded in the United Kingdom at >199 km away from natal colony. Home ranges during the nesting season are thought to be relatively small, as foraging birds appear to use open areas within 200-500 m of the colony. Occasionally, radio-tagged adult birds were observed to make longer foraging trips up to 1km or more away from breeding sites. Bank swallows are long-distance migrants. Banded birds from ON and SK have been recovered in northern Peru and northern Bolivia, respectively.	1 - >10km.
Genetic diversity		N/A
Phenotypic plasticity		N/A

[46] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[47] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.
[48] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing	The North American distribution likely initially increased post-European settlement, due to anthropogenic landscape changes (e.g. opening forests, increasing pastureland, etc.). Although wetlands and open water habitats are used as foraging areas at certain times, nesting bank swallows mainly rely on open terrestrial habitats for foraging (e.g. grasslands). The widespread and ongoing decline of grassland-obligate birds is linked to a number of regional changes, such as conversion of native grasslands to row crops, afforestation and urbanization of abandoned farms and pasturelands, rangeland degradation and agricultural intensification (e.g. from artisanal farms to monoculture annual crops). Thus, it is conceivable that some (or all) of these changes have also led to a reduction in							**N/A**

	suitable foraging grounds for breeding bank swallows, although this needs further study.							
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling								**N/A**
3.2 Mining and quarrying	During the last ~100 years, the excavation of sand and gravel from pits, quarries and roadcuts undoubtedly led to an increase in the availability of vertical banks for nesting bank swallows. Changes in government policies involving the use of roadcuts may have reduced habitat availability in some jurisdictions. Policy changes include removal of vertical slopes via grading. In Sweden, large-scale declines in the bank swallow population have been associated with changes to gravel and sand pit operations: (1) decreasing demand for aggregates, (2) bank stabilization and restoration of pits, (3) a switch from pits to quarries as an aggregate source and (4) concentrating gravel and sand extraction to fewer and larger pits. Clearly, these same changes have occurred in ON and possibly in other areas of Canada.							**Neg.**
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads	Of 336 band recoveries of dead bank swallows, collisions with vehicles (45.2%) was the most frequent cause of mortality. In Long Point, ON, road-kill mortalities vary annually and may be positively related to prolonged inclement weather conditions. In addition, conspecific attraction to road-killed corpses may increase rates of road-kill mortality in bank swallows. However, the estimated total mortalities over the breeding and post-breeding season was probably biologically insignificant considering the large local							**Neg.**

	population estimate (<0.01%).							
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	Colonies are sometimes persecuted by curious children, digging and inserting objectives (e.g. tree branches) in burrows. Some colonies are also either destroyed or partially destroyed during extraction operations at aggregate pits and also during road construction. Incidental take, the destruction of birds and/or nests during legitimate human activities, has been identified as a threat for bank swallows breeding in aggregate pits. A preliminary rough estimate of 58,000 eggs or nestlings destroyed annually by pit operations in Canada. BC, ON, Quebec and AB are responsible for 54, 22, 10and 8% of these losses, respectively. In some cases, river and ocean erosion control projects taking place during the breeding season have directly resulted in nest damage and nestling mortality, caused by rock walls and other materials being placed directly in front of nest sites.							**Neg.**
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting	Loss of breeding and foraging habitat is apparent, including through afforestation, although opening forests post-European settlement likely initially increased distribution.							**Neg.**
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities	Habitat degradation and disturbance from motocross and ATV use in pits and other areas may be of significance.							**Neg.**

6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression								**N/A**
7.2 Dams and water management/use	Control of water-level fluctuations and peak discharge rates (via dams) has substantially reduced the stochastic processes regulating bank erosion along many streams and rivers throughout North America. This has undoubtedly affected the historical distribution of breeding habitat. Large and often rapid fluctuations in water levels associated with the impoundment and release of water by hydroelectric dams can result in colony inundation (e.g. drownings of nestlings) and further habitat degradation. In theory, these activities could potentially lead to the creation of new nesting habitat; however, evidence of this has not been documented.							**Neg.**
7.3 Other ecosystem modifications	Widespread erosion control measures have increased in riverine, lacustrine and ocean coast environments throughout Canada and elsewhere. Especially in human settlement areas, hardening or armouring shorelines and riverbanks is commonly used to negate property loss and may result in loss of breeding sites.							**Neg.**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases								**N/A**
8.2 Problematic native species/diseases	Predation can be an important cause of nest failure at colonies, but is thought to only cause localized impacts. Changes in these species' populations may influence bank swallow numbers. Merlin and other raptor species (excluding American kestrel) have undergone population rebounds over the last several decades, especially in southern ON and the Maritimes. It is, however, unknown if raptor							**Neg.**

	populations are negatively impacting bank swallows where both species coexist. Several flea species are known to inhabit bank swallow burrows and can reduce nestling masses by about 5%. Several larval blowfly species frequently infest colonies and at least one species, *Protocalliphora chrysorrhoea*, is restricted almost entirely to inhabiting the nests of bank swallows and parasitizing nestlings. Although *P. chrysorrhoea* infestations may cause physiological stresses in nestlings, nestling mortality rates are unaffected. It is unknown if changes in parasite loads or species composition have occurred in bank swallows.							
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents								**N/A**
9.3 Agricultural and forestry effluents (including erosion)	Widespread pesticide use may cause decreases in the abundance or diversity of flying insects. In particular, pesticide use in South America (in wintering grounds) is of primary concern because banned organochlorine and organophosphate pesticides are still in use there. Surprisingly, even the use of highly selective, low toxicity mosquito control agents (i.e., *Bacillus thuringiensis israelensis* [Bti]) have been shown to alter diet compositions and reduce feeding and							**Neg.**

	reproductive rates of House Martins. Bti has been used worldwide, including Canada, since 1982.							
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Climatic changes (e.g. droughts, inclement weather) on wintering and/or breeding grounds may cause reduced adult survival and/or reproductive output. Throughout southern Canada and especially in densely populated regions, wetlands and estuaries have undergone tremendous net losses and cumulative impacts (e.g. climate change, invasive species, road expansion) continue to exacerbate wetland health and function. Thus, it is possible that the trends in wetland loss and degradation are having some negative impact on populations in Canada, although more study is needed. Because some wetlands may concentrate large numbers of roosting swallows, especially on migration routes or wintering grounds, these areas may have extremely important conservation value. Changes in the timing of emergent insects may be occurring as a result of climate change, such that there is a mismatch between the							**Neg.**

	availability and demand in food supply for birds (i.e., for provisioning young, post-fledging, migration, or during winter).							
11.2 Droughts	In the eastern hemisphere, apparent overwintering adult survival is reduced in drought years and negatively related to the rainfall levels from the previous breeding season.							**Neg.**
11.3 Temperature extremes	Hot days, defined as days with maximum temperature above 30°C, are rarely observed in the regions north of 60° latitude. Annual highest daily maximum temperature is expected to increase 1.8°C in the 2040s and 5.7°C by the end of the century. The impact of this increase in maximum daily temperatures on bank swallow is uncertain.							**N/A**
11.4 Storms and flooding	Inclement weather events are considered the primary cause of nestling mortality. Periods of prolonged rainfall can reduce insect availability, increase foraging constraints on adults and cause colony bank collapse. Breeding habitat in coastal regions may be under threat due to accelerated coastal erosion and high-water levels. This is more concerning in areas where bank swallows primarily rely on natural breeding habitat. Permafrost thaw slumps are increasing with Arctic warming and may provide suitable nesting habitat depending on slumping activities (i.e., banks). Active thaw slumps likely retreat too quickly (20 m annually) for bank swallows to establish colonies, but stabilized thaw slumps may provide suitable habitat. However, this is speculative because there are no records of bank swallows nesting in permafrost thaw slumps.							**Neg.**
11.5 Other								**N/A**
12. Other threats								
Although no single threat appears responsible for the decline of the bank swallow, cumulative effects from several sources may be driving declines.								**Neg.**

Species: Barn Swallow (*Hirundo rustica erythrogaster*)
Populations (if applicable): N/A
Percentage of North American population NWT is responsible for: It is the most widespread species of swallow in the world, found on every continent except Antarctica. In Canada, it is known to breed in all provinces and territories. The NWT is home to <3% of the Canadian population.
NWT General Status Ranks: At Risk
NatureServe Conservation Rank (NWT): S3B
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Threatened
Reasons for assessment or population trends: This is one of the world's most widespread and common land bird species. However, like many other species of birds that specialize on a diet of flying insects, this species has experienced very large declines that began somewhat inexplicably in the mid- to late 1980s in Canada. Its Canadian distribution and abundance may still be greater than prior to European settlement, owing to the species' ability to adapt to nesting in a variety of artificial structures (barns, bridges, etc.) and to exploit foraging opportunities in open, human-modified, rural landscapes. While there have been losses in the amount of some important types of artificial nest sites (e.g. open barns) and in the amount of foraging habitat in open agricultural areas in some parts of Canada, the causes of the recent population decline are not well understood. The magnitude and geographic extent of the decline are cause for conservation concern.
Sources used for assessments: COSEWIC (2011a), Zhang et al. (2019), Bonsal et al. (2019).

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[49] = 1.7		
Dependence on habitats that are sensitive to climate change[50]	Across their global range, Barn Swallows have proven themselves to be highly adaptable to changes in the availability of different types of nesting sites, as demonstrated by their propensity to nest in and on a variety of human-made structures. Before European colonization, Barn Swallows nested mostly in caves, holes, crevices and ledges in cliff faces. Following settlement, they shifted largely to nesting	1 – Broad generalist.

[49] Overall sensitivity score based on the average of habitat, abioticand biotic factor scores.
[50] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	in and on artificial structures, including barns and other outbuildings, garages, houses, bridges and road culverts. Barn swallows prefer various types of open habitats for foraging, including grassy fields, pastures, various kinds of agricultural crops, lake and river shorelines, cleared rights of way, cottage areas and farmyards, islands, wetlands and subarctic tundra. During migration, barn swallows gather over marshes, lakes and sloughs to feed on aerial insects. Roosting sites during fall migration in Canada are characterized by alder groves and cattail and bulrush marshes. On the wintering grounds, barn swallows are associated with various open, low vegetation habitats such as sugar cane fields, savannahs and ranch lands.	
Sensitivity to climate-relevant abiotic factors[51]	Because their nests are constructed of mud pellets, barn swallows require wet sites that have a source of nearby mud. An increase in precipitation in all seasons has been projected for the NWT (Zhang et al. 2019). They are sensitive to cold snaps in the spring and during nesting. As temperature is expected to increase across the NWT, the intensity/frequency of cold snaps is expected to decrease (Zhang et al. 2019).	2 – Somewhat sensitive or possibly very sensitive.
Sensitivity to climate-relevant biotic factors[52]	This species forages in the air and specializes on a diet of flying insects. In North America, the main insect groups are Diptera, but insects from many other families are consumed. Declines in insect prey availability are hypothesized to be potentially partly related to climate change.	2 – Somewhat sensitive or possibly very sensitive.
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	The influence of non-climate stressors is unclear but likely minimal in the NWT. Ectoparasites and changes in insect prey abundance are threats of low magnitude in the NWT.	1 – No pressures.
Adaptive capacity[53] = 2.5		

[51] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.
[52] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

Reproductive capacity[54]	Two broods are frequently produced each year, except in the far north. Generation time is two to three years. Females first breed at one year old; some males remain unpaired until two years old. In Canada, clutch size is generally four to five eggs in the east and three to five in the west (BC). Hatching success in BC is 70%. Maximum reported life span of about eight years and an average life span of four years.	1 – Early reproduction/many offspring.
Dispersal capacity[55]	Adult fidelity to breeding sites varies greatly among studies, ranging from between 12 and 88% in eastern North America. In Oklahoma, 16% of returning birds reused the same nest, while most other returning birds moved within an average of only 12 m from their previous year's nest. It is a long-distance migrant and winters through Central and South America. Most foraging takes place within a few hundred meters from the colony and usually within 500 m. In West Virginia, breeding adults will venture out to within 1.2 km of their nest site (equivalent to a foraging home range of 4.5 km^2). Adults do not defend breeding 'territories' per se, but do have minimum separation distances around active nests – ranging from 1.7m in BC to 3.7m in Mississippi and Oklahoma.	4 - <0.25km
Genetic diversity	More research is necessary to determine the extent to which population bottlenecks are occurring on the breeding groups versus the wintering grounds.	N/A
Phenotypic plasticity		N/A

53 Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
54 Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.
55 Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	**Notes**	Extent	Severity	Temporality	Timing	Probability	Certainty	**Overall level of concern**
1. Residential and commercial development								
1.1 Housing and urban areas	The barn swallow has become closely associated with human rural settlements. Despite population losses over the last 40 years, the distribution and numbers of this species are acknowledged to be far greater than they were before European settlement created a large amount of artificial nesting and foraging habitat that the species readily exploited.							**Neg.**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops	Following European settlement, the amount of open habitat needed for foraging greatly increased. This was due to the large-scale removal of forests for agriculture, which not only provided suitable foraging habitat, but also greatly increased the availability of nest sites because of the construction of barns and other wooden structures. In response, barn swallows expanded their breeding populations and extended their breeding range into areas where they formerly did not occur; most of these documented range expansions occurred in the second half of the 19th century. Loss of nesting and foraging habitats due to conversion from conventional to modern farming techniques is thought to be a main cause of decline. This is primarily owing to the widespread							**Neg.**

	conversion of old wooden farm buildings to more modern structures that often lack nesting structures for swallows and/or are typically sealed against their entry. Likewise, the amount of open foraging habitat in many parts of Canada (especially the east) has also been declining in recent decades due to the conversion of dairy farms (pastures and hayfields) and wetlands to intensive agriculture such as row crops. Even when newer structures remain open and accessible to barn swallows, one study noted that nestlings are far more subject to heat-induced mortality in modern metal-roofed barns than in older barns with wooden roofs. It is unknown the extent to which the species may be able to compensate for the recent decrease in the numbers of wooden farm buildings in many rural regions; however, the species is capable of colonizing regions away from open agricultural areas. The extent to which declines in the availability of artificial nesting sites is actually limiting the Canadian population is unclear. There are growing numbers of reports of suitable buildings, which were formerly heavily used by barn swallows, now standing empty. Moreover, the timing of the onset of barn swallow declines in the mid-1980s does not appear to coincide well with changes in the availability of artificial nest sites. Several studies, mainly conducted in Europe, have shown a strong link between maintaining farming activities with domestic animals (especially cattle) in the landscape and the occurrence of large colonies of barn swallows. Generally, the removal of cattle from pastures causes a decline in aerial invertebrate abundance. This directly affects swallow reproductive output and can cause the total disappearance of the species from local areas. No similar studies exist for North America, but the rapid conversion of cattle pastures and dairy farms to cereal crops in at least some regions could play							

	an important role in the decline of barn swallows in parts of eastern Canada. Elsewhere in Canada, however, the area of suitable foraging habitat may even be increasing, even in regions where barn swallow populations are in decline. For example, the area of open foraging habitat in the prairies is increasing due to the conversion of cropland to non-native grassland for pasture and hay (cattle numbers are increasing in the prairies) and to the conversion of forest to farmland. This suggests that loss of foraging habitat does not, by itself, explain barn swallow population declines.							
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing	See 2.1.							**Neg.**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling								**N/A**
3.2 Mining and quarrying								**N/A**
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads	Construction of bridges and culverts since the mid-1900s is also thought to be responsible for the species' range expansion (e.g. into areas of boreal forest).							**Neg.**
4.2 Utility and								**N/A**

service lines								
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	Although not quantified, unknown numbers (perhaps many) of barn swallow nests are intentionally destroyed, because the droppings that accumulate beneath them create sanitary and aesthetic issues. Nests are also disturbed or removed from bridges and other infrastructure during routine maintenance activities. Whether there has been any recent increase in the intensity of human persecution, which might correspond to the timing of recent declines in barn swallow populations, is unknown.							**Neg.**
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression								**N/A**
7.2 Dams and water management/use								**N/A**

7.3 Other ecosystem modifications	It has been suggested that the decline of barn swallows in Canada, as for several other aerial-foraging avian insectivores, could be related to large-scale declines in the abundance of flying insects and/or a change in their seasonal phenologies. The species' decline started sometime in the mid-1980s, which coincides with that seen in many other species of aerial insectivores. Declines appear to be stronger in the northern parts of the range (no trend information available for the territories). Light pollution in and around urban centres, climate change, loss and degradation of wetlands, acid precipitation and resulting calcium depletion, changes in agricultural land use practices (e.g. loss of pastureland in some regions), large-scale use of pesticides and the recent genetic development of insect-resistant row crops are among the many factors that could be affecting insect abundance. Loss of foraging habitat is also occurring due to reforestation of large tracts of eastern Canada.	W	U	S	N	M	L	**Low**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases	Barn swallow numbers were reported to have decreased in the late 1800s in New England following the increase of house sparrows that usurped swallow nests. One study reported a 45% reduction in barn swallow fledgling success at one site in Maryland due to competition with house sparrows. While this could have negative population-level effects, house sparrow populations have been declining significantly in Canada and across most of North America persistently over the past several decades. Not only has the level of this threat been diminishing over time, its timing does not overlap with the onset of recent declines in barn swallow populations. Nevertheless, house sparrows remain numerous and widespread and the threat they pose is likely additive. Another threat is increased nest predation from non-native predators such as fox squirrels in western Canada and rats in barns.							**Neg.**
8.2 Problematic	High nestling mortality due to high rates of ectoparasitism (mites,	W	U	S	N	H	L	**Low**

native species/diseases	fleas, feather lice, blowflies), which can limit productivity, is a threat. Barn swallows often reuse their nest sites from one year to the next and often within the same season. Hence, nests are often infested with a large number of ectoparasites. Little information on the effect of parasites is available for North America, nor is there any information as to whether rates or severity of infestations has been increasing. Possible increased predation of adults from increasing populations of several native species of diurnal raptors is another possible threat.							
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents								**N/A**
9.3 Agricultural and forestry effluents (including erosion)	Water contamination and poisoning by pesticides is a potential threat.							**Neg.**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne								**N/A**

pollutants								
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	The barn swallow is extensively studied and has served as a model organism for detailed studies on the effects of climate change and ectoparasites on breeding ecology. However, most of the research has been done on European populations and relatively few studies have been conducted in North America. In Europe, barn swallows are responding to climate change by nesting earlier due to warmer temperatures in spring. Climate change has been found to enable barn swallows to reproduce earlier in spring and to increase reproductive success. On the other hand, climate change has been proposed as an important limiting factor affecting several species of aerial insectivores, including barn swallows, in North America. By nesting earlier, insectivorous species could face greater risk of mortality and increased energetic costs during bouts of inclement weather (cold snaps) that occur in early spring and/or during the breeding season because of suppression of insect prey. More studies are needed to test this hypothesis and particularly how it might be operating across the barn swallow's range.	W	U	S	N	M	L	**Low**
11.2 Droughts	Southern Canada and the BC interior are projected to be at higher risk of drought under climate projections (Bonsal et al. 2019), but							**N/A**

	the NWT is expected to experience higher levels of precipitation in all seasons (Zhang et al. 2019).							
11.3 Temperature extremes	Direct and indirect mortality due to an increase in climate perturbations on the breeding grounds (cold snaps that are out of phase with the species' annual cycle) is thought to be a main cause of decline. As temperature is expected to increase across the NWT, the intensity/frequency of cold snaps is expected to decrease (Zhang et al. 2019).	L	U	S	LTF	L	L	**Low**
11.4 Storms and flooding	Mortality due to increased numbers and intensity of hurricanes encountered during migration is a potential threat.							**N/A**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Barren-ground Caribou (*Rangifer tarandus groenlandicus*)

Populations (if applicable): Porcupine herd is considered a geographically distinct sub-population by SARC. Other NWT herds are considered one unit (Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly, Ahiak, and Qamanirjuaq)

Percentage of North American population NWT is responsible for: Much of the winter range of the various herds is located in the NWT. Given approximately 730,000 barren-ground caribou (BGC) within herds that touch upon the NWT, the NWT could be considered home to approximately 45% of the global population (or ~91% of the Canadian population).

NWT General Status Ranks: Sensitive

NatureServe Conservation Rank (NWT): S3

Species at Risk (NWT) Act: Threatened (Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly, Ahiak and Qamanirjuaq herds). Porcupine herd – Not at Risk.

***Species at Risk Act* (Canada):** Assessed as Threatened, listing under consideration (all Canadian herds).

Reasons for assessment or population trends:

- BGC (eight central-eastern herds): Overall, numbers have declined by more than 85% for all herds where we have trend information, except the Qamanirjuaq herd, during the past three caribou generations. Overall trend demonstrates a continued population decline.
- Porcupine herd: Population has been increasing over the past three caribou generations and the current estimate is the highest since standardized population techniques started being used in the 1970s. Since 2001, birth rates, calf survival and post-calving survival have remained relatively strong in most years.

Sources used for assessments: Species at Risk Committee status report (2017b), ENR (2008), ENR (2015c), Auld (n.d.), Office of the Auditor General (2017), Government of Canada (2010), NWT and Nunavut Chamber of Mines (2020), Blyth et al. (2016).

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[56] = 3		
Dependence on habitats that are sensitive to climate change[57]	While caribou are adaptable based on the diversity of habitats that they occupy, little is known about their adaptability at individual scales.	3 – Depends on sensitive habitats that are not rare.

[56] Overall sensitivity score based on average of habitat, abioticand biotic factor scores.

[57] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive

	In general, BGC show long term fidelity to calving grounds, pre-calving migratory routes, post-calving areas and water crossings, despite large changes in the abundance of caribou, although shifts in migration routes and calving grounds are known to occur. There is no evidence for geographic fidelity to specific rutting areas; however, the pattern of annual use of rut areas has had limited analysis. In the taiga, caribou use of those forests is strongly influenced by forest fires and snowfall at the landscape scale. For instance, the Beverly herd selected stands of black spruce mostly 150-250 years old and with high amounts of foliose lichens (leaf-like lichens). The Bathurst herd avoided areas of the winter range with a high density of forest fire burns and selected the older patches of forest (>40 years old), which have more favourable snow conditions, higher cover of lichens and herbaceous forage. Increases in forest fire frequency/intensity projected for the NWT, may impact habitat availability (ENR 2008).	
Sensitivity to climate-relevant abiotic factors[58]	Inuvialuit sources indicate that barren-ground caribou prefer and are well-adapted to colder temperatures; in winter, cold weather prevents icing conditions and inaccessibility of forage. Less is known about how caribou cope with heat during summer, although caribou may be vulnerable to extreme heat. There has been some speculation in Indigenous knowledge sources that BGC may begin to range further north in an effort to avoid stresses related to this kind of heat. However, rate of warming of increases with latitude (ENR 2015). Caribou will seek remnant snow beds or stand in water, which likely is an attempt to keep cool and avoid insects. BGC hooves are flexible and can spread wide enough to lessen sinking into snow or soft ground. The hoof edges are sharp in winter to give a stronger grip on snow and ice.	3 – Likely very sensitive.
Sensitivity to	BGC are generalist foragers and select for nutrient	3 – Likely very

capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

[58] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

climate-relevant biotic factors[59]	content according to the stage of plant growth more than plant species. The ability to digest lichens is a key adaptation as lichens are high in digestible carbohydrates and are readily available in the winter taiga. Lichens are often a large part of the diet upon arrival in the calving grounds. In the range of the Bathurst herd, lichen coverage decreased significantly from 44% to 22% of the total calving ground area from 1990-2000, possibly because of shrub encroachment and accumulated grazing potential. Immediately after calving, females switch to greening vegetation. During summer 1985-96 there was a significant increase in mean foliage biomass, but forage quality (using leaf nitrogen as an index) decreased during that time. Similar trends are likely for the ranges of the more western herds in the NWT because climate trends, especially warmer springs and winters, are similar for the Arctic and Taiga Plains and Taiga Shield ecozones Parasites and diseases are an important part of caribou ecology, although their role at the population level and the effects of climate change have been less studied. Levels of bot and warble fly infestations are partly determined by weather. The warble fly activity index for the summer range of the Bathurst herd showed a significant increase as the summers became warmer, especially after the early 1980s. Foot rot also causes lameness – warm temperatures and muddy ground constitute favourable conditions for this soil-borne bacterium. Predators figure in a large way in caribou ecology. An array of predators and scavengers depend on BGC. The vulnerability of BGC to predation varies with environmental conditions and seasonal distribution. There is no indication that predation is expected to worsen due to the effects of climate change. Wood bison and moose range expansion may be favoured by climate change, but the nature of the relationship among these ungulates is unclear. No information is currently available regarding whether muskoxen will be favoured by climate change. There are concerns that if these species increase their ranges/abundance, the	sensitive.

[59] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

	predator population could be buoyed, which may have a negative influence on BGC. Likewise, the expansion of these species could increase potential for disease transmission. Impact of lemmings, voles, snowshoe hares, geese and ptarmigan on caribou forage is unknown. Since the mid-1990s, changes in fall condition of females, reflecting habitat conditions on the summer range and possibly driven in part by climate change may have influenced the timing of oestrus. Most herds have seen a shift in the peak of calving to several days later.	
Non-climate stressors = 4		
Sensitivity to potentially interacting non-climate pressures	Primary non-climate stressors for BGC include harvesting, forest fires and cumulative effects. Additional threats include predators, parasites/disease and impacts from development activities.	4 – Known major pressures.
Adaptive capacity[60] = 2.5		
Reproductive capacity[61]	Caribou usually calve at three years of age, although under high forage availability and a corresponding high rate of body growth, females can calve at two years of age. The females typically have a single calf every year, unless females are in poor condition. The calf's growth rate depends on the female's milk production; underweight calves have a low chance of survival. Generation time eight to nine years, based on adult survival and fecundity.	4 – Late reproduction/few offspring.
Dispersal capacity[62]	BGC exhibit long-distance migrations between wintering and calving grounds. Smaller-scale dispersal is also common, with BGC moving long distances in search of food and relief from heat and insects at summer ice and snow patches. Periodically, calving grounds will also undergo shifts in location as the caribou attempt to avoid unfavourable conditions relating to weather, snow depth, insects, predation, forage availability and human activity. For example, between 1984-1996, the consecutive overlap was consistently westward and the calving ground shifted	1 - >10km

[60] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[61] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.
[62] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

	approximately 250 km from east to west of Bathurst Inlet to an area where calving had been recorded in the 1950s. Most of the NWT tundra and taiga do not appear to have significant barriers limiting movements or dispersal.	
Genetic diversity	Assessment of genetic variability for the Porcupine, Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Ahiak and Beverly herds indicated some subpopulation structure, but the isolation-by-distance pattern was unclear as neighbouring herds were not necessarily more closely related. However, the apparent lack of subpopulation structure may also reflect the methods used. Assessment of the genetic variability among the herds relied on neutral genes that do not code for functional proteins. Using the functional gene complex associated with immune function (MHC), the Porcupine and Western Arctic herds both shared and had distinct MHC alleles. Also, mtDNA and nuclear DNA analyses may show different patterns since mtDNA is inherited by females and nuclear DNA by both parents. There is no evidence that over the long-term, NWT BGC herds depend on immigration for survival.	N/A
Phenotypic plasticity		N/A

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
13. Residential and commercial development								
1.1 Housing and urban areas	Habitat fragmentation caused by human activities has not been documented on a large scale within BGC ranges, although reduced use near human developments, including communities, represents a degree of functional habitat loss.							**Neg.**
1.2 Commercial and industrial areas	See 1.1.							**Neg.**
1.3 Tourism and recreation areas	See 1.1.							**Neg.**
14. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
15. Energy production and mining								
3.1 Oil and gas drilling	For the Porcupine herd, a decision on oil and gas exploration and development on the coastal plains of the Arctic National Wildlife Refuge in Alaska represents a significant potential threat. This decision, previously deferred through section 1002 of *the Alaska*	L	U	S	LTF	M	L	**Low**

	National Interest Lands Conservation Act (1980), would allow exploration and development in critical calving habitat used by the herd. Oil and gas exploration and development is, for the most part, occurring in the winter ranges of BGC only. The NWT has large undeveloped oil and gas reserves that could represent a significant portion of Canada's marketable petroleum resources. If this industry were to expand, the potential future threats associated with oil and gas could increase significantly. Community members in the Mackenzie Delta, where the construction of above-ground pipelines is possible, have suggested that these pipelines, if constructed, may inhibit the migration of caribou, as they will not pass under them, particularly during winter when deep snow will effectively shorten the gap between the ground and the pipeline. The proposed Mackenzie Gas Project, with infrastructure on the winter ranges of the Cape Bathurst and Bluenose-West herds, has been delayed until 2022, making this threat less imminent than it otherwise would have been. Production licenses, primarily occurring in the Mackenzie Valley, with some also in the Mackenzie Delta and Beaufort Sea, comprise <2% of the NWT land base.							
3.2 Mining and quarrying	Industrial development is considered by some to be one of the most significant factors affecting certain BGC herds. It can disturb caribou and affect their behaviour, the quality of habitat and forage and ultimately, the survivability of the species. It can also facilitate access for both humans and predators. Habitat fragmentation caused by human activities has not been documented on a large scale within BGC ranges, although reduced use near active mines represents a degree of functional habitat loss.	L	M	S	N	H	M	**Med.**

	The impacts from development are thought to be worse in the winter, potentially resulting in loss of habitat, increased predation and added hunting pressure, while development on or near calving grounds and migration corridors is also considered to have negative impacts on caribou. Since the 2008 market crash and resulting lower commodity prices, exploration and development activities have, for the most part, been declining in the NWT. Little to no 2D and 3D seismic activity has taken place since 2007. As of 2007, mineral leased claims, typically associated with active mines, comprised only 0.7% of the NWT land base. At the time the status report for BGC was published, there had been some recent increases in prospecting and mineral claims as a result of interest in diamond, gold, base metal, rare earth element and uranium exploration. However, this is no longer representative of the situation since the onset of the Covid-19 pandemic (substantial declines in 2020 relative to 2019) (NWT and NU Chamber of Mines 2020). Mineral exploration and mining have increased in areas such as the Kitikmeot and Kivalliq regions of NU. Of the NWT's BGC herds, the Bathurst herd likely faces the most pressure from human activities. • Potential future mineral exploration in the Peel River watershed (Porcupine herd) is a potential threat. • Established mines in the NWT include Diavik, Ekati, Gahcho Kue, Jericho and Snap Lake, though as of fall 2020, only Diavik and Gahcho Kue are fully operational. • Fortune Mineral Ltd.'s NICO Project – completed environmental assessment, within winter range of Bathurst herd. • Cheetah Resources Corp. is developing a rare earth mining project at the Nechalacho Rare Earth Elements Project site – within winter range of Bathurst herd.							

	• MMG Resources Inc.'s proposed Izok Corridor Project in Nunavut – on post-calving ranges of the Beverly and Ahiak herds. • Sabina Gold & Silver's Back River Project in the Kitikmeot region of Nunavut on the ranges of the Bathurst and Beverly herds. • Agnico Eagle's Meadowbank Gold Mine Project in Nunavut's Kivalliq region is on the summer range of the Qamanirjuaq herd. • Agnico Eagle's Meliadine mine operates in proximity to the core calving and post-calving range of the Qamanirjuaq herd. • Proposed uranium mine on Beverly herd's summer range. • Tundra Copper Corp. and Crystal Exploration – approved exploration activities in the core calving areas of the Bluenose-East and Bathurst herds, respectively. • Anconia Resources Corp. – approved exploration within the core calving area of the Qamanirjuaq herd.							
3.3 Renewable energy	While renewable energy projects are not considered a major threat for BGC at this time, the Taltson Hydroelectric Expansion is being proposed to link the NWT's current hydroelectric systems to project energy into the Slave Geological Province to service envisioned development along the proposed Slave Geological Province Road. Research showing that reindeer can see ultra-violet light emitted from powerlines and avoid them may have implications for BGC.	L	U	C	STF	M	M	**Low**
16. Transportation and service corridors								
4.1 Roads and railroads	Habitat fragmentation caused by human activities has not been documented on a large scale within BGC ranges, although reduced use near roads represents a degree of functional habitat loss. Roads provide easier access to remote areas of caribou range for industry, alter migration patterns and increase hunter access and the number of caribou harvested. The presence of roads, road construction, traffic and pipeline right-of-ways are examples of habitat disturbances that may be impacting some BGC herds year-round. Threats related to roads are generally highest in the winter range of BGC. As of 2007, the total length of linear features in the NWT (including	L	U	S-C	N	H	M	**Medium**

	main roads, winter roads, transmission lines, service roads and pipelines) was 5,658 km (equivalent to a density of 0.40 km/km^2; substantially less than that seen in other jurisdictions). This is highest in the Taiga Plains (3,645 km; 0.75 km/km^2) and Taiga Shield (1,122 km; 0.34 km/km^2) ecoregions. With the proposed projects noted below, this is expected to increase to some degree. Winter roads, all-season roads and highways totaling over 2,100 km in length occur within the Bathurst herd's range. Modeling human development scenarios shows that the number of proposed or constructed roads as part of mine developments is increasing on tundra ranges mostly, for the Bathurst herd. • For the Porcupine herd, improved access as a result of the Dempster Highway (NWT and YT) represents a potential threat. • 28 km all-weather road through the central barrens – currently under construction. • A portion of the nearly-completed Tłı̨chǫ All-Season Road overlaps with the historical winter range of the Bathurst herd and may pose risks in future years when the herd resumes use of that part of the range. • Construction of the proposed Mackenzie Valley Highway (over 800 km) would provide increased access to the winter range of the Cape Bathurst herd and pass near the ranges of the Bluenose-West and Bluenose-East herds. • Construction of the Mackenzie Valley fiber-optic link (1,154 km) may intersect with the range of the Cape Bathurst herd. • The 94-km first phase of the Slave Geological Province Corridor Project, a 413-km all-weather road from Highway 4 to the NU border, has received partial funding. The full road is							

	envisioned to meet up with the proposed Gray's Bay Port and Road project, which is routed to pass through the calving and post-calving range of the Bathurst herd to a deep-water port in Gray's Bay. • The approved Jay Project at the Ekati Mine was expected to increase traffic on the Tibbitt to Contwoyto winter road; although it is uncertain if that project will be going forward. Some amount of habituation to roads is expected to occur, as seen with the Dempster Highway.							
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths	Disturbances, such as low-level aircraft flights can increase caribou energetic costs if these activities interrupt caribou foraging or cause the caribou to move away in response to the disturbance.							**Neg.**
17. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	Harvest has a larger impact on the population of a herd during the decline phase of the BGC population cycle and at the phase of low numbers. The harvest of BGC and use of the land by harvesters is very widespread and occurs across most of the range. Indigenous harvest data are not always available for continuous periods of time, but the harvest can be substantial. Relative to harvests 30-40 years ago, the total number of BGC harvested by both subsistence hunters and resident hunters has decreased across the NWT. However, quantifying the subsistence harvest in the NWT is quite difficult; given that the GNWT does not track indigenous subsistence harvest and that what is tracked by indigenous governments and organizations is done sometimes by herd and sometimes by region, which complicates interpretation. Information is also not always	W	U	C	N	H	H	**Med.**

	consistently collected or shared. The Porcupine herd is increasing, which implies that current harvest is sustainable. The collaborative and precautionary approach to harvest management on this herd reduces the likelihood of harvest becoming unsustainable. Harvest levels on the Beverly, Ahiak and Qamanirjuaq herds are poorly documented and compiled harvest data are incomplete. Resident harvest is limited to one male per year on the NWT portions of the Beverly and Ahiak herds and closure of the commercial and outfitted harvest remains in place in the NWT for these two herds as well. There are no restrictions on Indigenous harvest of these herds. Reported harvest of BGC by resident hunters in the NWT peaked in the early 1990s and has declined steadily since then. Currently, there is no commercial harvesting of any NWT BGC herd. For many communities at or below the treeline, BGC harvesting takes place from late summer/early fall until late spring. Further north, BGC are accessible throughout the year. Hunting is likely not a current threat for herds where harvest restrictions have been implemented or where recent population estimates indicate stable to increasing populations. Harvest restrictions are in place for several herds. All harvest has been closed in the NWT on the Bathurst herd since January 2015and harvest on this herd in NU was recently reduced to ten bulls. Harvest restrictions are in place on the Bluenose-East herd in both NWT and NU. Cape Bathurst and Bluenose-West are currently managed to reduced total allowable harvest levels. Harvest on the Tuktoyaktuk							

	Peninsula herd is seasonally restricted to allow the herd to migrate across the Inuvik to Tuktoyaktuk. Non-traditional harvest practices are also considered a threat to BGC. These activities include reckless shooting, harvesting the leaders, overuse of motorized vehicles, wasting meat and leaving carcasses on the ground, not sharing meat and not using the entire carcass. One of the main concerns that arises from non-traditional harvesting is the loss of quality breeding males associated with sport hunting or male-only harvest practices. Wounding loss is a threat of unknown magnitude, but is recognized as a factor affecting caribou populations. Overharvesting is mentioned in a variety of reports from across BGC range and especially if the informal wild meat economy (such as when caribou meat is sold via social media groups) represents a wide-ranging impact on barren-ground caribou, harvest may represent an important threat.							
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources								**N/A**
18. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**

6.3 Work and other activities	Caribou collaring projects impact BGC through hair loss, icing, interference with feeding and irritation or strangulation if the collar shifts. The main concerns are that these kinds of research methods cause physical injury, stress and weakening of the animals and that these practices are culturally inappropriate and disrespectful.	L	L	C	N	H	L	**Low**
19. Natural system modifications								
7.1 Fire and fire suppression	Forest fires may impact forage availability and caribou movements, with associated impacts to survival, physical condition and migration. This threat is most notable in the winter range of herds that spend winter below the tree line. Forest fire projections are strongly influenced by moisture availability. If climate change results in a future that is warmer and drier, forest fire frequency and intensity is expected to increase. If, however, conditions become warmer and wetter, there may be no substantial change in forest fire frequency/intensity (Blyth et al. 2016). Large fires have the ability to strip the land of suitable forage for barren-ground caribou in their winter habitat. Regeneration of important lichen-supporting forest stands can take decades in the NWT. Wildfire cycles shorter than the regeneration time of a given region can stall forest stands in earlier seral stages, thereby reducing the carrying capacity of winter habitat. However, modeling conducted in Bathurst range suggests that regeneration time is still within the natural range of variation. However, caribou may still move through recent burns early in the winter and may also select habitats adjacent to the burn boundary. The annual burn rate and the severity of fires are higher in the western Taiga Shield and Taiga Plains than in other areas of the NWT. Whether those burns restrict the extent of the winter ranges is unknown. Burned areas are mapped as contiguous polygons, but burn	W	M	S	N	H	M	**Medium**

	severity varies widely and unburned areas within burns can be extensive; thus, maps of burns can be somewhat misleading to simple interpretation. Forest fires disturb an average of 600,000 ha of NWT forest annually. A weak trend indicates a slight reduction in both total area burnt and the number of fires larger than 200 ha between 1988 and 2008. The total area burned as a result of lightning ignitions increased over the last 40 years, possibly due to warmer temperatures during the fire seasons in the 1990s.							
7.2 Dams and water management/use	Impacts related specifically to hydroelectric development are limited to the influence these projects can have on ice conditions on large waterways and, by extension, the ability of BGC to safely cross this ice. This impact is noted specifically for the Beverly herd, where flooding of Nonacho Lake from the Taltson hydroelectric project has influenced ice conditions on the lake. This project has also affected the availability of winter forage, with sporadic flooding events damaging lakeside vegetation. If the projects listed in the draft NWT Hydro Strategy come to fruition, then the possible future impacts of this industry may be substantially larger than they are at present.	L	L	S	LTF	M	H	**Low**
7.3 Other ecosystem modifications								**N/A**
20. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases	The potential for disease transmission between white-tailed deer, which are extending their range in the NWT (e.g. as far north as Fort Good Hope) and barren-ground caribou, is a potential threat. Warmer temperatures will also increase the likelihood of invasive species.							**Neg.**
8.2 Problematic native species/diseases	Insects such as nose bot flies, warble flies and mosquitos can significantly influence BGC behaviour, body condition and ultimately productivity and survival. Harassment from mosquitos can be quite severe in the summer range of BGC, particularly when the	W	L	C	N	H	L	**Low**

	temperatures are hot and humid; caribou will be leaner than during cold, dry summers. Newborn calves can also be killed as a result of intense mosquito outbreaks. Parasites such as nose bots and warble flies are generally considered normal in BGC, but their impact on caribou health can be exacerbated if other factors are also affecting the health of the caribou. In general, the number of diseased BGC is seen to be increasing and there are different types of diseases and conditions being reported now. Many parasites, including warble flies and bot flies, have transmission phases that are temperature dependent either for the development time, the infective stage, or the activity of an intermediate host. However, warmer temperatures may not favour all parasites, such as gastro-intestinal worms. Predators figure in a large way in caribou ecology. The role of predation in caribou dynamics probably differs among herds. Predation can affect survival and reproduction and therefore abundance and there are reports of increasing predator populations in some areas, although recent information suggests a declining trend in the population of wolves and active den sites. Grizzly bears may have a greater impact on newborn caribou on calving grounds than wolves in some herds, but wolves are effective year-round predators of all sex and age classes of caribou. Harvest and predation play a stronger role in the decline phase of the cycle and at low numbers. Range expansion of other ungulates (i.e., moose, muskoxen) may increase the potential for disease transmission to BGC and may buoy predator populations.							
8.3 Introduced genetic material	Indigenous knowledge holders have pointed out that caribou and reindeer hybridization does occur. The Wildlife Management Advisory Council (NWT) reports that these hybrids rut and give birth earlier than BGC, which could favour hybrids in competition for range and forage.							**Neg.**

8.4 Problematic species/diseases of unknown origin	Other diseases and abnormalities mentioned by land users include cysts or white spots in the meat, blister-like spots on the meat (and stomach and lungs), swollen joints, lame animals, yellow/white puss on the meat, yellow-green mucous in the lungs, watery joints, white spots on liver, very little fluid in the meat, lungs sticking to the rib cage and bruises. In contrast, there are also numerous references to caribou being generally healthy and to improvements in body condition throughout the NWT. *Setaria*, a blood parasite recently recorded in BGC, is of concern, but very little is known about its ecology.	W	U	C	H	H	L	**Low**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
21. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents	There are instances of tailings ponds and hazardous wastes not being adequately managed in the past, so there is understandably concern about the reliability and effectiveness of management on current and future projects; however, at present, impacts to barren-ground caribou appear to be negligible.							**Neg.**
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants	The levels of mercury in kidneys have increased over time for the Porcupine herd, which is a potential concern as there are considerable uncertainties about atmospheric trends in mercury and implications for arctic ecosystems. Contrastingly, there was a declining trend in mercury and various radionuclide concentrations in	W	U	C	N	H	L	**Low**

	the kidneys of Cape Bathurst caribou between the mid-1990s and early 2000s, although aluminum concentration increased during this time. During the environmental assessments for mines, dust generated by mine activities, including roads, has been listed as a potential threat. Dust is carried by wind, rain and/or snow onto vegetation. Increased levels of some metals were measured in fecal pellets of caribou found in the vicinity of an abandoned gold mine on the Bathurst winter range. The levels of metals were not considered to be a risk for human health but there is the potential for adverse effects on caribou health. Dust-contaminated forage may be a factor in caribou showing reduced probability of use in the vicinity of the diamond mines on the Bathurst herd's range. Contaminants are not currently considered a threat as contaminant levels in caribou tissue are generally low. Variation in concentrations of heavy metals among herds is apparent, possibly related to the proportion of lichen in the diet. Lichens are important in caribou diets and are well-known for the propensity to accumulate atmospheric contaminants. Monitoring at the NWT diamond mines has revealed increased levels of some metals in lichens on the summer range of the Bathurst caribou herd.							
9.6 Excess energy (noise/light pollution)	Some projects currently under construction and some proposed future construction represent possible threats to BGC by acting as sources of disturbance (noise from roads). Minimizing noise disturbance is important for BGC. Noise is associated with changing BGC behaviour and stress. Generally, Indigenous knowledge holders have observed that after the disturbance subsides, BGC will return to the area, although this can take as long as ten years. In some cases, it was noted that BGC can	L	U	C	N	H	L	**Low**

	become habituated to sensory disturbances. Caribou can learn to adapt to human activities, although little is known about how to facilitate that adaptation. More typically, caribou responses to humans are similar to their responses to predators (ranging from being alert to displacement and avoidance).							
22. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
23. Climate change and severe weather								
11.1 Habitat shifting and alteration	Climate change may act as a continuing threat to BGC through a complex mechanism involving shifts in timing of green-up, changes in summer forage quality, increased rain-on-snow and icing events on winter range, longer fire seasons, melting permafrost and erosion, changes to freeze-up and thaw timing, changes to predator/competitor ranges and increasing shrub cover. The climate within overall BGC range is characterized by a short plant growth season whose onset is annually variable. Winters are long and cold. The climate is dry and the snow pack accumulates mostly in the fall, typically followed by light snow falling from December to March. Recent climate and weather trends indicate warmer temperatures, longer snow-free periods, deeper maximum snow depths, warmer ground with associated changes in nitrogen dynamics and increased plant growth. While trends in weather and vegetation are being measured related to a changing climate, it is more difficult to relate those trends to caribou habitat. The trends for habitat change and how change relates to habitat loss depend on the adaptability of caribou and the availability of alternative habitats. Superimposed on	W	U	C	N	H	M	**Med.**

	the longer-term trends of a warmer climate since the 1970s are decadal climatic patterns. This increases the complexity of interactions between a generally warming climate and decadal climatic patterns. Changes in climate that result in caribou gaining earlier or more access to vegetation could be beneficial. Plant growth has increased over the last three decades by 20-26%. The increases in plant biomass are strongest along the mainland arctic coast (Cape Bathurst and Queen Maud Gulf areas). However, the trends for increasing net plant productivity may not mean an increase in forage quality as, for example, the amount of solar radiation (or cloud cover) and temperature also affect the levels of compounds such as tannins in plants, which affects forage quality. Thus, the conditions that promote greater primary productivity may also lower the quality of some of the vegetation as food for herbivores. When Bathurst females arrive on the calving ground, lichens are a large part of their diet. Lichen coverage decreased significantly from 44% to 22% of the total calving ground area from 1990-2000, possibly because of shrub encroachment and accumulated grazing potential. Immediately after calving, females switch to greening vegetation. During summer 1985-96 there was a significant increase in mean foliage biomass, but forage quality (using leaf nitrogen as an index) decreased during that time. Similar trends are likely for the ranges of the more western herds in the NWT because climate trends, especially warmer springs and winters, are similar for the Arctic and Taiga Plains and Taiga Shield ecozones. Snow conditions can have a large impact on caribou. Deep or wind-packed snow and ice crusts make it hard or even impossible to access forage. Deep snow may also influence the ability of caribou to move							

	across the landscape. These deep snows are particularly hard on small caribou calves. Bathurst winter range has shown a trend toward warmer fall and later winter air temperatures, which, while reducing the annual maximum snow depth, increases the probability of thaw-freeze events (an increase in 'hard' snow or icy crust in the snowpack under a warming climate). Studies are currently examining the influence of changing snowpack characteristics on caribou distribution. Since the mid-1990s, changes in fall condition of females, reflecting habitat conditions on the summer range and possibly driven in part by climate change, may have influenced the timing of oestrus. Most herds have seen a shift in the peak of calving to several days later.							
11.2 Droughts	Excessively dry years reduce the quality of summer forage. There exists uncertainty with regards to projections of drought in the NWT due to climate change.							**Neg.**
11.3 Temperature extremes	Extreme weather events, especially cold conditions during the calving season, may increase the mortality rate of calves. During the summer, extreme heat events lead to heat exhaustion and exacerbate stress from biting insects.	W	U	C	LTF	M	L	**Low**
11.4 Storms and flooding	Increased risk of flooding in the NWT projected for some areas. However, the impact on BGC is uncertain (Auld n.d.; Office of the Auditor General 2017; Government of Canada 2010).							**N/A**
11.5 Other								**N/A**
24. Other threats								
The cumulative effects from multiple interacting threats are considered unprecedented. There still remains considerable uncertainty about when, how and if there is a threshold for cumulative effects at which clear and predictable effects on herd size and trend can be expected. Major projects subject to environmental assessment include cumulative effects assessments, but they are proponent- rather than issue-driven and have not made a significant contribution to managing cumulative effects.		W	H	C	N	H	L	**High**

Management is often challenging when complex, difficult decisions are needed in a timely manner. A management approach that is more reactive than proactive, along with a lack of timely implementation of management actions, threaten caribou conservation, because the ability to effectively react to change in caribou numbers and their environment is delayed. Also, in the context of jurisdictional complexity, the lack of overall land use planning, especially in the context of cumulative effects of industrial developments and human activities represents a potential threat. In particular, the lack of an overall approach to calving ground management has been identified as a specific threat.							

Species: Boreal Woodland Caribou (*Rangifer tarandus caribou*)

Populations (if applicable): Boreal caribou (woodland caribou [boreal population])

Percentage of North American population NWT is responsible for: Boreal caribou are native to Canada and are found nowhere else. There are approximately 34,000 boreal caribou in Canada; if the estimate of 6,500 in the NWT is correct, then approximately 19% of the boreal caribou in Canada reside in the NWT.

NWT General Status Ranks: At Risk

NatureServe Conservation Rank (NWT): S3

***Species at Risk (NWT) Act*:** Threatened

***Species at Risk Act* (Canada):** Threatened

Reasons for assessment or population trends: Boreal caribou need large tracts of undisturbed habitat so they can spread out to minimize predation risk. This adaptation results in naturally low densities across a large area, making them more vulnerable to systematic habitat fragmentation. Population size is small: about 5,300 mature individuals; 6,500 total population. While there is uncertainty in the estimate (e.g. in the eastern Sahtú region), it is unlikely that the total population size is larger than 10,000 in the NWT. Currently, there is variation across the NWT in rates and direction of population change. There are documented population declines in parts of the southern NWT where the majority of boreal caribou occur. Current and future threats leading to habitat fragmentation are expected to increase. A continuing decline in the amount of secure habitat and in population size is projected. There is no foreseen possibility of rescue from outside populations due to severely declining populations in AB and BC.

Sources used for assessments: SARC (2012a), Lewis et al. (2019), GNWT (2019), Government of Canada and GNWT (2019), GNWT (n.d.), Zhang et al. (2019), Serrouya et al. (2016), Larter et al. (2019), Deb et al. (2020), CMA (2017).

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[63] = 2.7		
Dependence on habitats that are sensitive to climate change[64]	Over-wintering habitat is considered critical – areas where spruce or pine forests are thicker, arboreal and terrestrial lichens are available and snow and lichen conditions are more favourable for feeding and mobility.	3 – Depends on sensitive habitats that are not rare.

[63] Overall sensitivity score based on average of habitat, abioticand biotic factor scores.

[64] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive

	The forest also provides shelter from winter winds and snow storms. Although this often includes dense conifer forests, other open habitat types are also used over the winter. There is also mounting evidence that summer habitat could be just as important for lactating females. In summer, boreal caribou use a much wider variety of food and habitat types, including preferential use of recent burns. Open old-growth lichen-bearing conifer forests are preferred during most of the year. Boreal caribou require large patches (>500 km^2) of secure boreal forest to effectively employ their anti-predator strategies to reduce predation risk. Unlike BGC, female boreal caribou space away from each other during calving. As a result, large areas of secure calving habitat are required to reduce predation risk and facilitate survival of calves and females. A wide range of dispersed calving sites are used. A net decline in suitable boreal caribou habitat is projected under both a moderate and high emissions scenario by the late 21st century (Deb et al. 2020).	
Sensitivity to climate-relevant abiotic factors[65]	Thick coats of semi-hollow hair allow caribou to withstand very cold temperatures and wind chills and provide buoyancy while swimming across rivers and lakes. The moult after calving transforms these caribou into dark sleek animals and as a result, shade, cool forests, or open areas exposed to the wind may be important for thermal regulation and insect relief during summer. Boreal caribou have larger hooves than BGC that help them stay on top of soft surfaces like snow or muskeg. They are known for their ability to move quickly over rough or snowy ground.	2 – Somewhat sensitive or possibly very sensitive.
Sensitivity to climate-relevant biotic factors[66]	Although boreal caribou are adapted to feeding on a variety of plants, the availability of lichen is thought to be critical to boreal caribou. Increases in forest fire	3 – Likely very sensitive.

capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

[65] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

[66] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

	frequency and intensity projected with climate change could impact availability of forest lichens (Lewis et al. 2019).	
Non-climate stressors = 4		
Sensitivity to potentially interacting non-climate pressures	The main threats to boreal caribou are habitat loss, degradation and fragmentation from human-caused and natural disturbances that result in increased predation risk. Habitat disturbance, which affects boreal caribou populations by increasing predation risk, is thought to be the primary factor leading to boreal caribou declines across Canada (ENR 2019).	4 – Known major pressures.
Adaptive capacity[67] (mean = 2.5)		
Reproductive capacity[68]	Female boreal caribou first breed at age two and produce their first calves at age three. Females likely produce calves up to a maximum age of at least 17 years. The generation time is ~7 years. Calf survival during the first six weeks of life is low; often 50% or less.	4 – Late reproduction/few offspring
Dispersal capacity[69]	While boreal caribou do not migrate the long distances typical of BGC, there is evidence that they move within their range to suit their requirements as the seasons change. Boreal caribou movements tend to be most restricted in later winter months when they concentrate in larger groups in patches of suitable habitat. These reduced movements are likely related to snow conditions, thermal requirements and shifts in habitat preference; predation and noise disturbance are thought to be contributing factors. It has been reported that boreal caribou migrate seasonally and move hundreds of kilometers within areas as large as 1,000 km^2. Maxima not noted in status report. There is some indication that some features (e.g. large rivers and human-made structures) can present a barrier to boreal caribou movement in some cases.	1 - >10km
Genetic diversity		N/A
Phenotypical plasticity	Boreal caribou are a medium-sized member of the deer family. It is possible that boreal caribou size may differ between areas – some areas are reported to have larger	N/A

[67] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[68] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.
[69] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

	caribou than others. It was noted during a meeting with the NWT Métis Nation that boreal caribou around Hay River have shorter, more muscular legs than in other regions.	

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas	Tourism is a cause for some concern. Increased tourism has attracted an influx of people into the Tłı̨chǫ region. There are concerns that tourists do not respect the land and their visits result in more airplanes, more use of ATVs and overall increases in noise and light disturbance. ATV and snowmobile use can drive boreal caribou away and the effects are exacerbated by the ease with which snowmobiles travel down seismic cutlines. The decrease in boreal caribou seen between Hay River and Point de Roche is thought to be due to increased human activity in the area. One harvester in Behchokǫ reported that there has been increased ATV use in the Tłı̨chǫ region over the past few years and that sometimes he sees as many as ten quads traveling together in a group, right through boreal caribou habitat. He said this activity pushes the caribou away and that off-road vehicle use is a main threat to the boreal caribou in this area.	L	U	S	N	M	M	**Low**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops	There is some limited agriculture currently around Hay River, but the GNWT has an agriculture strategy and would like to expand this sector. This would involve clearing more land and losing more boreal caribou habitat (Hodson pers. comm. 2020).	L	L	C	STF	M	M	**Low**
2.2 Wood and pulp								**N/A**

plantations								
2.3 Livestock farming and grazing	There is some limited agriculture currently around Hay River, but the GNWT has an agriculture strategy and would like to expand this sector. This would involve clearing more land and losing more boreal caribou habitat. Also risk of disease transmission if more livestock is brought into the NWT (Hodson pers. comm. 2020).	L	L	C	STF	M	M	**Low**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling	Industrial activities and development [in general] are considered major factors causing some of the largest impacts on boreal caribou across many regions in the NWT. Impacts from development are not limited to the time of the disturbance. It can take many years for boreal caribou to return to an area that was disturbed in the past as these disturbed habitats can be better for alternate prey and have may have lower food availability for boreal caribou. In addition, secondary impacts such as hunting and predation, that tend to increase as habitats become fragmented and access increases, may ultimately be more significant than those resulting from the initial construction or development work. There is some indication that human-made features can present a barrier to boreal caribou movement in some cases. Overall human-caused habitat disturbance (including industrial development) in the NWT range of boreal caribou covers 9.1% of the range. By region, this works out to: Gwich'in = 6.9%, Inuvialuit = 1.3%, Sahtú = 6.9%, Wek'èezhìı = 0.8% and Southern NWT = 16.1% (ENR 2019). Level of concern is high, given the moderate to high (southern) and low to moderate (northern) degree of habitat fragmentation that has	L	M	S	LTF	H	H	**Med**

	resulted from past oil and gas exploration and development activities.							
3.2 Mining and quarrying	Industrial development can result in changes to the landscape that force boreal caribou to change their movements and can make them not use an area for many decades. Industrial development can also lead to stress and poor health (ENR 2019). A new mine (Fortune Minerals; gold-cobalt-bismuth-copper mine) 80 km north of Behchokǫ̀, whose access road is within boreal caribou range, was raised as a specific concern. With regard to known boreal caribou movement patterns in the South Slave region, Osisko Metals at Pine Point is a concern (Hodson pers. comm. 2020). Human-caused disturbances, including coal mining exploration activities, are expected to increase in the future.	L	H	C	STF	H	M	**Medium**
3.3 Renewable energy	The NWT does not currently have any large-scale wind energy developments, but future projects are being considered.							**Neg.**
4. Transportation and service corridors								
4.1 Roads and railroads	Human-made features such as roads may be at least a partial barrier to movement in some cases. Boreal caribou are seen to avoid linear features in the landscape, with the result that roads can affect movement patterns and habitat use. Both the physical impacts on the ecosystem, as well as the increased noise and activity, could effectively fragment habitat for boreal caribou. Predators and hunters may also use these corridors to travel and hunt, which can increase their efficiency at targeting boreal caribou. Cleared areas, especially roads and seismic lines, make it easier for wolves and bears to travel through the forest and locate prey. Roads, road construction, traffic and pipeline right-of-ways are increasing or are proposed for regions of the NWT. During the environmental assessment of the Tłı̨chǫ All-Season Road, concerns were raised about the impact of the development on boreal caribou (Mackenzie Valley Review Board 2018). In the Mackenzie River valley, the construction of the Mackenzie Valley Highway is proposed. An	L	H	C	N	H	H	**Medium**

	increase in human disturbance and hunter access within the Mackenzie River valley corridor should be anticipated as the highway would transect current boreal caribou range in the NWT.							
4.2 Utility and service lines	Linear habitat features like seismic lines can impact boreal caribou in a variety of ways, including fragmenting and damaging habitat, creating barriers to movement and increasing predation and noise, among other effects. Boreal caribou population growth rates are primarily determined by adult female and calf survival. Therefore, habitat conditions that facilitate adult female and calf survival are critical for the long-term survival of boreal caribou. Linear features may have long lasting effects. Past studies have found varying effects of seismic lines on boreal caribou behaviour. In combination, boreal caribou behavioural responses have led to functional habitat loss in areas around seismic lines and other anthropogenic linear features in the NWT and other areas. There are approximately 35,416 km (average 0.18 km/km^2) and 57,772 km (average 0.24 km/km^2) of seismic lines in the northern and southern study areas, respectively. Some seismic lines were cut in the 1960s and 1970s, but the state of regeneration to preferred boreal caribou habitat on these lines is largely unknown. For boreal caribou in the NWT, the area of impact around seismic lines is approximately 400 m. Overall, human-caused habitat disturbance (from all sources) in the NWT range of boreal caribou covers 9.1% of the range. By region, this works out to: Gwich'in = 6.9%, Inuvialuit = 1.3%, Sahtú = 6.9%, Wek'èezhìı = 0.8% and Southern NWT = 16.1% (ENR 2019).	W	H	C	N	H	H	**High**
4.3 Shipping lanes								**N/A**
4.4 Flight paths	Although boreal caribou may adapt to vehicles on the ground, flights – in particular low-flying or landing aircraft – are different and will	L	L	C	N	H	L	**Low**

	continue to scare the boreal caribou and cause them to flee. Degree to which this affects NWT population not noted.							
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	Boreal caribou harvesting is primarily opportunistic and at a relatively low rate. Boreal caribou are generally only hunted in the winter when access to their habitat is possible using snow machines. Hunting pressure will cause boreal caribou to move out of an area. The available evidence suggests that the current harvest of boreal caribou is relatively low. Between 2001 and 2015, the average resident harvest of boreal caribou in the NWT was estimated to be 22 animals per year (0.3% of the estimated population). During this period, the resident harvest was predominantly bulls. An analysis of 2001-2015 data in response to reported increases in harvest indicated that the increase is due to increased harvest of the mountain woodland ecotype. The data indicate no increase in boreal caribou harvest by resident hunters. There are currently no regulated restrictions on Indigenous harvest of boreal caribou in the NWT, although current understanding indicates that Indigenous peoples in the NWT tend to only harvest this type of caribou opportunistically. Accurate Indigenous harvest information for boreal caribou is not available for all areas of the NWT, but based on regional harvest studies and Indigenous knowledge reports, the average number harvested in the NWT could be as low as 65 (1% of the estimated population) and as high as 190 (2.9% of the estimated population). Overall, the estimated total annual harvest of boreal caribou in the NWT most likely represents 3% or less of the estimated NWT population (Section 11 Conservation Agreement 2019).	L	M	S	N	H	H	**Medium**

	However, threats can be exacerbated when population numbers are low. There are concerns that harvest pressure might increase in the face of BGC declines. Some are concerned about the targeting of larger bulls as these are thought to be the best breeders. Further increases in access are anticipated with new developments such as the Mackenzie Highway and the Tłı̨chǫ All-Season Road. Non-traditional harvest practices are considered a threat to boreal caribou. These include reckless shooting, over-use of motorized vehicles, wasting meat and leaving carcasses on the ground, not sharing meat and not using the entire carcass. Caribou may move out of an area if traditional and respectful hunting practices are not followed.							
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting	It has been noted that logging or cutting trees can have a negative impact on boreal caribou because of their dependence on densely forested habitat. Disturbances like wildfire and timber harvest result in younger forests that are attractive to other prey species like moose and deer. If there is enough young forest to increase the density of other prey, wolf density may also increase, leading to more predation on boreal caribou (ENR 2019). Human-caused disturbances, including emerging forest uses, are expected to increase in the future. An NWT Biomass Energy Strategy has been developed that promotes the increased use of wood and wood pellets as an alternative source of energy; related actions which promote the harvest of sawlogs and wood in the NWT could lead to habitat alteration for boreal caribou if implemented. Forest Management Agreements (FMAs) were recently signed in the Fort Providence and Fort Resolution areas and land use permits have been issued for timber harvesting in both areas. Timber harvesting in each area will impact approximately 1,000-1,200 ha/year through the lifetime of the FMA.	L	H	C	N	H	H	**Medium**

5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities	Elders and harvesters from across the NWT have noted that research and in particular collaring, may affect boreal caribou negatively. These practices remain controversial in many communities. In many areas, collars are seen to affect boreal caribou and cause them to change their behaviour, or even cause disease. In addition to the behavioural changes, the area around the neck where the collar sits is at times worn raw and may become infected. Dehcho elders fear that collaring will impact a caribou's relationship with other caribou and otherwise impact the integrity of the caribou.	L	L	C	N	H	L	**Low**
7. Natural system modifications								
7.1 Fire and fire suppression	The main threat to boreal caribou is habitat loss, degradation and fragmentation from human-caused and natural disturbances that result in increased predation risk. Forest fires were identified as an important factor influencing the availability of boreal caribou habitat in the NWT. The majority of habitat disturbance in the NWT is natural (23.7% from fire and 9.1% from human disturbances). By region, fire disturbance: Inuvialuit = 1.3%, Gwich'in = 22.1%, Sahtú = 15.6%, Wek'èezhìı = 33.7% and Southern NWT = 33.4% (ENR 2019). Fires destroy habitat and the effects can last for many years, if not decades, although they are sometimes known to use recently burned areas at certain times of the year (CMA 2017). It is recognized that fires are natural occurrences and can facilitate forest renewal.	W	M	S	N	H	M	**Med**

	However, forest fires are thought to be increasing in many areas and impacting boreal caribou habitat as a result. Fires are seen as a definite threat to boreal caribou populations. Increases in fires may be related to climate change, with more lightening and drier summers being reported. Disturbances like wildfire and timber harvest result in younger forests that are attractive to other prey species like moose and deer. If there is enough young forest to increase the density of other prey, wolf density may also increase, leading to more predation on boreal caribou (ENR 2019). Wildfires can result in changes to the landscape that force boreal caribou to change their movements and can make them not use an area for many decades.							
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications								**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases	Most members of the deer family are considered to be susceptible to chronic wasting disease (CWD). CWD can be transmitted from animal to animal and can accumulate in the environment if shed from infected animals. Animals can be infected with CWD for years before they exhibit signs of the disease. There is currently no treatment or vaccine. CWD has not been detected in any wildlife species in the NWT to date, nor has it been detected in caribou population anywhere in North America. In Canada, CWD is found in captive and free-ranging populations in parts of AB and SK. In the NWT, a CWD monitoring program is in place (ENR, n.d.).	L	H	C	LTF	H	M	**Medium**
8.2 Problematic native	WOLVES: Wolves are the primary natural predators of adult female boreal caribou throughout most of Canada. Predators can have a	W	H	C	N	M	H	**Medium**

species/diseases	major impact on boreal caribou, especially wolves. Increases in wolf populations were noted in many studies. Wolf populations are said to be increasing in the Gwich'in Settlement Area, the Sahtú Settlement Area and the Dehcho region and wolf predation was identified as one of the main threats to boreal caribou in the Tłı̨chǫ region. However, wolf densities in the NWT appear to be substantially lower than those in southern areas, like BC (Serrouya et al. 2016). BEARS: Grizzly bears and black bears also prey on boreal caribou and bear populations are thought to be increasing as a result of less hunting pressure. Although no population studies have been conducted on black bears in the NWT, the general view is that they occur at low densities relative to other jurisdictions. Black bears are potentially a significant predator of boreal caribou calves. One study in Quebec found that 57% of newborn caribou calf mortality was caused by black bear predation. PARASITES: Parasites and disease are known to occur but are not generally a cause for concern. However, Gwich'in Settlement Area participants said there is an increasing trend towards unhealthy caribou in the Gwich'in Settlement Area. Unhealthy animals can be identified by having spots on organs, poor body condition, lack of fat, lumps and pus, or other evidence of disease. Biting insects are most active during periods of warm temperatures, thus longer warmer summers may lead to longer periods of insect harassment and, as a result, reduced body condition for boreal caribou. These conditions may occur with greater frequency in the future. Winter ticks (*Dermacentor albipictus*) were first documented on captured boreal caribou in the Dehcho and South Slave regions in 2015. Since then, the prevalence of ticks has increased, with the exception of 2019, coinciding with the first winter in a number of years where temperatures were below -40°C for an extended period of time							

	(Larter et al. 2019). RANGE EXPANSION: There are additional concerns about possible impacts of 'new' predators that are expanding their range northward. An increase in cougar numbers in the Tłı̨chǫ region was stated as a concern for boreal caribou. Cougars and their tracks have increasingly been seen throughout the Dehcho region over the past decade and they are suspected of preying on boreal caribou – although there is as yet no direct evidence of this occurring. Their increase may be associated with the concurrent increase in white-tailed deer in this area, as well as extensive oil and gas exploration in northern AB and BC, which is thought to push cougars northward. White-tailed deer expanded their range far into the NWT as a result of more moderate winters, leading to the possibility of the introduction of the meningeal worm (*Parelaphostrongylus tenius*) and chronic wasting disease. These parasites and diseases occur in white-tailed deer in AB and have caused ungulate population declines in other areas. Additional expansion of white-tailed deer range is projected over the 21st century, in response to changing climate conditions (Deb et al. 2020).							
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin	The presence of some previously unreported parasites (*Toxoplasma gondii*, *Eimeria*, *Giardia*, *Ostertagia gruehneri*, *Teledorsagia boreoarcticus*) and evidence of exposure to an unknown herpesvirus, to *Toxoplasma gondii*and an erysipelas outbreak in NWT muskoxen (Hodson pers. comm. 2020) indicate that further health and disease monitoring in boreal caribou should be conducted.	L	M	C	LTF	H	M	**Medium**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								

9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents	People have raised concerns about pollution and contamination from mining. Tailings ponds and hazardous waste (arsenic) have not been adequately managed in the past, so there is concern about future mining activities. Concerns raised with respect to the Pine Point mine include noise, light and dust pollution. Is has been suggested that pollution and acid rain may be affecting boreal caribou range and therefore the caribou. There were also concerns about contaminated historic mining sites posing a threat to boreal caribou near Behchokǫ̀. Currently, there are no large-scale developments that generate pollutants within boreal caribou range in the NWT. The primary pollutants within boreal caribou range in the NWT include waterborne pollution generated in AB (e.g. pulp mill and tailings pond effluent) that flows downstream in the Mackenzie River, or airborne pollution that is deposited by global atmospheric air currents. Little is known about the effects of pollution on the recovery of boreal caribou.	W	L	C	N	H	L	**Low**
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)	Indigenous knowledge studies indicate that boreal caribou do not tolerate noise or human disturbance well and that minimizing noise and light disturbance is important for boreal caribou. Although some habituation to consistent noise was noted in the Gwich'in Settlement	L	U	C	N	H	M	**Low**

	Area, noise was cited as a major factor impacting boreal caribou in many studies. People have said that boreal caribou that are highly stressed from sensory or other disturbances taste different. Some people have noted that noise seems to travel greater distances in the cold weather. Seismic cutlines or linear disturbance can also affect the way highway noise travels, meaning that noise from roads might affect boreal caribou even further from the road than previously thought. In the Dehcho region, the change from the relatively quiet transportation of dog teams to snow machines is considered partly responsible for a reduction in boreal caribou sightings (and an observed decline in boreal caribou harvesting). However, there is no scientific evidence that noise and light pose a major threat to boreal caribou in the NWT. Issues related to noise and light disturbance are local and may be most associated with populated centers, near roads and trails and some oil and gas developments.							
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Climate change is occurring more rapidly in the Mackenzie Basin than in most other areas of North America; however, many of these effects have not yet been observed or measured in the NWT. Anticipated regional effects include landslides from permafrost thaw, reduction in water levels, shorter winters (early spring melt, later freeze-up), more precipitation, lower forest yields and more forest fires (changing	W	H	C	N	H	M	**Medium**

	vegetation cover). In the forested part of the NWT, warmer and more variable weather in all seasons is already being observed. Changes in permafrost underlying peat plateaus are causing mortality of overlaying vegetation and a change from forest to bog-fen habitat. Rates of permafrost reduction have been measured at 0.5% (area cover) per year in a small area of the Dehcho. How these changes scale up to the regional level or at the level of the entire boreal caribou range in the NWT is under investigation. We may expect that permafrost thaw will change boreal caribou habitat, especially in areas of discontinuous permafrost. Higher/drier forested areas underlain by permafrost that support lichen subside as permafrost melts, become wetlands and the trees may die and lichen cover is lost (Hodson pers. comm. 2020). There is a moderate long-term impact concern associated with climate change in the NWT range. Magnitude is expected to be high since the entire Mackenzie River Basin is affected. Immediacy is moderate.							
11.2 Droughts	There exists uncertainty with regards to projections of droughts in the NWT due to climate change (Lee pers. comm. 2020).							**N/A**
11.3 Temperature extremes	The frequency and intensity of cold temperature extremes are projected to decrease in a change climate (Zhang et al. 2019). This is concerning for a species that is well-adapted to cold temperatures.							**N/A**
11.4 Storms and flooding								**N/A**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Bowhead Whale (*Balaena mysticetus*)
Populations (if applicable): Bering-Chukchi-Beaufort (BCB) population
Percentage of North American population NWT is responsible for: Bowhead whales have a nearly circumpolar distribution in the northern hemisphere. The BCB population summers in the eastern Beaufort Sea and Amundsen Gulf and winters in the Bering Sea. Both the Bering and Beaufort seas are important feeding grounds for all ages of bowheads.
NWT General Status Ranks: Secure
NatureServe Conservation Rank (NWT): It has not been assigned either a national or provincial rank.
***Species at Risk (NWT) Act*:** Not applicable
***Species at Risk Act* (Canada):** Special Concern
Reasons for assessment or population trends: The population was severely depleted by commercial whaling from 1848 until about 1915, a period of about 65-70 years. Since 1915, it has been subject to regular hunting for subsistence by Aboriginal people in Alaska and Chukotka and occasional hunting by the Inuvialuit of the western Arctic. In the absence of commercial whaling, this population has been recovering and was estimated at 10,400 in 2001. Nevertheless, it is not yet clearly secure because of its life history (e.g. long generation time, very low natural growth rate) and the possible impacts of habitat changes. There is uncertainty about how bowheads will respond to the rapid changes in their habitat due to climate change and increasing human activities such as shipping and oil exploration in high latitudes. Such habitat changes have already begun to occur and will intensify over the next 100 years. In view of the species' life history, it is important that hunting continue to be monitored and managed to ensure against over-harvest.
Sources used for assessments: COSEWIC (2009a)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[70] = 2.3		
Dependence on habitats that are sensitive to climate change[71]	Bowhead whales occur in Arctic and subarctic marine waters and in conditions ranging from open water to thick, extensive (but unconsolidated) pack ice. Whales tend to select inner shelf waters (≤50 m) and light ice conditions in the autumn. Also, they select	3 – Depends on sensitive habitats that are not rare.

[70] Overall sensitivity score based on average of habitat, abioticand biotic factor scores.
[71] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	shallow inner-shelf waters (≤50 m) under moderate and light ice conditions and deeper slope habitat (201-2,000 m) under heavy ice conditions. Some adults may summer far offshore in pack ice or at the ice edge. In the high Arctic, a seasonal bloom of phytoplankton is initiated during the spring melt as algae on the underside of sea ice are mobilized into the surrounding water column. Ice-edge habitat thereby generates a restricted zone of high productivity. Many species of copepods reproduce under the ice before the phytoplankton bloom and feed on ice algae. With a loss in ice habitat, less ice algae will be produced and this could result in less food for copepods. Species, including bowheads, that rely on the ice-edge community for foraging could be adversely affected by a reduction in the areal extent and a latitudinal shift of ice-edge habitat.	
Sensitivity to climate-relevant abiotic factors[72]	Adaptations to their Arctic environment includes a fairly sophisticated acoustic sense for ice navigation and long-range communication and a peaked head profile with a 'crown' for pushing up through ice to breathe. They are able to break thick ice (over 20 cm) to navigate under extensive ice fields. They have exceptional energy storage capability and thick blubber. The bowhead's range is affected over long time scales by sea ice fluctuations. During the hypsithermal (a warm period 7,500-10,000 years ago) bowheads occurred more widely in what is now the Canadian Arctic, with mixing between the eastern and western North American populations. Inuit believe that bowheads and other marine mammals are strongly influenced by the tidal cycle and tide-induced sea currents. Bowheads are said to be very active and to feed heavily in areas where the currents are strongest around the full moon when tidal variation is greatest.	2 – Somewhat sensitive or possibly very sensitive.
Sensitivity to climate-relevant biotic factors[73]	Bowheads eat zooplankton, particularly euphausiids and copepods. They have a fairly narrow feeding niche in high northern latitudes. Like other right whales	2 – Somewhat sensitive or possibly very sensitive.

[72] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

	(Balaenidae), they are specialized filter feeders evolved to exploit aggregations of euphausiids, copepods, amphipods and mysids. However, they may choose habitat with protection from predators, especially killer whales. The distribution of their primary food source (zooplankton) can be affected by temperature and salinity, nutrient availability, light intensity, bathymetry and physical ocean processes.	
Non-climate stressors = 2		
Sensitivity to potentially interacting non-climate pressures	The listing of bowhead whales is primarily related to the impact of historical commercial whaling operations. Since the cessation of these activities, the population has improved. Subsistence harvesting continues, but it appears to be within sustainable limits, especially in NWT waters. Other potential threats include climate change (impacts to sea-ice associated habitat, marine food species such as copepods and increased exposure to human activities), offshore oil and gas development, shipping and noise disturbance.	2 – Moderate pressures or possible major pressures.
Adaptive capacity[74] = 2.5		
Reproductive capacity[75]	Long generation time and very low natural growth rate. Bowhead whales become sexually mature at about 25 years of age and give birth to a single calf about every three to four years. Gestation is estimated to be 13-14 months or 12-16 months, with one offspring per pregnancy. The gross annual reproduction rate (calves/non-calf/year) from all available information on BCB bowheads from 1982-1989 was 0.05, but year-to-year variation was large. Longevity can exceed 100 years. Adult survival is high (probably close to 0.98). Calves are the age class that likely suffers the highest mortality.	4 – Late reproduction/few offspring
Dispersal capacity[76]	Bowheads are slow swimmers, averaging 3.9-4.5km/hr. However, the BCB population is widely	1 - >10km

[73] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).
[74] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[75] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.

	distributed. Maxima not noted.	
Genetic diversity		N/A
Phenotypical plasticity		N/A

[76] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling	Oil development in the Alaskan Beaufort Sea may be causing bowheads to migrate farther offshore. Avoidance responses were observed in relation to active seismic vessels as far as 20 km away. Reduced extent and thickness of sea ice in the eastern Canadian	L	U	S	LTF	L	L	**Low**

	Arctic due to climate change will likely lead to increases in ship traffic and in the amount and extent of mineral and hydrocarbon exploration in this region. There is concern that increased human activities in high latitudes (e.g. shipping, offshore oil and gas development, commercial fishing) will have negative effects on bowhead populations.							
3.2 Mining and quarrying								**N/A**
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads								**N/A**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes	There is uncertainty about how bowheads will respond to the rapid changes in their habitat due to climate change and increasing human activities such as shipping and oil exploration in high latitudes. Such habitat changes have already begun to occur and will intensify over the next 100 years. Movement patterns as observed by Inuit and scientists and as documented through satellite radio-tracking do not suggest that bowheads move through the Northwest Passage in either direction (eastward or westward) but there is some historical evidence of at least occasional movement through the passage. It is reasonable to expect that such movement will become more frequent in coming decades if and as ice conditions in that part of the Arctic ameliorate. Summering bowheads react to some vessel traffic at distances of 1-4 km by moving away from the ship's track, whereas drill ships	L	L	S	LTF	L	L	**Low**

	appear to induce avoidance reactions at distances of up to 10 km. Bowheads avoid seismic vessels at distances of 6-8 km or even at distances of 20 km. Reduced extent and thickness of sea ice in the eastern Canadian Arctic due to climate change will likely lead to increases in ship traffic and in the amount and extent of mineral and hydrocarbon exploration in this region. Some deaths may be due to ship strikes. Bowheads, as with other 'right whales' are among the slowest moving of whales, which may make them particularly susceptible to ship strikes, although records of strikes on bowheads are rare compared with records of strikes on some other large whales. About 1% of the bowheads taken by Alaskan Inupiat bore scars from ship strikes. Until recently, few large ships have passed through most of the bowhead's range, but this situation is changing as northern sea routes become more navigable with the decline in sea ice.							
4.4 Flight paths	Exposure to man-made noise and contaminants may have short- and long-term effects that compromise health and reproductive performance. Fall migrants appear to be diverted more readily than summer whales that are actively engaged in feeding. Startle reactions such as hasty dives and avoidance behaviour may occur in response to aircraft flying at altitudes below 460 m.	L	U	S	LTF	M	L	**Low**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals								**N/A**
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and	The depletion of bowhead populations by commercial whaling is	W	L	S	LTF	M	H	**Low**

harvesting aquatic resources	the main reason that the species has been listed as endangered in much of its range. The population was severely depleted by commercial whaling from 1848 until about 1915. Since 1915, it has been subject to regular hunting for subsistence by Indigenous people in Alaska, Chukotka and occasional hunting by the Inuvialuit of the western Arctic. In the absence of commercial whaling, this population has been recovering. Recent hunting for subsistence in eastern Russia, Alaska and Canada appears to have been within sustainable limits and has allowed continued population recovery. There are reports of bowheads entangled in harpoon lines and in fishing nets and lines, but these are rare. The significance of mortality from entanglement is uncertain but it is not thought to be a major threat at present. The development of commercial fisheries in the Arctic presumably will increase the risks of entanglement. The Inuvialuit of the western Arctic had been interested in re-establishing their harvest of bowhead whales since 1952, but no organized effort to hunt bowheads was made until the 1990s. During that decade, bowheads were taken in the western Arctic by the Aklavik Hunters and Trappers Committee – one in 1991 and one in 1996. No further licenses have been requested by (or issued to) the Aklavik Hunters and Trappers Committee. Most Inuit are concerned about losing their communal knowledge about the bowhead whale and their techniques for hunting it. They have a strong desire to preserve their culture and many believe that resumption of the bowhead hunt will help them do so. Bowhead hunting is co-managed by Fisheries and Oceans Canada and wildlife management boards created under land claim							

	agreements. The bowhead whale is listed in Appendix 1 of CITES, meaning that commercial trade in products is prohibited.							
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression								**N/A**
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications								**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases								**N/A**
8.2 Problematic native species/diseases								**N/A**
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**

8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents	Oil spills are a concern for all marine wildlife in the Arctic and the potential effects of oil spills on bowheads have been considered in a variety of studies. Offshore oil and gas exploration is rapidly increasing in the Davis Strait (off west Greenland) and Lancaster Sound is known to have significant hydrocarbon deposits. Baleen whales generally have lower tissue contaminant levels than toothed whales owing to the low trophic level at which they feed. The limited information available suggests that contaminant exposure poses no present threat to bowhead populations or to people who eat whales. However, any reduction in productivity of their planktonic food resources caused by chemical contamination could have a direct effect on bowheads.							**Neg.**
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)	Exposure to man-made noise may have short- and long-term effects that compromise health and reproductive performance. Bowheads are known to react to man-made underwater noise, with reactions varying by season, habitat and behavioural state. Fall migrants appear to be diverted more readily than summer whales that are actively engaged in feeding. Startle reactions such	L	L	S	LTF	M	M	**Low**

	as hasty dives and avoidance behaviour may occur in response to aircraft flying at altitudes below 460 m. Summering bowheads react to some vessel traffic at distances of 1-4 km by moving away from the ship's track, whereas drill ships appear to induce avoidance reactions at distances of up to 10 km. Bowheads avoid seismic vessels at distances of 6-8 km or even at distances of 20 km. However, such reactions may be short-term and it was suggested that the whales could habituate to ship (and other industrial) noise, possibly leading to increased risk of collisions. The main sources of man-made noise in the Arctic are ships, aircraft, seismic exploration, marine construction, drilling and motor boats.							
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Direct effects of climate change on Arctic marine mammals include the loss of ice-associated habitat. Indirect effects include regional or seasonal shifts in prey availability, which can affect nutritional status and reproductive success, alter the timing or patterns of migrations and cause changes in distribution and population structure. For example, Inuit in the high Arctic report that bowheads are now moving farther west in Barrow Strait in the summer with the retreat of the ice edge. Based on isotopic evidence, average seasonal primary productivity in the Bering Sea ecosystem declined by 30-40% from 1966-1997. One model of the effect of a CO_2 doubling on the Hudson Bay region suggested that sea ice would virtually disappear in the bay,	W	U	C	N	H	L	**Low**

	leading to substantially higher regional temperatures. This degree of climate change would likely alter food webs, although it is not known whether this would have a positive or negative effect on bowheads. There is uncertainty about how bowheads will respond to the rapid changes in their habitat due to climate change and other human activities. Such habitat changes have already begun to occur and will intensify over the next 100 years. Reduction in sea ice is likely to affect bowheads because of greater exposure to human activities. The bowhead's range is affected over long time scales by sea ice fluctuations. During the hypsithermal (a warm period 7,500-10,000 years ago) bowheads occurred more widely in what is now the Canadian Arctic, with mixing between the eastern and western North American populations. With a loss in ice habitat, less ice algae will be produced and this could result in less food for copepods. Species, including bowheads, that rely on the ice-edge community for foraging could be adversely affected by a reduction in the areal extent and a latitudinal shift of ice-edge habitat. The close association of bowheads with sea ice places them at risk of entrapment. This has been observed on a few occasions. Even without direct mortality from ice entrapment, bowheads can be prevented from reaching preferred feeding grounds during heavy ice years and this may affect survival. Inuit report that bowheads avoid areas where the ice cover is extensive or apparently continuous. Predation could increase if the refuge provided to bowheads by							

	sea ice cover diminishes as a result of climate warming.							
11.2 Droughts								**N/A**
11.3 Temperature extremes								**N/A**
11.4 Storms and flooding								**N/A**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Buff-breasted Sandpiper (*Tryngites subruficollis*)
Populations (if applicable): N/A
Percentage of North American population NWT is responsible for: Breeds in the central Canadian Arctic, including Banks Island and western Victoria Island in the NWT. The Canadian Arctic supports about 87% of the North American breeding range of this shorebird and about 75% of its global population.
NWT General Status Ranks: Sensitive
NatureServe Conservation Rank (NWT): S2S4
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Special Concern
Reasons for assessment or population trends: The species was once common and perhaps even abundant historically, but it suffered severe declines stemming from intensive market hunting in the late 1800s and early 1900s. By the 1920s, it was thought to be at the brink of extinction. Its population has grown since hunting was banned in North America, but numbers remain much lower than those before hunting began. There is evidence for population decline in recent decades and many conservation organizations consider the species to be of concern throughout its range. However, this species is difficult to monitor effectively and data necessary to estimate population trends are currently lacking. Outside the breeding period, loss and degradation of its specialized grassland habitat, both on its wintering grounds in South America and along its migration routes, are believed to pose the most significant threats.
Sources used for assessments: COSEWIC (2012a)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[77] = 1.7		
Dependence on habitats that are sensitive to climate change[78]	The buff-breasted sandpiper breeds in the Arctic regions of eastern Russia, Alaska, YT and north central Canada. The breeding grounds are exclusively within tundra habitats. On migration and during the winter, buff-breasted sandpipers occur primarily in grassland habitats. Availability of breeding habitat for the buff-breasted sandpiper in the Arctic is extremely variable both	2 – Generalist, but some sensitive habitats are important.

[77] Overall sensitivity score based on the average of habitat, abiotic and biotic factor scores.
[78] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	within and between years due to unstable environmental conditions (e.g. differential snow accumulation and melt across the breeding range). As a result, the species shows low breeding site fidelity and is both spatially and temporally opportunistic in its habitat use, taking advantage of optimal habitat conditions when and where they become available. Breeding habitat in the Arctic is projected to be affected by climate change, but impacts on this species are not entirely known. Climate change may impact nesting habitat through the drying of tundra ponds and shrub encroachment. Historically, buff-breasted sandpipers likely relied on short-grass prairie maintained by natural fires and grazing by bison or prairie dogs at North American stopover sites.	
Sensitivity to climate-relevant abiotic factors[79]	Males display in the first areas to be snow-free upon arrival to the breeding grounds, frequently in upland habitats of the coastal tundra, such as barren ridges, creek banks, pingos and raised, well-drained areas. As snow continues to melt, males display in moister areas, such as graminoid meadows. It is not known whether patterns of snow melt are changing, or how the birds might respond to any potential changes that may occur.	1 – Not sensitive.
Sensitivity to climate-relevant biotic factors[80]	Knowledge of diet is incomplete. Spring migrants primarily feed on terrestrial invertebrates, such as spiders and insects at all life stages. Plant seeds are also consumed. In the fall, birds feed on copepods, crane flies and gammarid crustaceans. On the breeding grounds, accelerated climate change may impact courtship and contribute to asynchrony between invertebrate food availability and chick hatch periods. In the Arctic, warmer temperatures have led to advancement in spring phenology, potentially decoupling the synchrony between breeding chronology and food availability.	2 – Somewhat sensitive or possibly very sensitive.
Non-climate stressors = 1		
Sensitivity to potentially	Habitat loss, fragmentation and degradation are likely the primary threats to buff-breasted sandpiper	1 – No pressures.

[79] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.
[80] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

interacting non-climate pressures	populations, especially at stopover sites and elsewhere in the non-breeding range. In the NWT, non-climate stressors are associated primarily with mining on the breeding grounds; this is likely of a low magnitude.	
Adaptive capacity[81] = 1		
Reproductive capacity[82]	Females lay a single clutch of four eggs in a nest on the ground. Age of first reproduction is unknown due to the apparent lack of natal philopatry, but is assumed to be one year. No information is available about generation time; however, a rough estimate of four to five years can be made based on the assumed age of first breeding and available data on adult survival rates. This corresponds with the generation times of two closely related shorebird species (Dunlin and Red Knot), which are five and six years respectively. Nest failure and nest predation were high in Alaska. Fledging success in Alaska ranged from 7-18%.	1 – Early reproduction/many offspring
Dispersal capacity[83]	Long-distance migrant, wintering in South America. Buff-breasted sandpipers cover a distance of about 26,000 km in their annual migrations. Most males defend relatively small display territories, ranging from 10-50 m in diameter, in close proximity to one another during courtship. However, some males defend much larger territories (up to 1 hectare) and territory size can vary over the breeding season for individual males. Leks tend to be ephemeral within the breeding season and males may attend multiple leks over a single breeding season. Once mated, females leave the lek area to nest and raise young elsewhere. The Canadian breeding range extends along the northern coast of YT, NWT and NU. Breeding site fidelity and natal philopatry appear to be extremely low in the buff-breasted sandpiper, although data are limited.	1 - >10km.

[81] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[82] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources; actual reproduction rate will depend on condition and context. Survival to maturity varies widely among species and years, even in species with few young; however, data on juvenile survival are too sparse to provide reliable information for many species.
[83] Dispersal distances are taken from maxima noted in sources. For many species, these are extrapolated from species of similar size; a reasonable assumption. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Genetic diversity		N/A
Phenotypic plasticity		N/A

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas	The widespread conversion of native short-grass prairie to crop production and human settlement in the Great Plains has resulted in a profound loss of stopover habitat during migration.							**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas	Tourism development in the winter range (e.g. roads, buildings) is a potential threat.							**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops	Throughout much of the migration and winter range, native grasslands have largely disappeared and the species has switched to using human-altered habitats. The buff-breasted sandpiper's regular use of croplands may expose the birds to agrochemicals, while changing agricultural practices (e.g. altered grazing regimes, switch to no-till farming) may decrease food availability and limit suitable habitat. For example, the increased use of no-till agriculture (as a conservation alternate to deep ploughing) may decrease prey availability for buff-breasted sandpipers. Most short-grass native grassland in the Canadian prairies disappeared by the late 1800s as a result of widespread cultivation and the elimination of bison, which buff-breasted sandpipers presumably relied on to exert sufficient grazing pressure. Today, less than 2% of the original northern short grassland ecosystem remains in Canada, with much of it having been converted to annual							**N/A**

	crop production and to tame pasture for livestock grazing. However, only a small proportion of existing grasslands likely provide suitable vegetation structure for this species. Though the area is rather small, sod acreage increased by 26% in Saskatchewan between 2001-2006, potentially benefitting buff-breasted sandpipers.							
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing	Until recently, grazed habitat in the Canadian prairies seemed relatively secure. However, recent concerns stem from the Canadian government's announcement in spring 2012 that it will be phasing out the Community Pasture Program over the next 15 years. How this might affect buff-breasted sandpipers is unknown, but loss of this program has the potential to affect hundreds of thousands of hectares of native rangeland that have been conserved since the 1930s. On the present-day wintering grounds, buff-breasted sandpipers are highly dependent on livestock grazing to maintain short-grass habitat structure. But ranching practices may not always promote the habitat conditions required by the species. For instance, if cattle and sheep are moved frequently (i.e., to minimize overgrazing), introduced late in the austral summer, or removed completely (e.g. when land is acquired by conservation agencies), the amount of short-grass cover that is associated with moderate to heavy levels of grazing diminishes or disappears altogether. Changes to livestock grazing patterns could have a strong influence on the distribution and abundance of buff-breasted sandpipers. More than 60% of the rangelands have disappeared in the Argentine Pampas since the 1880s, especially in recent decades. Subdivision of ranches is a potential threat in the wintering							**N/A**

	grounds.							
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling	In the Arctic, breeding habitat overlaps areas of mineral, coal and oil and gas development. Most oil and gas development in the north occurs in Alaska (which accounts for ~25% of the breeding range). For example, the species is known to breed within the National Petroleum Reserve, Kuparuk and Prudhoe Bay oil fields and the Arctic National Wildlife Refuge (ANWR) in Alaska – all sites of either active or proposed oil and gas drilling. Although some breeding habitat has been protected by ANWR, the United States Congress can authorize oil and gas development along the north coast of ANWR at any time. Short grassland is under increasing threat by oil and gas development in the Prairie provinces. Although the impact of development activities on buff-breasted sandpipers is not yet clear, the necessary infrastructure to support development projects (e.g. buildings, runways, roads) tends to be located in the drier upland habitat that represents prime courtship-display habitat for the species. Such projects may thus result in direct habitat loss and increased disturbance during the breeding season (e.g. repeated flushing of incubating females, nest abandonment). Furthermore, garbage that accumulates around development sites and Arctic communities likely attracts increased numbers of predators that prey on eggs and young, including Arctic fox, red fox, glaucous gull and common raven. This could be a particular problem in oil fields where trapping and hunting of predators is prohibited. One study failed to find any correlation between infrastructure development and nest survival, but their							**N/A**

	study had high variability in environmental conditions, nest survivorship and predator numbers between years and sites, which confounded the results.							
3.2 Mining and quarrying	In the Arctic, breeding habitat overlaps areas of mineral, coal, oil and gas development. On the Canadian breeding grounds, development is mostly associated with mining and coal exploration. Increased mining a potential threat in the wintering grounds. Although the impact of development activities on buff-breasted sandpipers is not yet clear, the necessary infrastructure to support development projects (e.g. buildings) tends to be located in the drier upland habitat that represents prime courtship-display habitat for the species. See 3.1 for further information.	L	U	C	N	H	L	**Low**
3.3 Renewable energy	The development of wind energy projects along the North American migratory route could have negative consequences for the species. Little is known about the effects of wind turbines on shorebirds. Wind farms could cause direct mortality if birds fly within the rotor sweep zone (as has been found with American golden-plovers, which associate with buff-breasted sandpipers on migration). Indirect effects could include the avoidance of traditional staging areas in the United States and Canada. Currently, several large wind energy projects are planned for areas used by buff-breasted sandpipers in the Great Plains and the Gulf Coast Plain. Thirty-one wind energy projects currently operate in AB and SK, the main migratory corridor for buff-breasted sandpipers in Canada. Other projects are being planned. In the future, increased demand for biofuel crops could also lead to the introduction of non-indigenous tall grasses in crop land now used by migrating buff-breasted sandpipers in the United States and Canada. The rising demand for biofuels derived from soybeans is partly responsible for the loss of cropland in the fertile							**N/A**

	grasslands of South America.							
4. Transportation and service corridors								
4.1 Roads and railroads	Road construction is a potential threat in the wintering grounds. Native short grasslands in North America are increasingly under threat by oil and gas development and associated road infrastructure.							**N/A**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	Buff-breasted sandpipers are known to be extremely tame and to return to wounded flock members, which, historically, made them particularly vulnerable to hunting. Heavily harvested in commercial hunts during the late 1800s and early 1900s, causing precipitous population declines. Birds were hunted primarily during migration through the central United States and to a lesser extent on the South American wintering grounds. With the exception of some birds and/or their eggs that might be taken for subsistence by Indigenous peoples on the breeding grounds, it is now illegal to hunt the species in the United States and Canada. However, hunting of the species still occurs in Latin America, although it is probably fairly minor.	L	L	S	N	H	H	**Low**
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational								**N/A**

activities								
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression								**N/A**
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications	The species' dependence on heavily grazed grassland for wintering habitat may put it at odds with conservation projects seeking to restore such habitat for other native wildlife species. The buff-breasted sandpiper's unusual habitat requirements (compared with other shorebirds) have likely led to inadequate protection of habitat across its range. On its Arctic breeding grounds, the species' preference for drier uplands conflicts with existing approaches that focus on wetland protection. With the exception of native pasture, many of the human-altered habitats now used by the species on migration tend to be viewed as being of low conservation value for most other species. Similarly, heavily grazed grasslands on the wintering grounds are not deemed a high conservation priority.							**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases								**N/A**
8.2 Problematic native species/diseases								**N/A**
8.3 Introduced genetic material								**N/A**

8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents								**N/A**
9.3 Agricultural and forestry effluents (including erosion)	The buff-breasted sandpiper's present-day reliance on a variety of human-altered habitats along its migratory route and on the winter grounds potentially exposes it to high levels of pesticides. Buff-breasted sandpipers showed exposure to organophosphorus and carbamate pesticides at agricultural sites in South America (i.e., rice fields and cattle pastures). However, exposure was not evident at stopover sites in North American agricultural habitat (i.e., organic rice fields and turf grass farms). The effects of agrochemicals on shorebirds may range from death to physiological impairment (deaths associated with Furadan noted in particular). Although Furadan products are now banned in the United States, they may still be permitted in Brazil and Uruguay. Sublethal effects of cholinesterase-inhibiting pesticides (i.e., organophosphorus and carbamate) include reduced body mass, loss of migratory orientation and decreased flight speed; although to date these impacts have not been studied in buff-breasted sandpipers.							**N/A**
9.4 Garbage and solid waste	Garbage that accumulates around development sites and Arctic communities likely attracts increased numbers of predators that prey on eggs and young, including Arctic fox, red fox, glaucous gull	L	L	C	N	H	H	**Low**

	and common raven.							
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Availability of breeding habitat for the buff-breasted sandpiper in the Arctic is extremely variable both within and between years due to unstable environmental conditions (e.g. differential snow accumulation and melt across the breeding range). Breeding habitat in the Arctic is projected to be affected by climate change, but impacts on this species are not entirely known. How the buff-breasted sandpiper will respond to the effects of climate change is unknown. On the breeding grounds, accelerated climate change may impact courtship and nesting habitat through the drying of tundra ponds, shrub encroachment and asynchrony between invertebrate food availability and chick hatch periods. A mismatch between peak food levels (occurring earlier in the spring) and chick hatch may be of particular concern for buff-breasted sandpiper, which breeds relatively late in the season compared to other shorebirds. It is also not known whether patterns of snow melt are changing, or whether the sandpipers might respond to this by shifting their migratory patterns. Many effects of climate change are already manifesting themselves	W	U	S	N	H	L	**Low**

	across the buff-breasted sandpiper's range, particularly in the Arctic, which has experienced rapid warming since the 1950s. In the Arctic, warmer temperatures have led to advancement in spring phenology, potentially decoupling the synchrony between breeding chronology and food availability. Likewise, warming is resulting in the northward advancement of shrub cover into the tundra.							
11.2 Droughts	Climate change is expected to cause more frequent and severe droughts in the Canadian prairies and the United States Great Plains, which may negatively impact wetland and seasonal pond habitat and lead to decreased food availability during migration. On the wintering grounds, recent increases in severe droughts and flooding are believed to have affected the species' habitat use in Paraguay.							**N/A**
11.3 Temperature extremes	Expected higher frequency and duration of heat events in the Arctic and lower frequency and duration of extreme cold events. However, extreme heat events are rarely observed north of 60°north latitude. It is uncertain how this would impact the Buff-breasted Sandpiper (Lee pers. comm. 2020).	L	U	S	ST F-LT F	M	M	**Low**
11.4 Storms and flooding	Rising sea levels and increased rainfall could flood the birds' coastal habitat on both breeding and wintering grounds and degrade freshwater habitat by increasing salinity levels. More frequent and intense storms could increase mortality of juveniles migrating along the Atlantic coast. In the future, risk of flooding due to climate change in coastal areas may diminish habitat. These areas are currently the prime wintering habitat because they remain largely unsuitable for crop production due to high soil salinity. On the wintering grounds, recent increases in severe droughts and flooding are believed to have affected the species' habitat use in Paraguay and a rise in heavy rainfall has been documented over the past 50 years in the sandpiper's Argentinean range.	L	U	C	N	H	L	**Low**
11.5 Other								**N/A**
12. Other threats								

							N/A

Species: Bull Trout (*Salvelinus confluentus*)
Populations (if applicable): Western Arctic population
Percentage of North American population NWT is responsible for: Occurs in YT, NWT, BC and AB. Overall, BC, YT and the NWT are the last remaining jurisdictions with wide distributions of bull trout.
NWT General Status Ranks: Sensitive
NatureServe Conservation Rank (NWT):
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Special Concern
Reasons for assessment or population trends: This freshwater fish is broadly distributed throughout the western Arctic drainage although populations are never abundant. There are areas with evidence of decline in numbers and distribution but quantitative estimates for the whole range are lacking. This is a slow-growing and late-maturing species that thrives in cold, pristine waters and many populations require long unimpeded migratory routes joining spawning to adult habitat. Therefore, the species is particularly vulnerable to habitat degradation, fragmentation of river networks by dams, negative effects from the invasion of the non-native eastern brook trout and overharvest, but these threats are localized within its range.
Sources used for assessments: COSEWIC (2012b)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[84] = 3.3		
Dependence on habitats that are sensitive to climate change[85]	Requires habitat that is cold, clean, complex and connected (more specific than other salmonids). Climate change may contribute to habitat degradation and fragmentation. Strong site fidelity to spawning area and overwintering habitat. Bull trout have specific requirements regarding channel and hydrologic stability that include depth, velocity and substrate parameters. The association with substrate appears more important for bull trout than for other species. Persistence in stream networks is strongly dependent on patch size (stream or	4 – Depends on sensitive habitats that are rare.

[84] Overall sensitivity score is based on average of habitat, abiotic and biotic factor scores.
[85] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	watershed size), connectivity and quality. Disruption of connectivity can lead to lower effective size of local populations by simultaneously reducing dispersal and local adult population sizes. Because eggs incubate over the winter, incubation sites are particularly vulnerable to anchor ice accumulations, as well as scouring and low flows. Females, therefore, often select spawning sites associated with groundwater sources that stabilize temperatures through the winter but are spatially limiting. Areas with perennial groundwater are very important for northern populations as this is where adults spawn and juveniles rear for three to five years. Habitats that possess perennial groundwater are not ubiquitous across stream networks and would be considered rare by many (Mochnacz pers. comm. 2020). Climate change will likely play a role in further restricting the availability of habitat for this cold-water specialist in the future, as well as reducing connectivity among refuges of suitable cold-water habitat. An assessment of the Cariboo-Chilcotin region of BC suggests that the thermal and precipitation effects of global warming will produce a long-term pattern of considerably decreased cold water stream habitat by the 2080s. Relevant to the NWT, northerly populations of the western Arctic population generally inhabit less productive habitat than their more southerly counterparts and their populations are therefore likely to be smaller and hence more susceptible to perturbations, than those found further south. Indeed, bull trout are thought to be the most sensitive species in the upper Liard River basin.	
Sensitivity to climate-relevant abiotic factors[86]	Narrow tolerance to environmental conditions. The bull trout is a cold water species generally found in water below 18°C, but most commonly in temperatures less than about 12°C. Temperature is an important determinant of the southern limit of this cold water fish and, as one moves north through its range, bull trout appear to increase in the number of sites where they occur. At least in some areas, actual	4 – Known very sensitive.

[86] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

	spawning does not occur until water temperatures drop below about 10°C. Spawning migrations are thought to be triggered by a hierarchy of environmental cues, including changes in river discharge and water temperature. The incubation period is temperature dependent and can take anywhere from 35 days to more than four months. High water temperatures and the resulting low dissolved oxygen levels, increase the rate of yolk absorption and decrease the size of fry. Successful incubation is dependent on several stream characteristics, including appropriate temperature, gravel composition, permeability and subsurface and surface flow. The optimal incubation temperature for survival to hatching is 2°C -4°C, with survival to hatching declining precipitously above 8°C. Groundwater inflows are important in providing stable temperature for egg development. Laboratory tests of thermal tolerance confirm field reports of bull trout having one of the lowest upper thermal limits and growth optima of North American salmonids. Although the low temperatures typical of bull trout habitat lead to relatively low optimum growth rates, such temperature preferences discourage or exclude the invasion of species with higher temperature requirements, which may otherwise compete with bull trout. This cold-water specialist may be especially vulnerable to climate change. Populations near its southern limit will be most susceptible, given that this limit is defined by temperature but the thermal and precipitation effects of global warming are likely to exacerbate fragmentation of bull trout populations throughout much of the range. Variables such as temperature, depth, velocity, substrate and cover are critical to the persistence of this cold-water specialist. The occurrence of bull trout is negatively correlated to the percentage of fine sediment filling interstitial spaces.	

Sensitivity to climate-relevant biotic factors[87]	Top aquatic predator. Their habitat use is strongly influenced by the presence, or absence, of other species. Opportunistic foragers. Throughout their distribution, they feed on a diversity of vertebrate and invertebrate prey, selecting for larger-bodied prey when available. Temperature may affect the ability of bull trout to compete with rainbow trout and cutthroat trout. Bull trout are more abundant than rainbow trout when they occur in sympatry at temperatures below 13°C, but the situation is reversed at higher temperatures.	2 – Somewhat sensitive or possibly very sensitive.
Non-climate stressors = 2		
Sensitivity to potentially interacting non-climate pressures	Strong environmental sensitivity given their very specific habitat requirements. In addition, the more northerly populations within the Designatable Unit may recover more slowly from adverse impacts compared to their more southerly counterparts, given their tendency for slower growth and less frequent mating. Given this likely susceptibility to perturbations, there is concern about the potential impact of development activities on bull trout habitat in the NWT. The potential spread of whirling disease to northern populations is particularly concerning.	2 – Somewhat sensitive or possibly very sensitive.
Adaptive capacity[88] = 2 plus 0.5 for low genetic diversity = 2.5		
Reproductive capacity[89]	Slow-growing and late-maturing species. Generation time ~7 years. Mature age five to seven years. Maximum age is unknown, but ages up to 24 years have been recorded. Strong evidence that bull trout display alternate-year spawning or resting periods between consecutive spawning events. This reproductive strategy, which is often condition- and survival-dependent, may enable them to accrue sufficient energy for reproduction in colder, less productive systems. Spawning may occur at two to three-year intervals in the NWT from all life history types. This strategy can also show a density-dependent response, with the proportion of bull trout spawning annually declining with increasing density. Like most	3 – Late reproduction/many offspring

[87] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).
[88] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[89] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.

	fish, fecundity in bull trout depends on female body size; the larger fluvial and adfluvial females produce more eggs (typically 2,000-5,000+) than the smaller stream-resident females (<1,000).	
Dispersal capacity[90]	Often isolated above natural barriers, adult resident bull trout typically disperse only short distances to spawn, rear, feed and overwinter (1-10km) (Mochnacz pers. comm. 2020). Migratory forms (fluvial, adfluvial, anadromous) undergo migrations between feeding areas and overwintering habitat and their distant natal habitat. Spawning migration distance can be up to 250 km, one-way. The presence of suitable corridors for movement between the different habitats they use for feeding, breeding and refuge, is crucial to the persistence of this largely migratory fish. Low levels of gene flow, significant genetic differentiation among bull trout populations and strong site fidelity to spawning areas and overwintering habitat suggest that migration between populations is low. This diminishes the likelihood of immigration providing a significant rescue effect. Significant dispersal between watersheds seems particularly unlikely, although some evidence of straying at the local level and at least one account of dispersal between watersheds does suggest a potential role for dispersal from nearby sources. Rescue is most likely between close, adjacent populations that are connected by contiguous habitat suitable for bull trout migration.	1 - >10km
Genetic diversity	Five designatable units are recognized, from two genetic lineages. The western Arctic population derives from the same genetic lineage as the YT population, the SK-Nelson Rivers population and the Pacific population. Levels of gene flow are considered to be low amongst bull trout populations. Genetic variability within bull trout populations is typically lower than that of many other freshwater salmonids, including other char. While depauperate neutral genetic variation within populations does not necessarily imply low variability at fitness-related traits, this coupled with high differentiation between populations, strongly suggests that bull trout have been subjected to large and repeated reductions in effective population	0.5

[90] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

	size. This will have resulted in part from the influence of postglacial dispersal on stochastic demographic processes such as founder events, bottlenecks and genetic drift. Contemporary factors will also influence these demographic processes, modifying historical patterns of intraspecific genetic variation (e.g. migration barriers). The extent of their impact varies spatially however and interacts with other important influential factors, such as watershed area and habitat complexity. As a long-lived, late-maturing, top aquatic predator with generally small populations, they are especially vulnerable to the effects of founder events and bottlenecking. Strong site fidelity is a characteristic linked to increased population differentiation. Other intrinsic barriers, such as avoidance of marine waters by most populations, could also constrain gene flow between local populations.	
Phenotypic plasticity	This group of fish (North American char, to which bull trout belongs) has extensive phenotypic plasticity. As is common among salmonids, bull trout most likely diverge in quantitative traits important to population persistence in specific environments. Local adaptation will likely be most evident at larger scales. Local extinctions through stochastic processes can be considered natural, even common, events for bull trout. Bull trout has evolved strategies to cope with such natural disturbances, including phenotypic plasticity and density dependent changes in life history traits, such as faster maturation and more frequent reproductive events at lower density.	N/A

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas	The degradation and fragmentation of freshwater habitat associated with disruptive land use practices, such as urbanization has been documented. The gradual demise of bull trout in developed areas over the last century suggests a trend of negative biological response to this environmental disruption.							**Neg.**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops	The degradation and fragmentation of freshwater habitat associated with disruptive land use practices, such as agriculture, has been widely documented. The gradual demise of bull trout in developed areas over the last century suggests a trend of negative biological response to this environmental disruption.							**Neg.**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								

3.1 Oil and gas drilling	The degradation and fragmentation of freshwater habitat associated with disruptive land use practices, such as mining and oil and gas development has been widely documented. The gradual demise of bull trout in developed areas over the last century suggests a trend of negative biological response to this environmental disruption. In this designatable unit, habitat disturbances from intense development pressure in the Lower Peace River basin within BC and AB warrant particular attention. Exploration for and extraction of oil and gas, as well as mining developments and timber harvesting and their accompanying developments (e.g. roads, urbanization) are of the most concern. To a lesser extent, similar concerns extend to the Lower Liard River basin within BC and YT.							**Neg.**
3.2 Mining and quarrying	See 3.1.							**Neg.**
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads	Negatively correlated with road density, including specifically in Canada. Activities such as road construction have been used as surrogate measures for bull trout habitat disturbance, following studies that demonstrated correlations between them. Road density, as a general indirect measure of habitat disturbance, has frequently been found to significantly negatively correlate ($P<0.05$) with bull trout occurrence. The exact mechanisms by which disruptive land use practices adversely affect the occurrence and abundance of bull trout are not well understood. Their impacts on habitat quality are likely related to changes in forest composition and age that alter the input of groundwater and woody debris, loss of deep pools, channel simplification, decreased vegetation cover and increased surface runoff, sediment inputs and nutrient pulses. These effects can lead to diminished water quality, reduced cover, increased thermal and light regimes, increased sedimentation and							**Neg.**

	altered flow regimes that destabilize streambeds. For example, increased stream temperatures are a common result of watershed developments when they result in loss of riparian vegetation (apply to all habitat degradation/fragmentation). Road construction can lead to fragmentation of bull trout habitat via numerous smaller blockages and hanging culverts. Other obstructions to movement can be more subtle than these obvious physical impacts; degraded habitat resulting from, for example, increased water temperatures and velocities, can also ruin and fragment suitable habitat patches. Existing fragmentation restricts gene flow, making isolated populations more susceptible to local extinction from stochastic and deterministic risks. With less chance of recolonization through regional connectivity, extinction at the regional scale becomes more likely. As a result of such fragmentation, bull trout's distribution may diminish in a way that is not directly proportional to the loss of habitat area. Rather, rates of extinction may accelerate beyond rates of habitat loss. Given that road length has nearly doubled in BC over the last two decades (82% increase between 1988 and 2005), a general decline in the quality of bull trout habitat in BC is suggested over that time period. In AB, using road density and levels of commercial forestry as indirect measures of habitat disturbance, local extirpation of bull trout has been forecast from 24-43% of stream reaches that currently support bull trout in the Kakwa River basin over the next 20 years.							
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**

5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals								**N/A**
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting	Based on the negative correlation between bull trout occurrence and road density/levels of commercial forestry, local extirpation of bull trout has been forecast from 24% to 43% of stream reaches that currently support bull trout in the Kakwa River basin, AB, over the next 20 years. See 4.1 for more information.							**N/A**
5.4 Fishing and harvesting aquatic resources	Once considered 'junk' fish because of their tendency to prey on other salmonids. Active eradication plans combined with easy road access resulted in bull trout being 'fished out' of some areas, including parts of southern AB and BC. Changing attitudes and management practices, however, mean that the threat of extirpation from overharvesting has been reduced for many Canadian bull trout populations. Nevertheless, not all populations that have been subject to strict angling regulations have shown signs of recovery. The lack of change in some systems may be partly attributed to bull trout's high catchability. Bull trout may congregate at tributary mouths or estuaries before the onset of spawning migrations. Coupled with their tendency to gather below barriers before spawning, this habit renders them highly catchable and susceptible to overharvesting. It has been suggested that more northerly populations experience less exploitation. Angler-mediated mortality from hooking, poaching and non-compliance to fishing regulations still poses a significant threat in some areas. The infrastructure of road networks developed to support urban and industrial activities can exacerbate this threat by increasing accessibility. Simulations using reasonable estimates of fishing effort, mortality from catch-and-release and illegal							**Neg.**

	harvest, demonstrate that many bull trout populations will continue to require restrictive angling regulations if they are to be sustained. Although there is no published information on the extent of mortality of bull trout in rivers where intensive fisheries exist for other Pacific salmonids, incidental by-catch mortality from commercial and recreational fisheries directed at these other fish poses at risk to bull trout. This may be borne out not just through increased hooking mortalities, but also through misidentification with other char and trout species; many anglers remain unaware of a key distinguishing morphological feature in bull trout, the absence of spotting on the dorsal fin. The introduction of sport fish, such as brook trout, adds to this threat. The potential for overexploitation of bull trout is recognized as a moderately severe threat in specific locations in the Upper Peace EDU. In addition, the increase in angler-mediated mortality that may be associated with increased accessibility will likely be a threat in remote areas of this Designatable Unit that have experienced recent increases in road development for primary resource extraction but where enforcement remains difficult. Sport harvesters in the NWT and YT are allowed to catch two bull trout per day; those in the NWT can have three in their possession at any one time.							
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and								**N/A**

other activities								
7. Natural system modifications								
7.1 Fire and fire suppression								**N/A**
7.2 Dams and water management/use	Several activities can fragment bull trout's habitat. Migratory populations need uninterrupted migratory corridors that connect spawning grounds with feeding and overwintering habitats. The viability of these populations, therefore, is linked to their need to access this diversity of habitat at different stages throughout their life cycle. Hydroelectric dams are obvious barriers to movement that can threaten the viability of bull trout populations across their range. They can isolate populations and prevent migration between productive juvenile and adult rearing environments, as well as alter and degrade bull trout habitat. The proposed site C dam on the Peace River if developed can be included as a threat to the populations in the Halfway-Peace, Murray, Moberly and Pine/Sukunka core areas. Conversion of river to reservoir habitats and associated changes in species assemblages and changes to life history strategies are likely. Fish passage facilities at the dam site may not be built. Although hydroelectric dams can pose a risk to bull trout populations, there are relatively few such developments in northern BC or in AB. Those that exist within this designatable unit are clustered around the Upper Peace River, although the proposed site C dam on the Peace River has the potential to profoundly affect bull trout populations in the Lower Peace EDU.							**Neg.**
7.3 Other ecosystem modifications								**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-	In western North America, rainbow trout, brown trout and brook							**Neg.**

native/alien species/diseases	trout are the most widespread non-native salmonines. In particular, brook trout is considered a substantial threat to bull trout populations. Brook trout compete with bull trout for food and space. The absence of resource partitioning or a niche shift by bull trout in the presence of brook trout makes them vulnerable to displacement, especially when resources are scarce. Life history characteristics of brook trout (faster maturation, shorter-lived and higher densities) will tend to compound this effect. Bull trout occurrence has been negatively associated with the presence of brook trout. Nevertheless, the ecological impacts of non-native brook trout on bull trout are highly variable and likely depend on environmental conditions, such as water temperature, as well as the spatial and temporal scales of observation. Introductions of this recreational fish across the Pacific northwest from its native eastern North American range began in the late 1800s. Ongoing introductions and its subsequent invasion have led to its wide establishment throughout much of bull trout's range and its presence in many of the same basins. Anecdotal evidence of bull trout's occurrence being negatively associated with the presence of brook trout strongly implicates this non-native fish in the decline in bull trout populations across much of its range. Hierarchical analysis confirms that brook trout can influence upstream displacement of bull trout, although the extent of displacement is strongly influenced by environmental conditions (including elevation and temperature). While complete elimination of bull trout is not a foregone conclusion of brook trout invasion, even partial upstream displacement of bull trout by brook trout may pose a serious threat to these low-density fish. Bull trout occurrence decreases with stream width so, as bull trout are displaced upstream, smaller and more isolated bull trout populations will become more vulnerable to local extinction through other causes.							

	The potentially devastating and unpredictable impact of non-native species on bull trout is illustrated by the crash in the early 1990s of bull trout in Flathead Lake and the Flathead River system in northwest Montana. The collapse of these bull trout populations that were previously considered to be abundant and secure resulted from the introduction of the combination of lake trout and the non-native invertebrate, the opossum shrimp. These species caused major ecosystem changes and cascading food web interactions. Brook trout in Canada are most prevalent in southern BC and southwestern AB. While most brook trout stocking within bull trout's range in AB has stopped, an ongoing Provincial Brook Trout Stocking Program continues to supply these fish to less than 100 lakes across BC (as of 2001). Several initiatives attempt to address concerns about the threat to bull trout from this continuing brook trout stocking program. An increasing abundance of lake trout in Williston Reservoir is also a growing but low severity threat at present.							
8.2 Problematic native species/diseases	Potential for spread of whirling disease. The threat posed by this disease is substantial if it spreads to northern areas. Limited capacity to contain and manage disease unless new resources are provided (Mochnacz pers. comm. 2020).	L	H	C	ST F	H	H	**High**
8.3 Introduced genetic material	Present day hybridization has only been detected among genetic lineage one bull trout (NWT bull trout are genetic lineage two) and dolly varden char. However, it has recently come to light that sympatry between bull trout and dolly varden extends to the northernmost tip of bull trout's known distribution and the most southerly range of a northerly form of dolly varden in the NWT: the Gayna River. Although they co-occur in the same river system, they are largely not syntopic, with the bull trout occupying downstream areas and the dolly varden isolated above barriers. There is not any genetic evidence of hybridization. Ongoing hybridization with							**Neg.**

	native dolly varden presents no risk to the integrity of bull trout populations. Bull trout are likely to be locally adapted to their spatially heterogeneous environment. This cautions against initiating artificial gene flow between populations (via stocking or hatchery production) as disruption of local adaptations would likely increase a population's vulnerability to extinction. Hatchery production of bull trout from Arrow Lakes Reservoir, BC, was stopped in 2000, partly over concern about genetic diversity losses. Competitive displacement of bull trout by brook trout may be exacerbated by gamete wastage resulting from hybridization. Although the geographical extent of hybridization is not well defined, genetic evidence has documented extensive hybridization in BC and Montana. This suggests that it may be widespread and common wherever the two species co-occur. Reduced survival and fecundity of these hybrids likely contributes to the prevention of hybrid swarms forming but their frequent production represents wasted reproductive effort.							
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents	The susceptibility of bull trout to detrimental changes in water quality from heavy metal contaminants released from mining activities is also poorly understood. There is, however, concern							**N/A**

	about the contribution of mining activity in AB's northeast slopes region to declining bull trout stocks in the area. Elevated levels of selenium, which can reduce recruitment in fish populations by increasing rates of deformities during early development, occur in the region. Muscle biopsies indicate that selenium concentrations do, in fact, exceed toxicity threshold values for negatively impacting reproductive success in most bull trout captured downstream of coal mining activity. However, further analysis of bull trout eggs is needed to understand the impact of selenium on bull trout survival and recruitment in these coal-impacted waters. Coal mine development planned for the Murray river area in the lower Peace River watershed may pose a risk to bull trout spawning in this area.							
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and	Climate change and associated global warming in North America is likely to exceed global means in most areas, with mean projected	W	U	C	N	H	H	**Low**

alteration	warming ranges lying between 3-5°C over most of the continent. Such temperature changes would limit the availability of suitable bull trout habitat and increase the risk of invasion and displacement, by other species that require warmer water. Changes like these are likely to have their biggest impact on bull trout populations in the south of its range, where temperature already defines its southern limit. Here, simulations of predicted 5°C warming result in a 69% decrease in the length of streams having thermally suitable habitat for cold water salmonids in a Wyoming drainage of the Rocky Mountains and a loss of 92% of thermally suitable bull trout natal habitat area over 50 years in the interior Columbia River basin of the USA. There has been no consideration of potential impacts, including potential range extensions, at the northern limits of the species' range.							
11.2 Droughts								**N/A**
11.3 Temperature extremes	Although thermal regimes are understood for some populations, the consequences of exceeding optimum temperature are unknown (Mochnacz pers. comm. 2020). Extreme heat events are expected to increase with a warming climate, although these events are still expected to be rare north of 60°N latitude. The impact on aquatic habitats is unclear (Lee pers. comm. 2020).	L	L-H	S	LTF	H	H	**Low**
11.4 Storms and flooding	An increase in winter precipitation and a decrease in summer rainfall are expected in western regions. Subsequent winter flooding caused by heavy precipitation or glacial floods could damage bull trout spawning and rearing habitat.	W	U	S	LTF	H	M	**Low**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Western, Yellow-banded and Gypsy Cuckoo Bumble Bees (*Bombus occidentalis mckayi, Bombus terricola, Bombus bohemicus*)
Populations (if applicable): Two *Bombus occidentalis* subspecies: *B.o. mckayi* and *B.o. occidentalis*. Only the *mckayi* subspecies occurs in the NWT.
Percentage of North American population NWT is responsible for: The western and yellow-banded bumble bees are only known to occur in North America. The western bumble bee occurs in northern AB, northern BC, NWT, YT and Alaska. The yellow-banded bumble bee occurs widely throughout Canada (except NU) and the northeastern and central United States. The gypsy cuckoo bumble bee has one of the largest ranges of all bumble bee species in Canada. It occurs in Europe, the far east of Asia, south into many parts of China, as well as the central and eastern United States and Canada. It is estimated that 10-20% of the gypsy cuckoo's range occurs in Canada.
NWT General Status Ranks: Sensitive, Sensitive, At Risk
NatureServe Conservation Rank (NWT): SNR, SNR, S2S3
***Species at Risk (NWT) Act*:** Not listed
***Species at Risk Act* (Canada):** Under consideration, Special Concern, Endangered
Reasons for assessment or population trends: These three species have been experiencing declines nationally. Southern populations of western bumble bee are experiencing a serious, apparently northward-moving decline. The yellow-banded bumble bee has experienced declines of at least 34% in southern Canada. The gypsy cuckoo bumble bee has declined in relative abundance over the last 20-30 years even where it was once common and where hosts are still relatively abundant. The cause(s) of these declines are uncertain, but are suspected to include pathogen spillover from managed bee populations, pesticide use (neonicotinoid compounds in particular) and habitat change, as well as host declines for gypsy cuckoo bumble bee. At present, there is little evidence of decline in NWT populations of these species and they enjoy a relatively undisturbed habitat and few threats in this jurisdiction. It is important to consider, however, the lessons from southern jurisdictions and to manage threats to these species in a precautionary manner.
Sources used for assessments: SARC (2019), ECCC (2019b)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
WBB Sensitivity[91] = 2.3	YBBB/GCBB Sensitivity = 1.7	
Dependence on habitats that are sensitive to climate change[92]	All three species require consistent access to nesting sites and overwintering sites. Overwintering sites are unknown. They are considered habitat generalists, but all three may have an affinity for open sites near forests and water.	2 – Generalist(s), but some sensitive habitats are important.

[91] Overall sensitivity score is based on average of habitat, abiotic and biotic factor scores.
[92] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	Although certain site characteristics are preferred to an extent, they all display considerable habitat plasticity. However, since the three species of interest appear to have affinities for habitat adjacent to forests, changes to forest habitat will likely have an impact on them. These effects may be positive or negative, depending on whether forests expand or contract, create or reduce forest edge habitat and whether they enhance or displace flowering plant communities. Droughts may have an impact on bumble bees' water availability and floral resources. Drought is also associated with increased forest fires, the number and intensity of which are expected to increase in the changes to soil moisture and other properties, which could affect quality or availability of nesting and hibernacula sites. Drought conditions have been a problem in parts of the NWT in recent years. Loss of permafrost may also impact bumble bee habitat, through changes to water regimes/storage, vegetation cover and soil drainage. Flooding may directly impact ground-nesting bees in floodplains or other low-elevation areas, either from immersion or increased susceptibility to mold. Some large-scale flooding has taken place in the Mackenzie River valley, Aklavik and Fort Good Hope, as well as near Fort Providence and in the Slave River delta in the last five years.		
Sensitivity to climate-relevant abiotic factors[93]	Bumble bees are considered a cold-adapted, non-migratory species, which makes them well-suited for life in the far north. Many insects are obligately ectothermic. Bumble bees must reach internal temperatures of at least 30°C before they are able to fly. This would be a problem for bumble bees in colder regions, except for the fact that they *can* generate their own metabolic heat. By shivering the muscles in its thorax, a bumble bee can make itself much warmer than its surrounding environment. Northern bumble bees also tend to have larger bodies, shorter legs and longer hair, all of which help them preserve heat and prevent heat loss. However, cold adaptations also make it harder for	WBB 3 – Likely very sensitive	YBBB + GCBB 1 – Not sensitive

[93] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

	them to thrive during long periods of hot weather. Hotter summer temperatures and more heat waves in the NWT could affect their ability to forage and grow their colonies. Bumble bees are intolerant of prolonged heat exposure; it can render them immobile, or result in death. Bumble bees whose active seasons end in early or mid-summer are most likely to escape the negative effects of heat waves (since they're most likely to occur in July/August). However, yellow-banded and gypsy cuckoo bumble bees are both active at least until the end of August, so they are not protected from heat waves by their phenology. The western bumble bee is likely active during the same period. The maximum thoracic temperature bumble bees can tolerate is roughly 44°C; anything higher is probably fatal. In natural conditions, bumble bees can cool themselves by ceasing flight, staying in the shade and/or going underground, but these behavioural changes are energetically costly, as they prevent bees from foraging. High temperatures and heat waves therefore pose a threat to bumble bees and have been implicated in local bumble bee population extirpations in Europe. The frequency of extreme summer temperatures (>30°C) is expected to increase across the heat waves are becoming more frequent and more intense. Extended exposure to high ambient temperatures can result in a phenomenon called 'heat stupor', where the bumble bee falls on its back, becomes immobilized and loses its normal reflexes; this is often followed by death. The time it takes for a bumble bee to experience heat stupor is probably species-specific. Heat tolerances have not been assessed in these three species. Animals with large bodies have small surface area to volume ratios, which makes them lose heat more slowly. Because of their heat intolerance, northern bumble bees are expected to be particularly vulnerable to the effects of climate change. The southern limits of their distributions are shifting northward in respond to warming, but the northern limits are not similarly increasing. As temperatures warm in the NWT, we can probably expect to see the distribution of western bumble bee decline. Yellow-banded and gypsy cuckoo bumble bees have		

	widespread distributions in North America that extend down into the north/central east coast of the United States. Presumably, these two species are more likely to tolerate periods of heat and wider temperature ranges than the western bumble bee, which is the largest of the three species and the only one with a truly northern distribution. For western bumble bee, climatic suitability models show that temperature and precipitation are strong drivers of the subspecies' distribution in northern Canada. However, these models may not be accurate for the NWT.		
Sensitivity to climate-relevant biotic factors[94]	The gypsy cuckoo bumble bee is an obligate nest (social) parasite of other bumble bees. Rather than develop nests of their own, females (there are no queen or worker castes) invade established colonies of their hosts and the workers of the host colony care for their young. Given this relationship, the gypsy cuckoo bumble bee might be even more susceptible to threats than the other two species – if its hosts' populations decline, the impacts of other threats are probably compounded. Most cuckoo bumble bee species are quite specialized and parasitize only one bumble bee host; more rarely, they can have as many as five hosts. While the gypsy cuckoo bumble bee is one of these rare generalists at a global scale, it's only confirmed host in the NWT is the yellow-banded bumble bee. However, since the gypsy cuckoo is known from locations where this particular host seems to be absent, this indicates that it must have other host species in the NWT (potentially western and cryptic bumble bees in the NWT). In general, female cuckoo bumble bees emerge approximately one month after the queens of their host species so that they can take over host colonies with workers already in place, but it is unknown if emergence synchrony of host/parasite will be affected by climate change (Environment and Climate Change Canada (ECCC)). All three species require consistent access to floral	2 – Somewhat sensitive or possibly very sensitive	

[94] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

	resources. They can use a wide range of food plants and habitats. Mark-recapture studies suggest that workers faithfully use the same forage patch throughout their lifetime. Western and yellow-banded bumble bees can use even more plants as food than other short-tongued bees as they have learned to 'rob' flowers with long petals of their nectar. Gypsy cuckoo bumble bee is likely a generalist forager, but it may be more selective about its nectar sources than western and yellow-banded bumble bees, as it tends to be associated with plants that flower close to wooded areas. With climate warming, summers begin earlier and end later, extending the length of the active season for bees. This could be positive if food resources are available when queens emerge to establish new colonies in spring, but if there is a timing mismatch with floral resources, the effects could be devastating.	
Non-climate stressors = 2		
Sensitivity to potentially interacting non-climate pressures	The most significant threats to these species relate to climate change-induced habitat alteration. For western bumble bees, an additional substantial threat is the risk of temperature extremes (heat intolerant). For gypsy cuckoo bumble bee, the most serious plausible non-climate threat is declines in host species; however, at least one plausible host in the NWT still has a healthy NWT-wide population (cryptic bumble bee). The import of honey bees and other bumble bees for pollination and honey also represents a potentially serious threat, although significant expansion of the industry is not expected in the near future. These three species are also likely to be affected by forest fires, linear development and wind turbines.	2 – Moderate pressures, or possibly major pressures.
Adaptive capacity[95] = 1.5		
Reproductive capacity[96]	Generation time = one year. Colonies are annual, with a single generation produced per year. Established western bumble bee colonies can contain up to 1,685 workers and produce up to 360 new queens. Female gypsy cuckoo bumble bees have twice as	1 – Early reproduction/many offspring

[95] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[96] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.

	many ovarioles as at least one of their hosts (yellow-banded bumble bee) and their eggs are much smaller. These differences might allow gypsy cuckoo bumble bee females to produce more offspring than their hosts and increase the chances that their offspring will receive a greater share of the colony's resources (food, protection) and improve their chances of survival. In temperate and arctic environments, the maximum size a bumble bee colony can reach is largely limited by food availability, which is closely tied to the length of the active season and weather conditions. Despite challenging climatic conditions, northern bumble bees develop relatively large colonies, perhaps because they tend to establish early in spring and produce reproductives quite late in the fall.	
Dispersal capacity[97]	Bumble bees are capable of flying distances of at least several kilometers. Dispersal capabilities for the three species of interest are not known. Estimates of different species' dispersal rates vary from 0.3 to 10 km/year. Potential geographic barriers for dispersal include mountain ranges and large water bodies, although individual species vary considerably in their ability to overcome such barriers. Female workers are generally thought to forage close to their nests, perhaps within 300-600 m, likely because the time and energetic costs of the flight are high. Bumble bees will forage much further from their nests (up to 1,750 m in one case) if there is a particularly abundant food source, but these instances are generally known only from agricultural systems with dense monocultures of flowering crops and high nectar rewards and these are uncommon in the NWT. Gypsy cuckoo bumble bee dispersal must be contingent upon and limited by the movements of its host(s).	2 – 1-10km
Genetic diversity	Small, isolated bumble bee populations with lower genetic diversity could be more affected by new diseases than large populations with high genetic diversity. The genetic diversity and isolation of bumble bee populations in the NWT is uncertain at	N/A

[97] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

	this time. Bumble bees are haplodiploid organisms with a type of sex determination that makes them extremely susceptible to extinction when effective population sizes are small. This means that as bumble bee populations decrease in effective size, the frequency of sterile males increases; their increasing proportion in smaller populations increases the rate of population decline causing an extinction vortex. This special form of genetic load is the largest known. In practical terms, if a bee population decreases to a few reproducing individuals, it is certain to become locally extirpated even under stable environmental conditions, unless its number increases within a few generations. A genetic study of the yellow-banded bumble bee in southeastern Canada has shown that it is experiencing inbreeding where its populations have declined and this may contribute to an increase in diploid male production and further declines (ECCC).	
Phenotypic plasticity		N/A

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	**Overall level of concern**
1. Residential and commercial development								
1.1 Housing and urban areas	Urban development can lead to natural bumble bee habitat loss, but private/public gardens and green spaces in developed areas can provide resources for bees, especially when large and containing native plant species.							**Neg.**
1.2 Commercial and industrial areas	Commercial development (factories and other commercial centers) can lead to natural bumble bee habitat loss; these are typically located within urban areas and are considered along with threat 1.1.							**Neg.**
1.3 Tourism and recreation areas	Recreation developments (ski areas, golf courses, campgrounds, resorts, etc.) can lead to natural bumble bee habitat loss. These types of developments are considered along with threat 1.1 as they are typically located in urban areas (and most are also uncommon in the NWT).							**Neg.**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops	Non-timber agriculture is a small sector of NWT commerce and does not involve large commercial monocultures in the NWT. Land use for agriculture is minimal in the thus has had minimal impact on wildlife and wildlife habitat to date. The number of farms/amount of farm land used in the NWT is relatively stable but may gradually increase in the future. The GNWT recently produced a strategy for growing this sector, but it is long term (>10 years) and focused on smaller-scale local food production and production in greenhouses, so is unlikely to have a major impact.							**Neg.**
2.2 Wood and pulp plantations	Not applicable. Zero hectares of forests were replanted/seeded in 2016.							**N/A**

2.3 Livestock farming and grazing	Livestock can modify habitat by reducing floral resources and cause soil compaction. Livestock farming or ranching is very uncommon in the NWT.							**Neg.**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling	A number of shale gas and oil wells were drilled in the central Mackenzie Valley between 2012-2015, but no commercial production resulted and there has been no activity since 2015. Natural gas production is limited to Norman Wells and Ikhil and accounts for <1% of national production.							**Neg.**
3.2 Mining and quarrying	Mining and quarrying could cause considerable local damage to bumble bee habitat, by altering topography, removing native plants and fragmenting landscapes. Diamond and gold mining are historically important industries in the other mineral/elements are mined as well. The vast majority of mines and deposits are located in the central/southeast, though other major projects are found along the western border. Although mining has been fairly stable, it might be expected to grow in the future.							**Neg.**
3.3 Renewable energy	The construction of wind and solar energy farms can damage bumble bee habitat. Wind turbines are known to cause significant insect mortality, but the proportion of bees affected relative to other insects is not known. The colour of wind turbines can be an attractant for many pollinators, including bees. Renewable energy is not currently a significant sector in the NWT: solar and wind power generation is largely limited to personal use or for powering individual buildings. Wind energy is currently only 4% of the NWT's energy use but the government is actively seeking opportunities to expand wind, solar and geothermal energy use in the territory. Solar and wind farms could potentially add or replace usable habitat for bumble bees: floral resources could be affected if terrain is covered with gravel, but land clearing could provide open							**Neg.**

	nesting habitat.							
4. Transportation and service corridors								
4.1 Roads and railroads	In general, roads represent sources of habitat fragmentation and disturbance. They can isolate populations, disrupt natural ecological process and cause avoidance behaviour, in addition to resulting in road kills where vehicles are present. For insects, it is clear that roadways can result in localized mortality (as evidenced by the state of vehicle windshields) and there is some indication that roadways can result in some degree of avoidance behaviour (although this is associated with species that do not fly). On the other hand, roadsides are often rich sources of plant species and may serve to create additional forest edge habitat. It has been noted that species that move along roadways (versus across) are likely benefitted by higher road density. In the NWT, the total extent of existing roads in the NWT is not significant. Additional projects are underway or anticipated. These activities will add to the total length of roadways in the NWT, which may have some impact on bumble bees. However, the disturbances caused by corridors will be fairly localized and the amount of undisturbed land nearby will remain significant. Roadways will also increase the risk of bees being killed by moving vehicles, but traffic volumes are expected to be low and it is uncertain what impact road kills might have on bumble bee populations.							**Neg.**
4.2 Utility and service lines	In general, linear disturbance represents a source of habitat fragmentation and disturbance. It can isolate populations, disrupt natural ecological processes and cause avoidance behaviour. However, most utility corridors are placed along existing roadways/right-of-ways.							**Neg.**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**

5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	Bumble bees collected for scientific surveys are not collected in numbers sufficient to disturb natural population dynamics or cause local extirpations/extinctions and collections are important for documenting species presence and distributions. Hunting of other terrestrial animals is done on a small, local scale and mostly for personal or community consumption, with minimal impact to natural habitats, other than some trapping or damage of terrain along access routes (on foot, by ATV, etc.).							**Neg.**
5.2 Gathering terrestrial plants	Berry plants and others are harvested by residents, but not at a scale expected to impact bee populations. As generalists, many alternative nectar sources are available in the unlikely event that a food plant species is locally extirpated from over-harvested. Natural plant resources are traditionally well managed and not over-exploited.							**Neg.**
5.3 Logging and wood harvesting	Timber harvesting can disturb or fragment habitat. Logging in the NWT is mostly small scale, family-run and local: individual operations harvest 500-10,000 m^3 per year and total annual yields of lumber have been stable for the past decade. The most productive areas are along flood plains of major rivers. There are some new initiatives to develop the wood pellet industry; some communities may explore this as an option for employment opportunities. Five-year timber harvesting permits have recently been issued in the Fort Providence and Fort Resolution areas, with expected harvests of 1,000-1,200 hectares/year.							**Neg.**
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and								**N/A**

military exercises								
6.3 Work and other activities	Relevant aspects of this threat have been covered in threats 6 and 7.							**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression	Fires are extremely common in NWT forests (about 274/year between 1988-2008), with 600,000 hectares affected annually. The annual total area burned fluctuates each year, but a weak trend indicates a slight reduction in both total area burnt and the number of fires larger than 200 hectares between 1988 and 2008. It is predicted that climate change will result in an increase in the frequency and intensity of fires, due to hotter, drier summers that provide a longer fire season. All three species are known to nest near forests and open areas by forest edges may be particularly valuable habitat. Fires can reduce available nesting habitat for ground-nesting bumble bees 20 years or more after a burn and fires often lead to dense regrowth of shrubs and grasses, reducing the amount of unvegetated (open) nesting habitat. Gypsy cuckoo bumble bees would be similarly negatively affected, due to the loss of nesting habitat for their hosts. As such, unmanaged wildland fires could be a potential future threat for all three species, since fire frequency and intensity is expected to increase over time with climate change. However, all three species are also known to display considerable flexibility in choosing nesting and foraging habitats and are able to travel considerable distances; they could therefore reasonably be expected to adapt to the use of alternate habitats after a fire in a particular locality.	W	U	S	N	H	L	**Low**
7.2 Dams and water management/use	There are three major hydroelectric facilities in the NWT: Snare Group, Bluefish and Taltson. Flooding has occurred around dams in the NWT and can destroy wildlife habitat, but the bumble bees' habitat is not generally associated with land adjacent to water bodies.							**Neg.**

7.3 Other ecosystem modifications	The only known host of the gypsy cuckoo bumble bee (yellow-banded bumble bee) is still present in the NWT and has been collected as recently as 2007. However, its recent relative abundance (2007-2017) is only 5.5%, down from 7.6% in historical records, although historical records are few. A possible (but unconfirmed) host, cryptic bumble bee has stable populations in North America and is widespread in the NWT. The western bumble bee may also be a suitable host, but no overlapping distributions have been recorded. Decline in host species is the most serious plausible threat to gypsy cuckoo bumble bee in the NWT. The fact that gypsy cuckoo is still common and stable in Europe (where its hosts are common and not declining) suggests that the swift decline of this species in south and eastern North America is primarily related to the decline of its particular hosts, rather than the direct effects of habitat loss. In North America, the rapid decline of members of the subgenus *Bombus* appears to have begun in the mid-1990s (ECCC).	W	H	S	LT F/ NE	L	M	**Low (GCBB)** **N/A (YBBB, WBB)**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases	Non-native honey bees (*Apis mellifera*) are present in the NWT. The total number of colonies in the territory, their origins and their current distribution is unknown. No formal surveys of beekeepers or colonies in the NWT have been performed. There is some level of beekeeping taking place in Hay River, Yellowknife, Fort Smith, Inuvik and Norman Wells and perhaps also Gamètì. There is a strong interest in beekeeping in the NWT based on attendance and interest in a recent Bee Health Symposium in Yellowknife. Additionally, the GNWT has named honey as a potential commercial opportunity. Honey bees are known to compete directly with native bumble bees, including *B. occidentalis*, reducing the foraging and reproductive success of the native species. A potentially problematic non-native species is the common	L	M	S	N	H	L	**Low**

	eastern bumble bee (*Bombus impatiens* Cresson 1863). This species is used in greenhouses and field crops for pollination. Escaped colonies compete with native bumble bees for habitat, or spread disease. According to the COSEWIC report on *B. terricola*, *B. impatiens* may already be used in the NWT for commercial pollination services, but no substantiating documentation was available when this report was prepared. The greenhouse in Inuvik has been bringing in bees for pollination each year, but these appear to be blue orchard mason bees (*Osmia lignaria*) and it appears as though reproduction has not been successful (no new cocoons). Although beekeeping and commercial pollination activities in the NWT are small and localized at present, there is a strong interest among the public in beekeeping for honey and pollination and support from the GNWT to pursue these activities under the NWT Agriculture Strategy.							
8.2 Problematic native species/diseases	No native plants or animals are known to be problematic (e.g. as predators, disease vectors, etc.) for bumble bees in the NWT. There is little evidence that predators are responsible for bumble bee population declines.							**N/A**
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin	Fungal and other pathogens are widely implicated in the decline of North American bumble bees. It is presumed that "pathogen spillover" is to blame. Pathogen spillover is strongly associated with commercially reared honey and bumble bee colonies. An aggressive and virulent strain of the microsporidian pathogen *Nosema bombi* is found in many declining bumble bee species, including wild and commercially-reared colonies of *B. terricola* and *B. occidentalis*. The fungus' high rate of transmission and impacts are likely significant. Commercially-reared bumble bee nests of	L	M	C	LTF	M	L	**Low**

	several species have been found to harbour other parasites, including *Crithidia bombi* and *Locustacarus buchneri*. There are no studies to confirm if these pathogens are present in the NWT. Declining bumble bee populations tend to have a high prevalence of pathogens. Interestingly, both subspecies of *B. occidentalis* have similar levels of parasitism (about 40%), but *B. o. mckayi* may be more stable than *B. o. occidentalis*. Since commercial bumble bee colonies are not widely used in the north, these relatively high levels of infection may be natural and not caused by pathogen spillover. If these infection levels are indeed natural, *N. bombi* and other pathogens may not have the same effect on northern bumble bee populations as they do in the south, perhaps because other threats that increase their susceptibility to infections are not concurrent or as prevalent in the north. Fungal pathogen prevalence in bumble bees is associated with large-scale agricultural/commercial fungicide use; this is not a significant factor in the NWT. Many other microsporidian pathogens exist worldwide and the potential of these to cause additional disease epidemics in bumble bees is uncertain. Small, isolated populations with less genetic diversity could be more affected by new diseases than large populations with high genetic diversity. Beekeeping, especially increased use of commercial bee colonies in the NWT, if it occurs, could increase the chances of this potential future threat.							
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								

9.1 Domestic and urban wastewater	Not applicable. This is the most common type of waste spilled in the NWT, in frequency of spills and in volume (93%). Effects on bumble bees, if any, are unknown. Probably not a threat.							**N/A**
9.2 Industrial and military effluents	Petroleum products degrade slowly and can be hazardous to plants and wildlife. Most communities in the NWT rely on fuel for heating and energy, which they receive via tanker trucks if they are accessible by roadway. Oil spills are a concern. The Enbridge Norman Wells Pipeline, which runs alongside the Mackenzie River from Norman Wells to Alberta, was shut down in 2016 because slope instability created concerns about pipe failures and environmental contamination. It has not been repaired and the line remains closed. Until very recently, there were concerns about the effects of the Mackenzie Valley Pipeline project on natural habitats. Although the project was approved by federal cabinet in 2011, it was abandoned by Imperial Oil in late December 2017. Regardless, it is not inconceivable that the project could be revived. Most oil spills in the NWT are small (<100 L). In the mining industry, discharges from tailing ponds, waste rock, exposed rock and accidental mill tailings spillage are pollutants that can be taken up by plants and animals. The effects of these effluents on bumble bees in unknown, but they are a continuous threat.							**Neg.**
9.3 Agricultural and forestry effluents (including erosion)	Not a current threat. In the NWT, permits are required for non-domestic pesticide or herbicide use. There may be active permits in Fort Simpson, within the range of all three species; however, pesticides are generally only used in buildings. Herbicides are occasionally used; for example, along railway corridors and at certain locations along the Enbridge pipeline. Agricultural effluents with the greatest potential threat to bumble bees are pesticides, particularly neonicotinoids as they are harmful to wild bumble bees even at small concentrations. These pesticides are systemic and spread through the plant to pollen and nectar. Pesticides have been globally implicated in pollinator declines. However, agriculture in general and plant production in particular is an extremely small							**N/A**

	sector in the NWT so this is not expected to be a threat.							
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	With climate warming, summers begin earlier and end later, extending the length of the active season for bees. A longer active season could be positive for bumble bees if food resources are available when queens emerge to establish new colonies in spring, but if there is a timing mismatch with floral resources, the effects could be devastating. Loss of permafrost may also impact bumble bee habitat, through changes to water regimes/storage, vegetation cover and soil drainage. Also, as temperatures have warmed, low shrub cover above the treeline has expanded and become more robust. Since the three bumble bee species of interest appear to have affinities for habitat adjacent to forests, changes to forest habitat will likely have an impact on them. These effects may be positive or negative, depending on whether forests expand or contract, create or reduce forest edge habitat and whether they enhance or displace flowering plant communities. Encroachment is likely occurring fairly rapidly and effects are expected to continue in the next ten years.	W	H	S	N-LTF	H	L	**Medium**
11.2 Droughts	Droughts may have an impact on bumble bees' water availability	L	U	S	N-	M	L	**Low**

	and floral resources. Drought is also associated with increased forest fires, the number and intensity of which are expected to increase in the changes to soil moisture and other properties, which could affect quality or availability of nesting and hibernacula sites. Drought conditions have been a problem in parts of the NWT in recent years.				LT F			
11.3 Temperature extremes	Bumble bees are generally considered adapted to cool temperate climates in the northern hemisphere, including arctic, subarctic and boreal regions. Arctic temperatures are rising faster than the global average. The entirety of the NWT is expected to be affected by climate change, although some regions may warm more quickly than others. There have been a number of extended heat waves in the NWT in the past decade and the frequency and intensity of extreme summer temperatures (>30°C) is expected to increase across the NWT. High temperatures have been implicated in local bumble bee extirpations in Europe, including in Finland following a heat wave with a maximum temperature of 33°C. The lethal effects of heat waves may be the result of a number of factors, including the severity of the heat wave, the duration of the heat wave, water loss, or starvation. Individual heat waves are not expected to be a threat to all bumble bees within their entire NWT distribution. Because of their heat intolerance and limited northern distribution, we can probably expect to see the distribution of *B.o.mckayi* decline. However, yellow-banded and gypsy cuckoo bumble bees have widespread distributions in North America that extend down into the north/central east coast of the United States. Presumably, these two species are more likely to tolerate periods of heat and wider temperature ranges than the western bumble bee.	L	L/ M	S	ST F	H	M	**Low (GCBB and YBBB)** **Med. (WBB)**
11.4 Storms and flooding	Flooding may directly impact ground-nesting bees in floodplains or other low-elevation areas, either from immersion or increased susceptibility to mold. Some large-scale flooding has taken place in the Mackenzie River valley, Aklavik and Fort Good Hope, as well as near Fort Providence and in the Slave River delta in the last five	L	U	S	ST F	H	M	**Low**

	years.							
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Canada Warbler (*Wilsonia canadensis*)
Populations (if applicable): N/A
Percentage of North American population NWT is responsible for: Occurs in all provinces and territories except NU and NL and Labrador. Breeding range in the NWT is in the southwest corner of the territory, from Fort Simpson in the north to Fort Liard. High densities have been reported in this area (0.65 pairs/ha).
NWT General Status Ranks: Undetermined
NatureServe Conservation Rank (NWT): N/A
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Threatened
Reasons for assessment or population trends: Most (80%) of the breeding range of this species occurs in Canada. While regional trends may vary, overall, the species has experienced a significant long-term decline. This decline is particularly evident in the case of the species' Canadian range and there is no indication that this trend will be reversed. The reasons for the decline are unclear, but loss of primary forest on the wintering grounds in South America is a potential cause.
Sources used for assessments: COSEWIC (2008a), Environment Canada (2016), Ferrari et al. (2018).

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[98] = 2.3		
Dependence on habitats that are sensitive to climate change[99]	In its breeding range, the Canada warbler uses a wide range of deciduous, coniferous and mixed forests, with a well-developed shrub layer and a structurally complex forest floor. It is most abundant in moist, mixed forests. It also occurs in riparian shrub forest on slopes and in ravines, in stands regenerating after natural and anthropogenic disturbances and in old-growth forests with canopy openings and a well-developed shrub layer. The Canada warbler requires a well-developed shrub layer in its breeding habitat. The breeding range is expected to see increases in temperature as climate change progresses (Lee pers. comm. 2020).	2 – Generalist, but some sensitive habitats are important

[98] Overall sensitivity score is based on average of habitat, abiotic and biotic factor scores.
[99] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	During migration, the Canada warbler occurs in woodlands, typically with a dense and brushy understory, often near watercourses. These might include swamp forests (Ohio), forested areas along watercourses (Minnesota), thickets near water (Texas), low- to mid-story vegetation within humid forests from sea level up to 2,500 m elevation (Mexico) (Roberto-Charron pers. comm. 2020). In its wintering range, the Canada warbler uses primarily mature cloud rainforests located at an altitude of 500-2,500 m, as well as second-growth forests, forest edges, coffee plantations, agricultural field edges and semi-open areas. Migratory bird species that travel long distances are particularly sensitive to the impacts of climate change because any change along the route could negatively impact the population. There is little information to directly link climate change to the current population decline of Canada warbler, but it has been suggested that there's a large potential for avian distributional shifts in response to climate change (Environment Canada 2016).	
Sensitivity to climate-relevant abiotic factors[100]	No physiological tolerance limits noted in status report. However, increases in adverse weather conditions associated with climate change (e.g. heavy rain, extreme temperatures and intense wind storms) could result in higher nest failure and direct mortality throughout the range. These conditions could also create thermoregulation problems for adults and young, disrupt migration and damage wintering habitat (Environment Canada 2016).	2 – Somewhat sensitive or possibly very sensitive.
Sensitivity to climate-relevant biotic factors[101]	Reduced availability of insect prey as a result of temporal mismatch is a concern for this insectivorous species. Birds often exhibit a strong synchronization between their reproductive timing (i.e., hatching) and peak food abundance, but climate change has caused the timing of peaks in some insects to advance. Because warming is less severe in wintering areas than in their breeding grounds, they may experience migration cues at dates that are too late for them to	3 – Likely very sensitive.

[100] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.
[101] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

	arrive at breeding grounds at the optimal time. As a result, climate change is creating a temporal mismatch between reproduction and maximal prey abundance for species that are not adapting to the changing climate at the same rate as their prey. Populations of migratory birds that exhibit long-distance migrations and breed in seasonal habitats are more vulnerable to climate change because the temporal mismatch is more likely and more severe. Although no species-specific data are currently available, Canada warbler is an insectivore, migrates long distances and breeds/forages in seasonal habitats, so a climate-induced mismatch between breeding and prey availability is certainly plausible (Environment Canada 2016).	
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	Deforestation, often intensive, associated with agriculture, forestry, development and urbanization is an important threat in large areas of the range. Collisions with buildings and communications towers, pesticide use and domestic cat mortality are also concerning. These threats are not seen in a significant manner in the NWT, however.	1 – No pressures.
Adaptive capacity[102] = 1 plus 0.5 for genetic diversity (trailing edge) = 1.5		
Reproductive capacity[103]	Typically, monogamous laying four to five eggs. One clutch is produced annually. The generation time is estimated at two to three years, taking into account the species' age at first breeding (one year) and maximum lifespan (eight years). Adult survival is considered low. Compared to other warblers, Canada warbler tends to arrive late on breeding grounds, begin fall migration early and exhibit a rapid and compressed migration. Canada warbler's residency on the breeding grounds is brief compared to other warblers, placing particularly strong constraints on the duration and timing of breeding and timing of migration. This factor reduces the possibility of producing more than one clutch per season and adapting to climatic changes, thereby limiting the species' ability to respond to threats and possibly recover from such threats once they are alleviated (Environment Canada 2016).	1 – Early reproduction/many offspring

[102] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.

[103] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.

Dispersal capacity[104]	Species is a long-distance migrant. Average territory sizes range from 0.4-2 hectares. Adaptable to some habitat fragmentation. No indication of strong tendency towards site fidelity.	1 - >10km
Genetic diversity	See Ferrari et al. (2018). Canada warblers demonstrate trailing edge populations in the southern portion of its range. Trailing edges may harbour high levels of genetic diversity and unique genetic variants. They may also be at risk of extinction from climate change.	0.5
Phenotypic plasticity		N/A

[104] Dispersal distances are taken from maxima noted in sources. For many species, these are extrapolated from species of similar size; a reasonable assumption. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas	Intensive deforestation in Canada warbler's wintering areas has been suggested as an important threat, although this conclusion is generally based on the intense levels of deforestation in these areas, rather than a direct-causal relationship between the Canada warbler population and this threat. The ultimate causes of deforestation have been identified as human encroachment, increased pasture area, conversion of shade coffee to sun-tolerant coffee, timber harvest, plantations of native fruits, other agricultural activities and monocultures (Environment Canada 2016). Habitat loss has been observed in the eastern part of its breeding range, where wet forests have been drained for urban development and forest converted to agricultural land. During their nocturnal migration, Canada warblers can collide with man-made structures such as buildings, communications towers, power lines and wind turbines. Even if such kills are episodic, they may be significant at the population level. Canada warblers are considered to be highly vulnerable to collisions with buildings, including low-rises, high-rises and communications towers (Environment Canada 2016).							**Neg.**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								

2.1 Annual and perennial non-timber crops	See 1.1. In 1991, it was determined that the forested area in the northern Andes (Peru, Ecuador and Colombia) had declined by approximately 90% from its historical levels and by 1998, an estimated 69% of the Andean forests in Colombia were cleared for agriculture. Although there have been some local gains over the past decade, continued loss of forested areas within the range of this species are continuing (particularly in Colombia). There has also been substantial forest loss between 2000-2012 throughout large portions of the migratory range, particularly in Central America (Environment Canada 2016). In the western part of the range, boreal mixed-wood forest has been converted to agriculture, potentially decreasing the amount of Canada warbler habitat (SK, Manitoba, AB).							**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing	See 1.1. Uncontrolled grazing by cattle has also contributed to the degradation of forest habitat in the migration, wintering and breeding range. Cattle grazing occurs along the boreal fringe of western Canada (primarily in aspen forests) in areas that might otherwise be suitable for Canada warbler. The effects of cattle grazing on the habitat depend on the timing, duration and soil properties (Environment Canada 2016). Cattle grazing could have an impact as it impacts the shrubby understory (Roberto-Charron pers. comm. 2020).							**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling	Forests in western Canada are being lost due to permanent conversion by activities such as oil and gas drilling, mining, pipelines, transmission lines and roads. These activities can cause substantial habitat loss, degradation and fragmentation in localized areas. Activities associated with these industries can also lead to							**N/A**

	unintentional destruction of nests, eggs, nestlings and/or adults. Energy extraction and mining can alter local hydrological regimes and soil moisture by direct water removal (e.g. for fracturing) and hydroelectricity facilities (e.g. dams). Because Canada warblers are more abundant near riparian corridors throughout their range and are known to breed in forested swamps, bogs and near open water in their eastern range, they would likely be affected by changes in hydrological regimes. The construction of wells, pipelines and seismic lines is especially prevalent in northern AB and northeastern BC (Environment Canada 2016).							
3.2 Mining and quarrying	See 3.1. Mining activities occur across the Canadian range of Canada warbler. The provinces/territories that have the most boreal forest zone dedicated to mineral leases and are within Canada warbler's range include AB, ON and Manitoba. The level of impact resulting from these industries on Canada warbler's population is unknown (Environment Canada 2016).							**Neg.**
3.3 Renewable energy	During their nocturnal migration, Canada warblers can collide with man-made structures such as buildings, communications towers, power lines and wind turbines. Even if such kills are episodic, they may be significant at the population level (Environment Canada 2016).							**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads	See 3.1. The occurrence of Canada warblers is negatively affected by the proximity and length of paved roads in forested landscapes. Road development may be a particular threat to Canada warblers breeding in the boreal mixed-wood forests of northern AB, where a significant increase in road development associated with industrial development is expected until 2030. Habitat loss is also associated with pipeline developments and road construction in the northern Andes.							**Neg.**
4.2 Utility and service lines	During their nocturnal migration, Canada warblers can collide with man-made structures such as power lines. Even if such kills are episodic, they may be significant at the population level							**Neg.**

	(Environment Canada 2016).							
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals								**N/A**
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting	See 1.1. The Canada warbler requires a well-developed shrub layer in its breeding habitat. Given this, it exhibits a certain degree of adaptability to human disturbances such as forest harvesting. The species occupies forests regenerating following harvesting, particularly stands between six-20 years post-harvest in the east and 20-30 years post-harvest in the west. This is presumably because the shrub layer peaks during early regeneration stages. Canada warbler also appears to be relatively tolerant to the habitat fragmentation that results from forest harvesting. Forests in western Canada are believed to be in decline due to their permanent conversion by logging, road construction, oil and gas drilling and other industrial infrastructure. 70% of stands more than 90 years old in northwestern Canada have already been harvested and converted to plantations by forestry activities. Models developed to predict the cumulative impacts of current industrial development (including forestry) planned in northeastern AB indicate that, at the current rate of development, old-growth stands of softwoods would be eliminated within 20 years and old-growth stands of hardwoods within 65 years. Even under a management scenario involving the application of best practices, a major decline in old-growth stands is also predicted. Although the loss of old-growth forests may be offset by stand regeneration, post-treatment silvicultural practices that reduce the	L	L	S	N	H	M	**Low**

	shrub layer could adversely affect the quality of Canada warbler habitat in these areas. There are limited logging and forestry activities in the NWT, particularly in the Liard River valley (Roberto-Charron pers. comm. 2020). Forest harvesting in general, can have short term negative impacts on nesting birds by disrupting breeding activities. The nests and/or eggs can be inadvertently harmed or disturbed as a result of clearing trees and other vegetation (e.g. pre-commercial thinning). Nesting failure could also result from disruptive activities experienced by a nesting bird (Environment Canada 2016).							
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression	The Canada warbler occupies stands recovering from fire, although the species is less abundant in stands regenerating from fire than those regenerating from harvest. This relates to habitat composition following fire v/ harvest (Roberto-Charron pers. comm. 2020).	W	L	S	N	H	L	**Low**
7.2 Dams and water management/use	See 3.1.							**N/A**
7.3 Other ecosystem	Insect populations are exhibiting significant declines worldwide. These declines are considered a global pattern, but are more severe	W	H	S	ST F	M	L	**Low**

modifications	in heavily disturbed locations. Causes of the declines in insects include loss of insect-producing habitats (e.g. wetland drainage, peat extraction, intensive agriculture, wetland destruction, industrial activities, urban development, forest fragmentation), prey-breeding temporal mismatch, habitat acidification and pesticides (organochlorine pesticides, biological insecticides, neonicotinoids). Reductions in available insect prey in breeding, migratory and/or wintering areas has been implicated as a contributing factor in the declining population trends in aerial insectivores in general. Although Canada Warbler is not an aerial insectivore, it primarily forages on insects and therefore the effects of changes in insect availability may be similar to those suspected for aerial insectivores (Environment Canada 2016).							
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases								**N/A**
8.2 Problematic native species/diseases	Grazing by forest ungulates, such as white-tailed deer, that reduce the shrub layer, may reduce the quality of Canada warbler habitat in localized regions. Deer populations are increasing throughout the southern range of Canada warbler. At present, the level and extent to which this threat is affecting the Canada warbler population is uncertain, but it would be most prominent in the northeastern United States and southeastern Canada where white-tailed deer are particularly abundant (Environment Canada 2016). Domestic and feral cats are the largest source of human-related mortality of birds in Canada. An estimated 2-7% of all birds in southern Canada are killed by cats annually. This is less of a concern in northern areas and within interior forests (Environment Canada 2016). Parasitism and predation may be of particular concern to Canada	L	L	S	LTF	M	L	**Low**

	warbler during breeding because it lays a single brood (Environment Canada 2016).							
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents	Long-range atmospheric transport and deposition is the dominant source of mercury to many aquatic habitats over much of the landscape. Bio-available mercury is also mobilized within watersheds by forestry activities, hydroelectric reservoir creation and various industrial-related activities. Mercury concentration increase from west to east across Canada in freshwater food webs. Mercury exposure can decrease reproductive success, alter immune responsiveness and cause behavioural and physiological effects in birds. Mercury may be biomagnifying in terrestrial songbirds that eat invertebrates (Environment Canada 2016). Acid precipitation has been identified as a contributing factor in the decline of spruce-fir forests through the eastern United States and this is presumably occurring in Canada as well. Acidification may modify habitat leading to altered soil invertebrate assemblages, loss of favoured nesting and/or foraging sites, increased vigilance and incubation and increased predation risk. Acidification also contributes to the leaching of calcium from soils. As passerines obtain calcium from their food during the egg-laying period,							**Neg.**

	calcium deficiency during this period may lead to birds laying eggs with shells that are thin, weak and more porous, which can lead to breeding failure. Although there is no direct evidence for Canada warbler, acidification of its breeding habitat could negatively affect the species (Environment Canada 2016).							
9.3 Agricultural and forestry effluents (including erosion)	Although largely undocumented for this species, pesticide use on both breeding and wintering grounds has been implicated in direct mortality and habitat loss of many avian species. There is some indication that neotropical migrant insectivores are still being exposed to organochlorine pesticides in North America. This may be legally through exceptions in the restriction laws, or illegally. These pesticides may still be in used in Central and South America for nuisance mosquito control and agricultural and other applications. Organophosphorus/organophosphate and carbamate compounds have been used increasingly since the majority of organochlorines were restricted in North America in the 1970s and banned in the 1980s. Birds and other vertebrates are sensitive to these pesticides if they ingest or otherwise absorb enough of it. The direct impacts of neonicotinoids are unknown for insectivorous species such as Canada warbler. The exposure of Canada warbler to neonicotinoid pesticides is unknown, but given its habitat preferences, is probably low on its breeding grounds even given the pesticide's mobility and persistence in the environment. In wintering habitat, coffee plantations are known to use high levels of pesticides and have associated run-offs. It is unknown how these may affect Canada warbler (Environment Canada 2016). In the NWT, permits are required for non-domestic pesticide or herbicide use. There may be active permits in Fort Simpson; however, pesticides are generally only used in buildings. Herbicides are occasionally used; for example, along railway corridors and at certain locations along the Enbridge pipeline. Agriculture in general and plant production in particular, is an extremely small sector in							**Neg.**

	the NWT.							
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)	See 1.1. Light pollution is a major concern for migratory birds.							**Neg.**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides	Some populations may be affected by geological events, specifically breeding populations in Appalachians (Roberto-Charron pers. comm. 2020).							**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Migratory bird species that travel long distances are dependent on multiple, spatially disparate, habitats during their annual cycle (breeding, migration and wintering). This makes them particularly sensitive to the impacts of climate change because any change along the route could negatively impact the population. There is little information to directly link climate change to the population decline of Canada warbler, but it has been suggested that there's a large potential for avian distributional shifts in response to climate change (Environment Canada 2016). See 7.3 for discussion about insect availability and temporal mismatches developing as a result of climate change.	W	U	C	N-LTF	H	L	**Low**
11.2 Droughts	Fire activity is strongly influenced by weather and the extent, intensity and frequency of forest fires are projected to further increase because of warmer and drier springs and summers (Environment Canada 2016). Instances of drought conditions will also likely affect Canada warblers, given their preference for water	L	U	S	ST F-LTF	M	L	**Low**

	features when selecting breeding sites (Roberto-Charron pers. comm. 2020).							
11.3 Temperature extremes	The increased frequency of adverse weather conditions (including extreme temperatures) caused by climate change could result in higher nest failure and direct mortality throughout Canada warbler's annual cycle. This may also create thermoregulation problems for adults and young and affect prey availability (Environment Canada 2016).	L	M	S	LT F	H	M	**Low**
11.4 Storms and flooding	The increased frequency of tropical storms and other adverse weather conditions (e.g. heavy rain, intense wind storms) caused by climate change could result in higher nest failure and direct mortality throughout Canada warbler's annual cycle. Severe weather could also reduce foraging opportunities, create thermoregulation problems for adults and young, disrupt migration and damage wintering habitats.	L	M	S	LT F	M	M	**Low**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Collared Pika (*Ochotona collaris*)
Populations (if applicable):
Percentage of North American population NWT is responsible for: This small rabbit-relative is a Beringian relict that is restricted to talus slopes in alpine areas in northwestern BC, YT and NWT. This region comprises over half the global range of this species. Outside of Canada, collared pikas occur in southern and central Alaska. The NWT accounts for 25% of the national range of collared pika and 14.1% of the global range.
NWT General Status Ranks: Sensitive
NatureServe Conservation Rank (NWT): S3
***Species at Risk (NWT) Act*:** Not assessed
***Species at Risk Act* (Canada):** Special Concern
Reasons for assessment or population trends: Their Canadian range is witnessing climate-driven shifts in habitat, temperature and precipitation at faster rates than elsewhere in Canada. A demonstrated sensitivity to climate variability, coupled with poor dispersal ability and the naturally fragmented nature of its populations, heightens the vulnerability of this small mammal to climate change. The species is well-studied in a very limited portion of its range, but baseline information on population trends at the range level and a clear understanding of the extent and severity of climate impacts to this species and its habitat in the coming decades is limited. However, the best available information suggests that this species may be particularly sensitive to a changing climate, including concomitant increases in precipitation variability, leading to reductions in habitat availability. The potential negative impacts of climate change to the persistence of this species over the long term is substantial.
Sources used for assessments: COSEWIC (2011b)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[105] = 2.7		
Dependence on habitats that are sensitive to climate change[106]	Collared pika is a Beringian relict species that is specialized (restricted) to talus slopes in alpine areas in northwestern BC, YT and NWT. This region is witnessing climate-driven shifts in habitat, temperature and precipitation at faster rates than elsewhere in Canada. Loss of suitable alpine habitat	3 – Depends on sensitive habitats that are not rare.

[105] Overall sensitivity score is based on average of habitat, abiotic and biotic factor scores.
[106] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	may occur through (a) changes in the species composition of alpine vegetation communities, (b) a direct loss of habitat due to treeline advance, or (c) climate becoming physiologically intolerable. A loss of alpine habitat would increase distances between suitable patches, possibly reducing gene flow, rescue effects and regional persistence. The extent and configuration of talus patches that characterize collared pika habitat have not likely changed since historical times and are not likely to be affected by a changing climate.	
Sensitivity to climate-relevant abiotic factors[107]	Collared pikas have a demonstrated sensitivity to climate variability, including concomitant increases in precipitation variability, leading to reductions in habitat availability. Annual survival has been linked to both winter climate and the timing of spring haypile initiation. Collared pika densities are generally higher on south-facing slopes, likely due to higher primary productivity and lower annual snow cover. North American pikas have several physiological characteristics that make them well-adapted to cold environments but limit their ability to cope with excess heat (higher basal metabolic rate than predicted by models and lower thermal conductance than predicted based on body size). Their low thermal conductance allows them to maintain their normal body temperature during cold months with a minimal expenditure of energy. However, their upper lethal body temperature is 43°C and death can occur after two hours of exposure to an ambient temperature of 28°C. Without access to shade, the limits of ambient temperature may be as low as 25.5°C. However, behavioural thermoregulation is likely (remaining below the talus during hot periods). Collared pikas use habitat that provides microclimate conditions that can ameliorate weather extremes, but creating cool and moist refugia in summer months and insulation in winter.	3 – Likely very sensitive.
Sensitivity to climate-relevant	Collared pikas are generalist herbivores. They live in spatially fragmented alpine habitats and demonstrate	2 – Somewhat sensitive or possibly

[107] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

biotic factors[108]	dynamics characteristic of a classical metapopulation. The expected consequence of climate-related habitat changes would likely alter metapopulation structure and ultimately regional persistence.	very sensitive.
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	Due to the remote nature of its range in Canada, direct disturbance to collared pika habitat and populations has been minimal and is expected to remain so in the coming decades. The principal threat that has the potential to impact the persistence of this species is climate change.	1 – No pressures.
Adaptive capacity[109] = 1.5 plus 0.5 for low genetic diversity = 2		
Reproductive capacity[110]	Pikas are considered sexually promiscuous. They become sexually mature after their first winter and, after a 30-day gestation period, produce a litter of three to four offspring. Juveniles emerge to the surface 30 days later and disperse within days. Pikas generally do not live longer than four years and generation time is just over two years. Their growth rates are among the fastest known for lagomorphs.	1 – Early reproduction. many offspring
Dispersal capacity[111]	Poor dispersal ability. They are rarely found more than 6-10 m from talus while they are foraging or haying. Dispersal by juveniles to find home ranges is a significant factor in terms of metapopulation dynamics and gene flow/population persistence. Long distance dispersal often requires them to cross lowland habitat that they generally avoid. Dispersal by juveniles may be as far as 2 km, but dispersal is more commonly no more than ~350-630 m from talus sites. Adults exhibit high site fidelity once a territory is established.	2 – 1-10km
Genetic diversity	Generally, alpine-dwelling pikas, such as the collared pika, typically disperse very short distances and their populations tend to be small and isolated. These factors can lead to the development of low levels of genetic diversity within populations and high levels of genetic differentiation among populations. Collared	0.5

[108] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).
[109] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[110] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.
[111] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

	pikas, however, do not display the degree of population genetic differentiation seen in its close relatives. One study found only a very small level of genetic divergence among collared pika populations in Alaska and YT suggesting a very recent population expansion had occurred. However, evidence from microsatellites indicated that they are not prone to frequent inbreeding and the population maintained its genetic diversity even after having undergone a significant decrease in density.	
Phenotypic plasticity		N/A

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas	Localized disturbances such as tourism activities may affect populations where they occur if modifications to the talus affect access to haypiles, reduce crevices used for shelter, increase predator abundance, or alter the vegetation along the talus edge. These activities could also negatively affect recolonization and maintenance of populations. Level of activity within the NWT not noted.							**Neg.**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**

3. Energy production and mining								
3.1 Oil and gas drilling								**N/A**
3.2 Mining and quarrying	Localized disturbances such as mineral exploration may affect populations where they occur if modifications to the talus affect access to haypiles, reduce crevices used for shelter, increase predator abundance, or alter the vegetation along the talus edge. These activities could also negatively affect recolonization and maintenance of populations. Level of activity within the NWT not noted.							**N/A**
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads	Localized disturbances such as road construction may affect populations where they occur if modifications to the talus affect access to haypiles, reduce crevices used for shelter, increase predator abundance, or alter the vegetation along the talus edge. These activities could also negatively affect recolonization and maintenance of populations. Level of activity within the NWT not noted.							**Neg.**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	They are valued by Indigenous people, in part, because they are traditionally hunted for food during extended excursions above treeline, where few other sources of meat are available. Harvest of collared pikas by non-First Nations is not known to occur in the NWT.							**Neg.**
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and								**N/A**

wood harvesting								
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression								**N/A**
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications								**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases								**N/A**
8.2 Problematic native species/diseases	Nothing outside of the normal reported. Competition among co-existing herbivores (e.g. hoary marmots, Arctic ground squirrels) is a possibility, but the effects on pika population dynamics are unknown. Collared pika are affected by a number of internal and external parasites, but the effects on survival, reproduction and population dynamics are unknown. Predation is not well understood, but likely predators include foxes and raptors. The snowshoe hare cycle is known to stimulate production of a large							**Neg.**

	surplus of young predators, many of which might be pika predators as well. Flushes in the population sizes of red foxes and ermines following snowshoe hare peaks and declines within collared pika range could put additional predation pressure on pikas in alpine areas.							
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents								**N/A**
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**

10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides	Avalanches do not normally occur in coarse talus, but when they do occur, landslides can both destroy and create pika habitat.	L	L	S	STF	L	H	**Low**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Collared pika range in Canada is witnessing climate-driven shifts in habitat, temperature and precipitation at faster rates than elsewhere in Canada. Clear understanding of the extent and severity of climate impacts to this species and its habitat in the coming decades is limited. Because pikas appear capable of substantial behavioural thermoregulation, the extent to which these changes would affect population dynamics is an open question. However, best available information suggests this species may be particularly sensitive to a changing climate, including concomitant increases in precipitation variability, leading to reductions in habitat availability. The potential of negative impacts of climate change to the persistence of this species over the long term is substantial. The most likely risks to collared pika persistence are related to the direct effects of temperature, moisture or weather conditions and habitat changes. Pikas survive best under cool, dry conditions and changes in either direction (i.e., high temperatures, or cold wet conditions) leave them susceptible to death through exposure. Loss of suitable alpine habitat may occur through (a) changes in the species composition of alpine vegetation communities, (b) a direct loss of habitat due to treeline advance, or (c) climate becoming physiologically intolerable. A loss of alpine habitat would increase distances between suitable patches, possibly reducing gene flow, rescue effect and regional persistence. The magnitude of these impacts is potentially high over the long-term but is fundamentally unknown due to lack of information on both baseline abundance and distribution and population-level	W	M	C	N	H	M	**Med**

	responses to projected changes. There is evidence in other regions that the alpine treeline has and is advancing upslope to encroach on alpine tundra habitat. Further, a pan-Arctic expansion of shrubs into formerly shrub-free tundra habitat appears to be occurring, the cause of which has been hypothesized to be warming growing season temperatures. Strong summer warming (>1.5°C) is occurring over parts of collared pika range for which weather data exists. Given the diet breadth of collared pika and lack of information on nutritional consequences of anticipated changes to vegetation communities, the population-level consequences are unknown, but are unlikely to be major in the next decade or two. Because of their sensitivity to temperature and moisture, distribution or abundance may respond prior to measurable changes in the alpine vegetation communities. Under warming scenarios, mountain permafrost probabilities in the region are predicted to decline progressively, with zonal boundaries rising in elevation. Modeling suggests a 20% to complete disappearance of permafrost if mean annual air temperature rises 1-5°C. The impact to collared pika would be indirect, via effects on vegetation communities; the nutritional consequences are unknown. Collared pikas may benefit from an early spring snowmelt due to earlier plant growth that results in improved foraging and caching opportunities. Insofar as American pikas are concerned, there is some suggestion that ecological niche models may overestimate future extinction risks. The Arctic climate impact assessment predicts precipitation increases for areas north of 60° (2071-2090). At the same time							

	however, warmer spring temperatures over western and northern Canada have resulted in widespread decreases in spring snow cover, as part of a hemispheric-wide trend of earlier melt of snow and ice. Despite increasing precipitation, temperature-driven increases in potential evapotranspiration are predicted to increase, leading to an overall drying effect across the landscape due to warmer temperatures and a longer growing season. Winter mortality (icing of food plant resources or exposure) would be expected to rise as a consequence of increasing frequency of winter precipitation falling as rain rather than snow. Winter freezing and thawing events in alpine and high latitude ecosystems are expected to increase in frequency due to climate change and increasing winter rainfall is already occurring in western North America.							
11.2 Droughts	Droughts are expected to increase in some parts of the NWT (Lee pers. comm. 2020). How this may impact collared pikas is uncertain.							**N/A**
11.3 Temperature extremes	Heat waves and/or extreme heat events are projected to increase. Although rare north of 60°, given the limited tolerance of collared pikas to heat, this could be concerning (Lee pers. comm. 2020).	W	M	S	STF-LTF	H	M	**Medium**
11.4 Storms and flooding	The effects of anticipated increases in storms and flooding across the NWT remains highly uncertain for collared pikas (Lee pers. comm. 2020).							**N/A**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Common Nighthawk (*Chordeiles minor*)
Populations (if applicable): N/A – 3 subspecies (*C.m. minor, C.m. hesperisand C.m. sennetti*), but without discrete genetic or morphological differences
Percentage of North American population NWT is responsible for: The species breeds throughout Canada, as far north as southeastern YT and southern NWT in the west and slightly north of the boreal shield in the east. It also breeds throughout the United States and locally south into Central America. It winters in South America. The Canadian population is about 10% of the global population.
NWT General Status Ranks: At Risk
NatureServe Conservation Rank (NWT): S2B
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Threatened (proposed for downlisting to Special Concern)
Reasons for assessment or population trends: This aerial insectivore is a widespread breeding bird across southern and boreal Canada. Its population in southern Canada has declined by 68% since 1970, but the rate of decline has slowed appreciably over the past decade and the species appears to be quite abundant in suitable boreal habitats. Concerns remain over the effects of human activities and changing climates in reducing food and nest-site availability. The causes of decline are not well known, but include threats that reduce the numbers of aerial insects on which this species forages, which can be attributed to agricultural or other pesticides and changes in precipitation, temperature and hydrological regimes. An increasing frequency of severe or extreme weather events is also likely impacting this species by reducing its productivity and increasing mortality.
Sources used for assessments: COSEWIC (2018b)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[112] = 2		
Dependence on habitats that are sensitive to climate change[113]	The common nighthawk breeds in a broad range of open and partially open habitats, including forest openings and post-fire habitats, prairies, bogs and rocky or sandy natural habitats, as well as disturbed areas. It is also found in developed areas that meet its habitat needs. Nest sites (typically just an egg on the ground) include forest clearings, bare patches in	1 – Broad generalist

[112] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.
[113] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	grassland, gravel pits, outcrops, road or rail sides and, rarely, fence posts. The availability of suitable roosting sites may be an important habitat requirement for common nighthawk. While a broad range of sites are used, including the ground, tree limbs, rooftops and fence posts, repeated use of particular sites suggests that key features are required, including unobstructed flight paths, shade from the sun and camouflage. Common nighthawk appears to be an opportunistic generalist in its choice of foraging habitats, often aggregating in areas that attract concentrations of flying insects, such as waterways and lit areas. It may rely more on wetlands when breeding in grassland habitats in southern Canada, where it feeds on a wide range of flying insects, than in boreal habitats, where it may feed mainly on beetles from terrestrial sources. Although nighthawks migrate singly in the spring, in the fall, migrating flocks of a few to thousands of birds pass over particular sites, suggesting that specific landscape features or habitat characteristics are optimal for flight efficiency or for foraging during migration. Larger flocks may be associated with certain rivers or coastlines and their appearance across large areas may coincide with the passage of cold fronts.	
Sensitivity to climate-relevant abiotic factors[114]	The northern limit of the species' breeding range in the NWT and NU is uncertain, because of limited search effort. Microhabitat requirements are more specific and better understood. Nests are typically in open sites with dry, well-drained substrates that will not overheat and that have shade nearby for young to shelter from the sun and predators. Climate change continues to increase the frequency and severity of temperature variation worldwide. Hot weather can overheat nighthawk chicks. High precipitation, especially when accompanied by cold temperatures, is well-known to increase mortality and decrease reproductive success in aerial insectivores. There are no studies documenting its population-level	3 – Likely very sensitive

[114] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

	effects on common nighthawk per se, but effects of precipitation can be locally severe. For example, high precipitation in BC in 1990 apparently caused starvation and nest failure in common nighthawk and cold, rainy weather coincided with a mass nighthawk die-off in Massachusetts in 1905.	
Sensitivity to climate-relevant biotic factors[115]	Common nighthawk's strong reliance on availability of aerial insects increases its vulnerability to threats that affect survival. The synchronous timing of its brief fall migration with the emergence of flying ants may indicate a reliance on that food source at that time. For aerial insectivores in general, climate warming may be reducing the availability of insect prey overall. Extremes of precipitation affect the abundance of flying insects and have occurred more frequently in recent years across wide portions of the range of common nighthawk. Climate change may also result in phenological mismatch between peaks of insect abundance and the times of year when these birds most need food resources, such as at egg laying, moult, chick-rearing and migration. The risk of such asynchrony may be particularly severe for long-distance migrants, such as common nighthawk, because temperature shifts are more dramatic at higher latitudes and because cues that trigger migration from wintering grounds poorly predict conditions on distant breeding grounds. There is widespread evidence for shifts in the timing of both insect and bird breeding and some evidence linking such mismatches to reduced reproductive success or population declines. On balance however, the evidence for a causal link between the two is equivocal for terrestrial birds, although well-established for birds in other systems.	2 – Somewhat sensitive or possibly very sensitive
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	Threats are poorly understood, but the most serious threats in the NWT, given the absence of significant habitat destruction/disturbance/fragmentation and pesticide use, likely include changes in aerial insect abundance and community composition (associated with climate change) and direct impacts of climate change (phenological mismatch, changes in precipitation, temperature extremes).	1 – Not sensitive

[115] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

Adaptive capacity[116] = 2		
Reproductive capacity[117]	Common nighthawk reaches maturity at approximately two years of age, lays one to two eggs and raises one brood per year. The limited data available on longevity suggest it lives for four to five years on average, with a generation time of about two to three years. Restricted breeding season, combined with small clutch size, limit its annual productivity and potential rate of population recovery.	2 – Early reproduction/few offspring
Dispersal capacity[118]	Long distance migrant that summers in North America and winters in South America. Juvenile and adult return rates are poorly known, though females have been known to return to nest sites for up to five years in a row. Dispersal within and between breeding seasons is also unknown, apart from a few studies showing that at least some adults return to the same nest site for up to five years.	2 – 1-10km
Genetic diversity		N/A
Phenotypic plasticity		N/A

[116] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[117] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.
[118] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas	Common nighthawk may use disturbed, even highly urbanized habitats, but its flexibility is constrained by its need for a supply of flying insects for foraging and specific nest-site features. In urban environments, where habitats providing flying insects and appropriate nest-site characteristics can be easily characterized (by artificial lighting and gravel roofs, respectively), they have been reported in increased abundances. In urban residential and commercial environments, which comprise only a small portion of common nighthawk range in Canada, changes in roof construction may threaten local populations, by removing nesting conditions appropriate for egg and chick production. Specifically, changes from pea gravel roof surfaces to larger gravel, un-walled and poorly drained roofs and use of smooth surfaces such as rubber, have all been associated with local declines of nighthawks. Currently, flat roofing is not being replaced at a high rate (although new construction could be an issue) and commercial roofs are generally flat, although the conversion of pea gravel to larger-grained gravel could have an adverse effect. Nighthawks also use a variety of habitats and affected individuals could conceivably relocate to new nesting sites if needed, although the ability to relocate may be limited.							**Neg.**
1.2 Commercial and industrial	See 1.1							**Neg.**

areas								
1.3 Tourism and recreation areas	There is evidence that nighthawks use recreational areas such as campgrounds or golf courses when these create openings in the forest.							**Neg.**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops	Overall, Canada's prairie regions have lost most of their native grassland to planted grass and cropland, including a 10% loss between 1985 and 2001. Expansion of agricultural land has leveled off in recent decades, although agricultural intensification, such as increased farm area and growth in high-input, high-yield crops, including corn and soybeans, is continuing in western Canada and much of the United States. Deforestation and agricultural intensification is occurring throughout most of the species' wintering range. However, the net effect of these changes on common nighthawk habitat is unclear, because the relative importance of suitable habitat types is poorly understood. The species may also benefit from agricultural conversion given habitat preferences (Roberto-Charron pers. comm. 2020). Declines in flying insects worldwide and locally have been directly attributed to agricultural intensification, through its reduction of plant diversity, alteration of wetlands and use of pesticides. The latter effect is continuing, especially in prairie Canada, although no studies have yet focused on the impact to common nighthawk. Recent studies suggest that it often forages on insects from terrestrial rather than wetland habitats in boreal areas during breeding. However, their large aggregations over wetlands, in other habitats and times of year, suggest that loss of wetlands may have an importance that is not yet fully documented. Agricultural intensification may also reduce roosting and nesting habitat. Loss of edges and conversion of agricultural grasslands to croplands remove needed cover and increase disturbance for most							**Neg.**

	ground-nesting bird species. In prairie habitats, the common nighthawk is more abundant in grassland habitat rather than in cropland and it is less abundant under intensive grazing or under grazing conditions that promote growth of shrubs. Whether such patterns underlie local population declines or shifts in habitat use is unknown and some agricultural practices, such as moderate grazing or conversion of aspen parkland to agriculture (Roberto-Charron pers. comm. 2020), may actually sustain suitable nesting habitat. Locally, nighthawk nesting sites have been crushed by livestock or agricultural equipment, but presumably with negligible effects at the population level. Conversely, reforestation of areas originally cleared for agriculture, following the cessation of farming, may be a threat. Reforestation may be reducing habitat availability for several species that require cleared areas, including common nighthawk, especially in southern ON and Quebec. In both cases (agriculture and reforestation), it is the loss of landscape features that is associated with regional declines in common nighthawk (Roberto-Charron pers. comm. 2020). It is unlikely that much additional land will be converted to agriculture (except perhaps in some northern areas, e.g. near Prince George, BC), although existing agricultural land may be farmed more intensively (e.g. through conversion of hay and fallow to cash crops). The number of farms in Canada is declining and those remaining are becoming larger and more intensively farmed. There is a continuing declining of native prairie, although impacts on nighthawks are likely negligible. This species has been found nesting in some grass and crop areas.							
2.2 Wood and pulp plantations								**N/A**

2.3 Livestock farming and grazing	See 2.1. Livestock farming and ranching may be both a threat and a potential benefit to this species. Nests are at risk from trampling by cattle, most commonly in areas with dairy cattle. Trampling is unlikely to be an issue in the prairies, where livestock grazing is seen as a net benefit in maintaining short vegetation that can be used by nesting or roosting nighthawks.							**Neg.**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling	In general, activities of the oil and gas industry are not considered a threat. There may be some localized negative disturbance effects, but nighthawks also use land cleared for survey lines and well-pads as nesting habitat, resulting in a net benefit.							**N/A**
3.2 Mining and quarrying	In general, mining and quarrying pose little threat to this species. Nighthawks will nest in or near old coal mines and new mines, quarries, or gravel pits could be of benefit by providing new cleared habitat. Noise from operating mines may put stress on individuals nesting nearby, but this is unlikely to be a population-level concern.							**N/A**
3.3 Renewable energy	Studies show that wind turbines are not generally a threat to this species.							**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads	Nightjars often roost along roads, where they risk collision with vehicles, especially where roads intersect feeding aggregations. When compared to other land bird species, common nighthawk has among the lowest reported collision rates with vehicles, buildings, communication towers and wind turbines, although these figures do not account for population size or exposure. Nonetheless, losses from collisions may be offset by gains from the open nesting habitats that these corridors provide. Almost all individuals of this species are exposed to roads at some point during their lifecycle, as they are attracted to roads for							**Neg.**

	warmth when roosting and for insect prey. Roads thus provide benefits in terms of food availability, roosts and associated cleared habitat. New gravel roads in the boreal forest may provide a particular benefit, although nighthawks (especially males) are susceptible to collisions with vehicles on gravel roads, though less so on paved roads. This is likely a greater concern along the migration route and in the wintering grounds (Roberto-Charron pers. comm. 2020).							
4.2 Utility and service lines	Males have been reported as being particularly susceptible to colliding with telephone and power lies during aerial courtship displays. Installation and maintenance of power lines provides clearings which serve as nesting habitat for this species. There is no evidence that nighthawks collide with structures such as power lines or communication towers.							**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths	At one US airport, 82% of bird strikes involved this species, but this seems to be an unusual exception.							**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals								**N/A**
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting	Logging is likely beneficial to this species in most cases, as it often maintains heterogeneity in the landscape, creating small-scale clear-cuts that provide openings for nesting and foraging habitat. Logging may affect the availability of aerial insects on which to forage, although this effect may sometimes be positive and nighthawks are quite adept at locating food. As this species tends to nest late into mid-summer, it may be affected by summer timber							**N/A**

	harvesting.							
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities	Scientific research on this species will continue, but is low in impact and will not have a measurable effect.							**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression	The common nighthawk breeds in a broad range of open and partially open habitats, including forest openings and post-fire habitats. Across the boreal forest, which comprises most of the Canadian range of common nighthawk, wildfires are increasing, exposing new nesting habitat and causing peaks in the abundance of insect food, notably beetles. One study noted the affinity of common nighthawk for post-fire habitats and the relatively high abundance of this species in suitable boreal habitats exposed to fire in northern ON. In both forest and grassland habitats, fires may destroy nests locally, a particular hazard for a species with a short breeding season but a long incubation and nestling period, in comparison to other land birds. Conversely, wildfires create un-vegetated areas that are often selected for nesting and can cause insect outbreaks, whereas fire suppression may allow bare ground to become vegetated and unsuitable for nesting. Fire suppression is less frequent and of lower concern in northern boreal areas, as fires are	W	U	S	N	H	L	**Low**

	more likely to be human-caused and actively suppressed in southern Canada.							
7.2 Dams and water management/use	New dams can dry out wetlands that support populations of flying insects and may flood nests and nesting habitat, an effect that may continue after construction as water levels fluctuate during dam operations. The scale and severity of this threat may be negligible overall, but local populations may be severely affected by large projects, such as the planned site C project that will flood common nighthawk habitat along the North Peace River of BC. The construction of new dams dries out lowland habitat downstream (e.g. Bennett dam), which may impact insect populations. The fluctuation of water levels caused by operation of existing dams may flood nests, in an ongoing impact.	L	L	S	ST F	M	L	**Low**
7.3 Other ecosystem modifications	Because the species is an aerial insectivore and most such species are declining, most hypothesized threats relate to the availability of aerial insect food. One third of monitored insect populations are declining, mainly because of habitat alterations, pesticide use and climate change (threats from climate change addressed in #11 below). Potential changes in insect abundance and community composition due to pesticide use could continue to have an impact on common nighthawk, perhaps including spruce budworm (*Choristoneura fumiferana*) control in eastern Canada, although pesticide use is declining and evidence of its effects are mixed. This threat may impact nighthawks breeding in the managed, southern portion of the Canadian range, as well as during migration and on wintering range, as there is evidence that common nighthawk spends winters in agricultural landscapes. However, the lack of data has made it difficult to quantify this threat, which may be very significant for this species and other aerial insectivores.							**N/A**

	Neonicotinoid pesticides, which have been used increasingly since the 1990s, are known to cause declines in insect populations in the agricultural lands where they are applied and in associated aquatic environments. In turn, these insect declines have been correlated, although not causally linked, to declines in several insectivorous bird species in Europe. Those aerial insectivore species that are declining the most pass the winter in countries that spend the most on insecticides.							
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases	Especially in urban and suburban habitats, medium-sized non-native predators, such as domestic and feral cats, have increased in numbers, potentially increasing the risk of predation, especially on eggs and young. This ground-nesting species is likely exposed to predation by cats (including feral cats) and the Norway rat (*Rattus norvegicus*), especially in urban and rural areas in southern Canada, although studies suggest that nest success rates there are still quite high (90%)and nests located on roofs are less accessible to these non-native predators.							**N/A**
8.2 Problematic native species/diseases	Although common nighthawks often avoid natural predators, increases in American crow (*Corvus brachyrhynchos*) numbers have been related to increased predation on common nighthawk in at least one urban study and increases in gulls (*Larus* spp.) to increased competition for urban nest sites in Quebec and BC. Increases in crows and gulls in the greater Toronto area from the 1970s to 1990s corresponded with a decrease in breeding nighthawks, which was reversed when crows and gulls decreased again in the early 2000s. Nest predation by such native predators might be more prevalent in southern Canada than in the boreal region. Predation rates in the south are often high for ground-nesting species, although there is little evidence of the importance of this threat for nighthawks per se. Nest predation by native predators (e.g. raccoon, American crow,							**Neg.**

	grey jay (*Perisoreus canadensis*)) appears to be more prevalent in southern Canada than in the boreal region. There is little evidence to support the negative effects of this threat on nighthawks, although predation rates are often quite high for other ground-nesting species.							
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents								**N/A**
9.3 Agricultural and forestry effluents (including erosion)	Direct evidence that agricultural, forestry and other (e.g. mosquito control) pesticides affect Common Nighthawk is lacking, but individuals that breed in Canada likely migrate through and winter in agricultural areas where such pesticides are used. Lethal organochlorides, such as DDT, are banned in North America, but are still present in insectivorous migrant birds as they return there to breed after wintering in Central and South America, where such chemicals continue to be used. Less lethal carbamates and organophosphates, as well as neonicotinoids, while tightly regulated in North America, are in widespread use throughout the range of Common Nighthawks. The severity of their direct effects on insectivorous birds may be underestimated. It is possible that some nighthawks consume pesticides or insects							**N/A**

	with high pesticide loads, especially in the United States and Mexico. However, there is no evidence that this is an issue and little information on how this species would be affected.							
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants	Two airborne pollutants that prevail in some boreal habitats present potential threats to common nighthawk: mercury, which can have a variety of sub-lethal effects in birds, including reduced reproductive success and acid rain, which might exacerbate the effects of mercury and reduce the availability of aquatic insects that provide calcium needed by birds. Evidence for negative effects on boreal bird populations is mixed, however. There is no evaluation of effects of these contaminants on this species, which may occur if this species consumes insects that emerge from contaminated wetlands.							**Neg.**
9.6 Excess energy (noise/light pollution)	Many flying insects rely on light cues for navigation and developmental phases; for example, the emergence of aquatic insects can be disrupted by artificial lighting. There is growing evidence that these effects can reduce insect populations. Conversely, at a local level, insects attracted to artificial lights provide a concentrated food source that Common Nighthawks frequently exploit. Whether this attraction yields a net benefit has not been examined for nighthawks, but has been for bats, in which any benefit of increased food appears to be outweighed by disruption of daily routines and increased risk of predation. Conversely, light pollution may impact Common Nighthawk migration (Roberto-Charron pers. comm. 2020). Noise from operating mines may put stress on individuals nesting nearby, but this is unlikely to be a population-level concern.							**Neg.**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/								**N/A**

tsunamis								
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Climate change is evident throughout the species' range, although its effects on population levels are uncertain. Models predict an increase in the incidence of fires and gradual expansion of boreal habitats into lowlands north of the boreal forest, likely with a net positive benefit for the species. For aerial insectivores in general, climate warming may be reducing the availability of insect prey overall. In particular, it may result in phenological mismatch between peaks of insect abundance and the times of year when these birds most need food resources, such as at egg laying, moult, migration and, especially, chick-rearing. The risk of such asynchrony may be particularly severe for long-distance migrants, such as common nighthawk, because temperature shifts are more dramatic at higher latitudes and because cues that trigger migration from wintering grounds poorly predict conditions on distant breeding grounds. There is widespread evidence for shifts in the timing of both insect and bird breeding and some evidence linking such mismatches to reduced reproductive success or population declines. On balance however, the evidence for a causal link between the two is equivocal for terrestrial birds, although well-established for birds in other systems.	W	M	S	ST F	M	L	**Low**
11.2 Droughts								**N/A**
11.3 Temperature extremes	Changes in temperature regimes and temperature extremes may be detrimental. Nests can fail from effects of hot or cold temperature extremes, flooding, or predation. Climate change continues to increase the frequency and severity of temperature variation worldwide. Hot weather can overheat nighthawk chicks, whereas the cold snaps challenge the species' tight energy budget and	L	M	C	ST F	M	L	**Medium**

	reduce the availability of flying insects. These effects are worse when combined with precipitation impacts.							
11.4 Storms and flooding	Extremes of precipitation affect the abundance of flying insects and have occurred more frequently in recent years across wide portions of the range of common nighthawk. High precipitation, especially when accompanied by cold temperatures, is well-known to increase mortality and decrease reproductive success in aerial insectivores. There are no studies documenting its population-level effects on common nighthawk per se, but effects of precipitation can be locally severe. For example, high precipitation in BC in 1990 apparently caused starvation and nest failure in common nighthawk and cold, rainy weather coincided with a mass nighthawk die-off in Massachusetts in 1905. Intense storms might present localized threats to aerial insectivores, which only forage on the wing and often at frontal edges (confluences of cold and warm air masses) where flying insects are concentrated. The intensity of tropical storms in the North Atlantic has been increasing since the 1980s, while population declines across aerial insectivores also intensified. Being a long-distance migrant may increase the vulnerability of common nighthawk to this threat.	L	L	C	ST F	M	L	**Low**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Dolly Varden (*Salvelinus malma malma*)
Populations (if applicable): Western Arctic populations
Percentage of North American population NWT is responsible for: This subspecies is found in northeastern Eurasia and northeastern North America (YT, NWT and Alaska). Approximately 5-10% of the global population of this subspecies resides in Canada.
NWT General Status Ranks: Sensitive
NatureServe Conservation Rank (NWT): S2S3
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Special Concern
Reasons for assessment or population trends: This fish from freshwater and marine habitats in Canada's western Arctic has a very limited area of occupancy associated with a relatively small (17) number of locations that are key for spawning and overwintering. Aboriginal traditional knowledge suggests declines in some populations and the small area and number of key habitats make the species particularly susceptible both to point source (e.g. overexploitation, stochastic events) and broader-scale events (e.g. climate change) that may eliminate or degrade habitats.
Sources used for assessments: COSEWIC (2010a), Mochnacz et al. (2020), Dunmall et al. (2013, 2016, 2018), Gallagher et al. (2018, 2019), Morrison et al. (submitted)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[119] = 3		
Dependence on habitats that are sensitive to climate change[120]	Dolly Varden in Canada use coastal estuarine waters in the Beaufort Sea and freshwater drainages that flow northward into the Beaufort Sea. Known freshwater habitats vary from wide open braided streams to high elevation, high gradient streams. The most specific and limiting habitat for Dolly Varden is its spawning and overwintering habitat. This habitat is characterized by perennial groundwater upwelling into existing river channels where adequate oxygen and suitable temperatures are conducive to adult and juvenile survival and egg incubation during the winter months (see Mochnacz et al. 2020 for additional details on spawning habitat in two rivers). These crucial areas	4 – Depends on sensitive habitats that are rare.

[119] Overall sensitivity score is based on average of habitat, abiotic and biotic factor scores
[120] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	have long been recognized by Gwich'in and Inuvialuit. These areas of open water, often supporting a growth of filamentous algae throughout the winter, contrast sharply with the rest of the river that typically freezes to the bottom. For anadromous Dolly Varden, additional habitats that provide migration routes to/from feeding areas in the sea and opportunity for smoltification are required to complete their life cycle. Total area of key habitat for dolly varden (western Arctic population) is estimated to be <1.0 km^2. An estuarine band of water, spanning the 75 0km length of the coast along the Beaufort Sea, forms for the summer and is absent in winter. This band is usually two to ten km wide and is relatively warm and brackish compared to adjacent marine water (5°C - 10°C, 10-25% salinity v/ -1°C -3°C, 27-32% salinity). An abundant supply of summer food such as mysids and amphipods can be found in this seasonal habitat feature. There is no evidence that climate change would facilitate a northward range expansion of dolly varden, as no global climate models predict an increase in suitable overwintering habitat (i.e., river sites with groundwater springs).	
Sensitivity to climate-relevant abiotic factors[121]	The thermal and conductivity range within which Dolly Varden are found has been documented, but the physiological limits of northern form Dolly Varden are not well studied. The water depth at spawning sites is 0.2m to 1.5m in currents of 0.3 m/s to 0.6 m/s, but aspects of habitat use vary by life stage. Moving water cleans the spawning grounds and provides oxygen to the developing embryos. Oxygen levels range from 2.6 to 14.5 mg/L. Of note is the tolerance of low oxygen (0.2mg/L) at the Fish Hole on Little Fish Creek, tributary to Big Fish River. Water temperature at the spawning grounds ranges from 0-8°C. Conductivity, which reflects mineralization and salinity in water, ranges from 120-350 µmhos/cm at 25°C for areas fed by karst-type groundwater. Some of the overwintering sites have considerably higher concentrations of ions. The measured pH of groundwater inflows is mildly	3 – Likely very sensitive.

[121] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

	alkaline, ranging from 7.6-8.8. Visibility in freshwater habitats is most reduced during the spring melt and can be as little as 2.5cm compared to 2m or more in later summer. According to some elders, Dolly Varden make their migrations when the water is clear, not murky. Physiologically, Dolly Varden do not appear capable of surviving in saline or brackish water in winter. It is believed that anadromous Dolly Varden overwinter inland because they cannot tolerate extreme salinity or temperatures much below 0°C such as supercooled sea water. They do, however, venture to feed in saline habitats (33 ppt) as shown by the level of 34 sulphur in their muscle tissue. For juveniles, estuary environments provide a salinity gradient conducive to smoltification. As well, the level of the stable isotope ^{34}sulphur found in muscle tissue in sampled Dolly Varden indicated that feeding occurred in habitats of higher salinity than brackish waters. Thermal death was observed in southern Dolly Varden subjected to 20°C. Dolly Varden have no physiological defenses against freezing, so must move to parts of the river that are reliably open throughout the winter, including open areas or areas under ice that are not completely frozen to the bottom. Abiotic factors, such as increased precipitation and warmer air temperatures are likely to result in greater short-term changes to groundwater above permafrost.	
Sensitivity to climate-relevant biotic factors[122]	Generally opportunistic, rather than specialist feeders, consuming a wide variety of taxa. A small invertebrate, *Apherusa glacialis*, associated with the underside of ice floes was identified in Dolly Varden diets when ice floes were greater than 8km offshore. Scarcity of food does not appear to be a factor currently limiting the population of Dolly Varden. In streams where spawning habitat is spatially limiting (e.g. Fish Hole Creek – Babbage system, Little Fish Creek – Big Fish system), Dolly Varden may be sensitive to displacement and competition from Pacific salmon (Dunmall et al. 2013; Dunmall et al. 2018). However, these two species successfully co-occur in	2 – Somewhat sensitive or possible very sensitive.

[122] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

	Alaska. Potential impacts from future interactions are unknown (Mochnacz pers. comm. 2020). The trend towards the earlier timing of the sea ice breakup is correlated with the observation of greater annual growth of anadromous Dolly Varden from Rat River. One study found that Dolly Varden were in poorer body condition in years when the Arctic ice pack did not recede enough from the coast to facilitate coastal upwelling and consequential enhancement of primary production. On the northeastern coast of Alaska, Dolly Varden may go to water warmer than where they foraged in order to aid digestion. Inuvialuit report more grizzly bears and river otter sightings in recent years in the Mackenzie Delta. The observed trend of lowering water levels at some fishing sites may improve access to Dolly Varden by bears and eagles. Gwich'in agree that increased otter activity on the Big Fish River and Rat River may be contributing to the decline of Dolly Varden populations.	
Non-climate stressors = 2		
Sensitivity to potentially interacting non-climate pressures	Non-climate stressors in the NWT include industrial development and overharvesting. Of these threats, overharvesting is the most important, especially at spawning and overwintering areas. Other potential threats are indirectly linked to climate change, including the possibility of increased marine traffic, which could increase exposure to contaminants and facilitate the movement of alien species.	2 – Moderate pressures or possible major pressures.
Adaptive capacity[123] = 3		
Reproductive capacity[124]	Generation time 6.6 years (anadromous)/5.1 years (non-anadromous), excluding male residuals (3.9 years). For anadromous males, average age of maturity ranged from 5-10 years and for females, average age of maturity ranged from 5-7 years. Anadromous females reach maturity earlier than males in most studied populations. The average age of maturity for residual males ranged from 3-5 years.	3 – Late reproduction/many offspring

[123] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[124] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.

	In the North Slope populations and the Rat River, spawning occurs every second year for most, except in Big Fish River where many female Dolly Varden appear to spawn every year. Few Dolly Varden live long enough to spawn more than twice. Non-anadromous Dolly Varden do not breed with the anadromous form. Dolly Varden in the Rat River rarely live more than eight years. The maximum age observed on the Vittrekwa River is 10 years. Mature anadromous Dolly Varden from the Firth River ranged from 4-15 years of age. Post-spawning mortality rates of adults were estimated at 45-50%. Fecundity generally increases with the size of female, but is not consistent between drainages. Fecundity in non-anadromous, isolated populations appears to be lower (max 653 eggs), although only one population was measured. Max eggs/female in anadromous fish is 5,151.	
Dispersal capacity[125]	Breeding anadromous adults return to their natal stream to spawn, as do most non-spawners, although a few non-spawning adults may overwinter in non-natal streams. This pattern of migrating to and from the sea continues for the rest of the lives of the anadromous form, except for some spawners that remain in freshwater the year that they spawn. Residual Dolly Varden do not migrate. Non-anadromous Dolly Varden also do not migrate, perhaps due to the long distance to sea or a geographical barrier.	3 – 0.25-1km
Genetic diversity	There are three different geographical barriers that limit gene flow. First, waterfalls and strong currents/rapids prevent fish from migrating upstream. Occasional downstream movement of fish from upstream of waterfalls does occur although it is not known whether these displaced fish spawn and contribute to the gene pool of the fish native to downstream habitats. Second, lacustrine Dolly Varden have a limited opportunity to move out of the lake, especially if the lake is remote and the inflow/outflow to/from the lake is poor habitat. Third, geographical	N/A

[125] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

	distance can act as a barrier to the movement of individuals and thus gene flow between populations. All of the geographically isolated inland fish are believed to be non-anadromous. The primary behavioural barrier to gene flow is the fidelity of anadromous Dolly Varden to their spawning grounds. Anadromous Dolly Varden are composed of genetically distinct populations associated with each of the different drainages from which the fish originate. The behaviour of returning to natal spawning grounds maintains the genetic isolation of each population of Dolly Varden even though members from different populations mix at sea and visit drainages other than their drainages of origin to overwinter. Among the sampled anadromous populations in northwestern Canada, there is a trend of greater genetic diversity of the western drainages compared to the eastern drainages (i.e., greatest genetic diversity in the Firth River). A difference in chromosome number suggests that northern and southern Dolly Varden are genetically incompatible and would not provide viable offspring.	
Phenotypic plasticity	Dolly Varden demonstrate migration dimorphism (i.e., consecutive migratory, skipped migratory and resident individuals), which can result in differences in body size and colouration. This behaviour is also associated with differences in spawning frequency (consecutive or alternate years). It is unclear whether these behaviours are in response to environmental conditions like prey availability or water temperature (in addition of polygenic traits). This may have a bearing on assessing climatic influences on Dolly Varden (Gallagher et al. 2018, 2019).	N/A

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	**Overall level of concern**
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling	Offshore industrial infrastructure can disrupt the movement of and feeding of dolly varden (e.g. Roland Bay). Fish expend extra energy to move away from marine seismic activity. Roland Bay is a YT development. Nothing noted in the report about NWT offshore development.							**N/A**

3.2 Mining and quarrying	The Gayna River area is not protected and is a potential mining site for zinc and other minerals (Eagle Plains). Inland mining activity in close vicinity to dolly varden habitat could have a detrimental effect, for example, diverting water out of rivers would further stress the already reduced water levels reported in several drainages. Potential resource exploitation in the vicinity of dolly varden habitat could directly impact the quality of the fish habitat. Sand, gravel and rock material along the Dempster Highway in the James Creek area (tributary to the Vittrekwa River) is valued by the GNWT. Winter seismic activity can destroy or dam creeks by breaking willows.	L	M	C	N + ST F	H	M	**Medium**
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads	Transportation corridors could improve access to remote dolly varden and facilitate more fishing of stocks. Water drawn from rivers and lakes to construct the ice road is thought to deplete fish-bearing waters.	L	L	C	N + ST F	H	M	**Low**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals								**N/A**
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources	Dolly varden has been and still is part of the traditional diet of the Gwich'in and Inuvialuit. Harvesting of dolly varden takes place at sites along the coast throughout the summer and along rivers,	L	M	S	N	H	M	**Medium**

	particularly during the fall migration to spawning and overwintering grounds. These dolly varden are believed to have originated from the Firth, Babbage and Fish rivers and possibly some Alaskan drainages. Overharvesting has been identified as the primary cause of observed declines in dolly varden, but other factors are now being taken into consideration as limits to harvest have been violated in some cases and have not resulted in full recovery of stocks. The replacement of dog teams by snowmobiles beginning in 1959 made fishing at the Fish Hole spawning/overwintering site more accessible by reducing travel time to three to four hours instead of ten hours-two days. This facilitated a greater harvest. The demand of a large harvest in addition to habitat change may have brought the population level of dolly varden in the Big Fish River to a point where it may not recover. Big Fish River was closed to all fishing in 1987 when the population witnessed a drastic decline. Some fish are presently harvested by a mixed stock fishery on the coast and a small subsistence harvest, which was re-opened in 1992. Recreational fishing of dolly varden is regulated in the NWT and Yukon. The GNWT permits catch and release of dolly varden in the Gwich'in Settlement Area and Inuvialuit Settlement Region with the purchase of a territorial fishing license. In the YT, a general daily catch limit of five dolly varden applies to recreational fishers with a valid fishing license. Fishing in Ivvavik National Park is only permitted with the purchase of a fishing license specific to the park. Dolly varden harvest in Aklavik and Fort McPherson is guided by the 'Rat River Char Fishing Plan'. Compliance with the plan has grown since its inception, but violations still occur from time to time. There was a voluntary closure to the fishery for three years, beginning March 2006, when the population numbers continued to							

	decline. In 2009, the Rat River Working Group decided to allow the collection of 225 fish for monitoring/scientific purposes and a harvest of 1,000 fish for consumption by user groups from local communities. One study projected that the Rat River population would reach extinction in approximately 80 years if the trend observed between 1997 and 2004 continued and the fishery was re-opened with a quota of 2,000 fish. A lower percentage of male and female spawners since 2000 suggests a reduction in the reproductive pool and may indicate decreasing fertility. Dolly varden are particularly vulnerable to harvesting at their spawning and overwintering grounds when a high number of fish are concentrated in a small area. Seining activities at these sites could also impact egg survival by disturbing or destroying redds. The largest breeding males are disproportionately harvested as they can be caught with all mesh sizes of net used. These large males are needed to stimulate spawning. The loss of these prime breeders has been skewing the sex ratio to females in the Big Fish River. There is also a general trend towards a lower representation of older age classes in the Rat River since 1999. The impact of illegal harvesting by visitors to the Firth River is not well documented or controlled. It is unclear which populations are most impacted by the mixed stock fishery along the coast because the origin of harvested fish is not well monitored.							
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities	Detrimental effects of tagging on fish have been associated with population declines. A 225 quota on Rat River has been established for scientific/monitoring purposes. No other information was noted	L	L	S	N	H	L	**Low**

	on the impact of scientific work on dolly varden.							
7. Natural system modifications								
7.1 Fire and fire suppression								**N/A**
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications								**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases	Marine traffic, which may increase with a warming climate, could bring in invasive species that may be detrimental to endemic populations. Climate warming trends have been associated with the northward expansion of more southerly species. Both climate change models and empirical observations suggest that Pacific salmon could become more abundant in general (Mochnacz pers. comm. 2020) as well as within the Arctic basin, where they could have numerous interactions, both positive and negative, with dolly varden (western Arctic population) (e.g. predation on young, competitor at spawning sites, provide food supply for dolly varden). This trend will likely continue (Mochnacz pers. comm. 2020). The risk of introduction of whirling disease is unknown and should be assessed (Mochnacz pers. comm. 2020).	L	L-M	C	N	H	L	**Low-Medium**
8.2 Problematic native species/diseases	Inuvialuit report more grizzly bears and river otter sightings in recent years in the Mackenzie Delta. The observed trend of lowering water levels at some fishing sites may improve access to dolly varden by bears and eagles. Gwich'in agree that increased otter activity on the Big Fish River and Rat River may be contributing to the decline of dolly varden populations. Gwich'in suggest that seals contributed to the population decline of dolly	L	L	C	N	H	L	**Low**

	varden. Infectious pancreatic necrosis (IPN) virus was found in northern form dolly varden sampled from the Firth, Babbage, Big Fish and Rat River systems and is considered enzootic. It can have a detrimental effect on hatchery-reared fish, but its effect on northern form dolly varden is unknown.							
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents	Indirect effects of a warmer climate include increased marine traffic as ice recedes in the Arctic. This increases the risk of contaminants in the dolly varden that feed along the coast. Exposure to petroleum hydrocarbons due to oil spills can have adverse effects on fish. Other chemical contaminants such as mercury are a concern of subsistence harvesters. Rising temperatures associated with climate change could increase levels of contaminants, such as mercury.	L	L-M	C	N	H	L	**Low**
9.3 Agricultural and forestry effluents (including erosion)								**N/A**

9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis	Earthquake activity in the late 1970s and early 1980s may have adversely affected the quality and quantity of the overwintering/spawning grounds at Fish Hole.							**N/A**
10.3 Avalanches/ landslides	The frequency of landslides along the Rat River has increased in the past two decades. A photographic baseline of known dolly varden overwintering and spawning habitat on the Vittrekwa, Big Fish and Rat Rivers was established in 2007 to document habitat changes. Note that the timing, magnitude and spatial extent of landslides all affect level of impacts, which made the scoring here somewhat difficult (Mochnacz pers. comm. 2020).	L	U	S	LTF	M	L-M	**Medium**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	In addition to the factors noted above, observed trends attributed to climate change that may impact dolly varden include: shallower water in rivers and channels, warmer water, increasing number and size of sandbars, more willows, disappearance of eddies, more mudslides or landslides and drying out of small creeks. The coastal band of brackish water used as a transportation corridor and feeding area by dolly varden (stable buoyancy boundary) could be disrupted by changes to any of the three factors that stabilize it: (1) dominant easterly winds, (2) freshwater entering the Beaufort Sea from YT North Slope river systems and (3) proximity of sea ice in spring. Lower water levels in the Husky Channel, Peel River watershed, the Mackenzie River delta, Philips	W	M-H	C	N	H	M	**Medium**

	Bay at the mouth of the Babbage River, Nunaluk Spit, Firth River delta, Malcolm River and dry stream beds in the Rat River all suggest that less freshwater is available for forming the stable buoyancy boundary. There are also noticeably fewer drift logs in rivers compared to the 1970s, indicating that spring high-water levels are not as voluminous. There is already a trend of reduced sea ice, earlier breakup and recession of sea ice along the Beaufort Sea. The trend towards the earlier timing of the sea ice breakup is correlated with the observation of greater annual growth of anadromous dolly varden from Rat River. One study found that dolly varden were in poorer body condition in years when the Arctic ice pack did not recede enough from the coast to facilitate coastal upwelling and consequential enhancement of primary production. Inuvialuit note that sea ice conditions have been changing (i.e., no ice seen from shore at Shingle Point 2003-2005 [summer]) and may be affecting the harvest at Shingle Point. Dolly varden migrating further away from shore and out of reach of fishing gear may explain why fewer dolly varden are being caught since year 2000. Recent reduced flow rates in the Big Fish River may exacerbate temperature-induced egg mortality. Lower water levels, lower water salinity and possibly lower groundwater flow at Fish Hole along the Big Fish River could be limiting the recovery of dolly varden. The spawning and overwintering habitat at Fish Hole on the Little Fish River branch of the Big Fish River degraded in 1996 when high water changed the borders and flow direction within the river system. Further degradation could be attributed to reduced groundwater flow into the Fish Hole and erosion of steep banks along the spawning areas.							

	The thawing of permafrost associated with climate change could accelerate the deposition of materials into spawning areas, smothering redds and reducing the survival of eggs and fry. There is no evidence that climate change would facilitate a northward range expansion of dolly varden, as no global climate models predict an increase in suitable overwintering habitat (i.e., river sites with groundwater springs).							
11.2 Droughts	Loss of spawning/overwintering habitat on Rat River through desiccation in unusually warm, dry years may have contributed to general declines. Aerial photographs of the Rat River taken in the summer of 2008 depict some unusually dry creek beds. Inuvialuit note that water levels at several other sites are lower now. The Firth River delta used to be deep enough for schooners to dock, but this is no longer possible. Global climate models have not been able to accurately simulate trends in precipitation for the western Arctic. Nevertheless, it has been suggested that a decline in precipitation in the last five decades has contributed to the desiccation and reduction of spawning and overwintering habitat in the Rat River. Desiccation of habitat could result from an increase in evaporation with warming temperatures. Modeling results suggest that an increase of 1°C -4°C in mean annual air temperature could reduce the geographical distribution of dolly varden (western Arctic populations) by 29-90%. This decrease is based on projected reduction of suitable habitat.	L	H	C	N	H	M-H	**Medium-High**
11.3 Temperature extremes	Thermal niche that dolly varden occupy in freshwater is known, but the physiological consequences of exposure to temperatures beyond this range are not understood. However, ecologically similar species (i.e., brook trout) do not respond favourably when exposed to extreme temperatures and dolly varden are expected to exhibit a similar response (Dunmall et al. 2016; Mochnacz pers.	L	U	S	LTF	L	L	**Low**

	comm. 2020; Morrison et al., submitted).							
11.4 Storms and flooding	According to Indigenous knowledge, smaller fish are impeded by strong winds when travelling through rough coastal waters and may delay migration until winds abate.	L	L	S	N	H	L	**Low**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Dolphin and Union caribou (*Rangifer tarandus groenlandicus x pearyi*)
Populations (if applicable): Barren-ground caribou (Dolphin and Union population)
Percentage of North American population NWT is responsible for: Dolphin and Union caribou occur only in the Canadian Arctic. The population is shared between NU and NWT. Approximately 15% of the population occurs within the NWT during summer.
NWT General Status Ranks: Sensitive
NatureServe Conservation Rank (NWT): S2S3
***Species at Risk (NWT) Act*:** Special Concern
***Species at Risk Act* (Canada):** Special Concern (re-assessed as Endangered; listing pending)
Reasons for assessment or population trends: Although there is too little information to assess long-term population trends of Dolphin and Union caribou, there is evidence that the population declined between 1997 and 2007. There is no possibility of rescue from neighbouring populations. Dolphin and Union caribou are considered to be discrete from Peary caribou and BGC, based on their morphology, genetics and behaviour (i.e., the distinct rutting area as well as the herd's seasonal migrations across the sea ice of the Dolphin and Union Strait). Dolphin and Union caribou are vulnerable to major environmental events such as changes in the timing of sea ice formation, changes to the thickness of sea ice and icing and crusting events on their fall and winter range.
Sources used for assessments: SARC (2013b)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[126] = 2.7		
Dependence on habitats that are sensitive to climate change[127]	The migration path of Dolphin and Union caribou requires crossing the frozen Dolphin and Union Strait twice a year. Later sea ice formation affects the fall migration, but may also cause a longer staging time along the south coast of Victoria Island as the caribou wait for sea ice to form. This may increase foraging pressure on coastal plant communities and intra- and inter-specific competition for food. Some caribou die during this crossing, particularly on newly formed, weak sea ice.	3 – Depends on sensitive habitats that are not rare.

[126] Overall sensitivity score is based on average of habitat, abioticand biotic factor scores.
[127] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	Dolphin and Union caribou are found dispersed across the tundra. They are not fussy about their general location, although they will preferentially go to areas where the tundra vegetation is particularly green and healthy. It was also noted that because Victoria Island is a huge island, the caribou have no trouble finding ice-free vegetation. They seek islands, shorelines, snow patches, valleys and spots that are either damp or shaded. Calving areas likely provide snow-free or shallow snow-covered sites.	
Sensitivity to climate-relevant abiotic factors[128]	Weather, temperature and other factors influence migration routes and timing. Snow cover influences habitat selection as key habitat requirements are terrain and vegetation features that offer choices as caribou adjust their foraging to snow conditions. Caribou often seek patches of snow in the spring and lay in them to cool down. However, they also use water for heat relief. They avoid iced-over deep snow as it prevents them from feeding. Caribou will also stay in areas where there is less snow when the snow is hard from very cold weather. Although adapted to extreme cold, high temperatures negatively affect Dolphin and Union caribou. Warmer temperatures cause a long and intense insect season and extremely hot temperatures may also cause the caribou to lose condition. Warm weather increases the likelihood of calf survival. Ice-covered snow and/or tundra vegetation have caused problems for Dolphin and Union caribou in the past. The ice crust prevents feeding and makes travel difficult. Additionally, a variable freeze/thaw cycle in the fall may cover vegetation in ice and starve caribou. Terrain (slope and aspect) affect the snow conditions and timing of snow melt, which consequently affect the availability of forage and the energetic costs of the caribou foraging through the snow.	3 – Likely very sensitive.
Sensitivity to climate-relevant biotic factors[129]	Dolphin and Union caribou eat many different types of plants, depending on the time of year and plant availability, although they depend heavily on lichens.	2 – Somewhat sensitive or possibly very sensitive.

[128] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.
[129] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

	It is unknown how the strongly regional effects of a warmer climate on plant growth could offset the greater ecological costs of parasites including gastro-intestinal nematodes. The annual variation and trends in the timing and amount of plant growth relative to weather are unknown for Victoria Island. Likewise, the effects of the timing of snow cover on foraging are unmeasured. For Svalbard reindeer, summer moisture can limit plant growth for the dry communities used in the winter, which may reduce caribou forage. This is likely also the case for Victoria Island as a large part of the Dolphin and Union caribou seasonal ranges has a continental climate, which means it is relatively dry. Changes to vegetation that result from climate change can cause a shift in migration patterns.	
Non-climate stressors = 3		
Sensitivity to potentially interacting non-climate pressures	One of the primary threats to Dolphin and Union caribou is climate change-related habitat changes. Beyond this, the most substantial threats are from increased ship traffic/ice breaking through the Northwest Passage and harvesting. These are both considered serious threats.	3 – Likely major pressures.
Adaptive capacity[130] = 2.5		
Reproductive capacity[131]	Dolphin and Union caribou will start to calve when they are two to three years old and generally calve every year. Pregnancy rates are annually variable. The reproductive lifespan is likely about 12 years as caribou are relatively long-lived.	4 – Late reproduction/few offspring
Dispersal capacity[132]	Caribou seek easy terrain when migrating. They will take a route around rocky mountains instead of over them, but will go over hilltops. Caribou may walk in trails in the soft snow or may avoid soft snow and travel on hard ground. In particular, soft snow in the spring may hamper caribou and tire them out. The hard snow of the winter allows for easier movement. Freezing rain and slippery ground may alter the way caribou travel as well.	1 - >10km

[130] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.

[131] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.

[132] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

	Dolphin and Union caribou have a very strong instinct to travel. Caribou may swim two miles, but five miles is considered a bit of a stretch. The length of pre-calving and fall migration has changed during the 20th century. This is also typical for barren-ground caribou, despite the energetic costs of moving a greater distance. Reasons for migration between spatially distinct seasonal ranges are complex and likely involve access to higher abundance or quality of forage, or reduced risk of predation. Dolphin and Union caribou could potentially disperse to neighbouring islands (Banks, Melville or Prince of Wales islands), which are currently the range of Peary caribou. This dispersal is possible because sea ice connects the islands for most of the year. There are also indications of environmentally-forced dispersal during historical severe winters.	
Genetic diversity	Nuclear DNA analyses suggest that Dolphin and Union caribou are distinct from barren-ground caribou and they share haplotypes with members of adjacent herds, although the retention of some distinct genetic lineages suggests local adaptations by these caribou. The genetic uniqueness of Dolphin and Union caribou is reflective of a severe population bottleneck that may have occurred in the early 1990s.	N/A
Phenotypic plasticity		N/A

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas	Relatively few active land use permits occur on Victoria Island, with about 14 land use permits scattered along the south coast (mostly related to military sites and campgrounds).	L	L	S	N	H	H	**Low**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling								**N/A**
3.2 Mining and	Habitat fragmentation caused by human activities has not been	L	M	C	LTF	M	M	**Low**

quarrying	documented within Dolphin and Union caribou ranges; however, mineral developments are increasing on mainland winter range within NU and data are lacking to properly assess impacts. Some people are concerned that mining may cause caribou to shift their annual migration routes. However, others have indicated that mines do not bother caribou. Inuit have requested that mining be restricted, or should not happen near caribou calving grounds, as it will disturb the caribou. Increased industrial activity may cause caribou to scatter rather than staying in a large herd. Relatively few active mineral claims and leases occur on Victoria Island. A scattering of active mineral leases and mining-related land use permits are present about 50km east of the head of Prince Albert Sound and active mineral leases (no land use permits) occur near the head of and east of Minto Inlet. On the Dolphin and Union caribou mainland winter range, land use permits and active mineral leases are clustered along the greenstone belt south of Hope Bay, south of the head of Elu Inlet and greenstone formations in the High Lake and southwest of High Lakes area. A gold mine east of Bathurst Inlet on Melville Sound at Hope Bay was slated for start of production in 2012, but as of February 2012 was placed in care and maintenance indefinitely. Associated with this development are a series of exploration sites that run down the greenstone belt 60km to the south. West of Bathurst Inlet, a proposed copper-zinc mine at High Lake, south of Grays Bay, has gone through the preliminary approval process and is now combined with the larger Izok Corridor project. The proposed High Lake mine is an underground mine with a 45 km road to a shipping port for the ore. Both these projects have increased human activity and potential disturbance to caribou winter range associated with them. Mineral exploration occurred in							

	the Shaler Mountains of northwest Victoria Island in the 1990s but so far, the exploration has not led to development.							
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads	In was generally noted that road-building near Bathurst Inlet may impact caribou in several ways, particularly if the number of caribou is low: traffic on the road and the physical presence of the road itself may change caribou behaviour. As well, disturbance during road construction may cause avoidance. Development that includes roads, seasonal or year-round, is a greater concern because roads increase access for hunting and tend to facilitate more development.	L	M	C	LTF	M	M	**Low**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes	A possible and serious threat is the effect of increased ship traffic on the sea ice crossed during fall migration. How a longer shipping season and more frequent ship passages will affect fall migration will depend on the timing of ship traffic in relation to when the caribou are preparing to cross the ice. Inuit interviews indicated that ships can run during the summer months when the Dolphin and Union caribou are on Victoria Island, but that shipping activities should cease in September, October and November for the southern migration and in April and May for the northward migration. In Cambridge Bay, there are concerns about the impact ship traffic can have on Dolphin and Union caribou during the fall. Most shipping through the Northwest Passage takes the southern route, which includes the Coronation Gulf and Dolphin and Union Strait. Increased shipping will likely result from reduced sea ice season and thinner ice. Dolphin and	L	H	S	N	H	H	**High**

	Union caribou migration movements were delayed as a result of the artificial maintenance of an open water channel in the sea ice near Cambridge Bay. Shipping through the Northwest Passage has increased since the 1990s, reaching an annual peak by 2010 of 22 vessels. However, Canadian Ice Service noted uncertainty in predicting a rapid increase in shipping in the Northwest Passage due to the variability of sea ice conditions.							
4.4 Flight paths	Flights, particularly helicopter flights, should be higher over calving areas.							**Neg.**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	While the number of Dolphin and Union caribou harvested annually is uncertain, the annual harvest rate is believed to be 7-11% of the total estimated population. This is an unsustainable harvest unless the herd is increasing rapidly and has strong calf recruitment. Harvesting may become an increasingly important threat, especially if mortality rates from predation or drowning increase. The cessation of the herd's migration in earlier years was attributed, at least in part, to the introduction of rifles, although this is uncertain. Harvesters in Cambridge Bay indicated that there was a possibility of high wounding loss impacting the herd. Levels of commercial harvesting appear to vary. Kugluktuk and some communities in the Kivalliq region support some commercial harvesting, while Cambridge Bay stopped issuing tags in 1997. Peaks in the Kugluktuk commercial harvest occur when the caribou are close by and other communities ask for some meat; otherwise, the commercial harvest is usually low. Hunting can be a benefit to conservation as it provides information about distribution, health and condition, but without data to inform management decisions about the effects	L	H	C	N	H	H	**High**

	of hunting, it can also serve as a threat.							
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities	There may be impacts associated with all-terrain vehicles, including quads and side-by-sides (GNWT pers. comm. 2020).	L	U	S	N	H	M	**Neg.**
6.2 War, civil unrest and military exercises	Relatively few active land use permits occur on Victoria Island, with about 14 land use permits scattered along the south coast (mostly related to military sites and campgrounds).							**Neg.**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression								**N/A**
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications								**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases								**N/A**
8.2 Problematic native species/diseases	Muskoxen abundance increased on Victoria Island during the 1980s and 1990s. A possible consequence of higher numbers of muskoxen is that they provide alternate prey for wolves and therefore could maintain high numbers of wolves even while	W	U	C	N	H	L	**Low**

	caribou are declining. Muskoxen use of plant communities during the period of increasing abundance appears to have changed on southern Victoria Island (from lower-lying sedge and willow communities/upland drier communities to all communities, including sedges, which are also used by caribou). Overlap in diet and habitat use is not evidence for a competitive relationship, although overlap increases the possibility. The overlap between Dolphin and Union caribou and other barren-ground caribou herds in the Dolphin and Union caribou winter range around Bathurst Inlet is increasing, as Dolphin and Union caribou are moving further south and west and other BGC herds are moving further north into Dolphin and Union caribou areas. Intra- and inter-specific forage competition – although possible – are unknown. Predation is not considered a threat to Dolphin and Union caribou; however, wolf numbers appear to be increasing and it's likely that predation has also increased. Reported wolf sightings on Victoria Island appear to have increased over the past two decades, but are likely still at low overall densities compared with predators sighted during aerial surveys of mainland populations. The impact of wolf predation on Dolphin and Union caribou numbers is unknown. It is understood that in places where the wolf population increases, caribou numbers decrease. Grizzly bears kill young caribou and may harass the herd. Grizzly bear numbers have been increasing. The apparent increase, at least in NU, may be related to fewer bears being shot for food in recent years. Additional factors may be related to changes in abundance of large prey populations (muskoxen							

	and caribou), or the progression of greater plant productivity northward as a result of climate change, resulting in higher quality forage and possibly increased small mammal populations. However, the impact of grizzly bears on Dolphin and Union caribou is likely limited. Warmer temperatures are already manifesting as trends in higher indices of warble parasites. The prevalence and intensity of parasite infections and diseases in Dolphin and Union caribou is only beginning to be described. An increase in insect harassment for caribou has been observed since the 1970s. Mosquitoes cause caribou to gather, move in circles and shake to get the insects off. This wastes energy and prevents feeding. If they lose too much body fat, they may not survive migration, water crossings and the winter. It has also been reported that warble flies are being seen in spring as well as summer now. Recent (2007) local knowledge suggests that Dolphin and Union caribou are healthy. There were concerns raised around increased incidence of tapeworm (1998) and the possibility that the caribou are being exposed to more disease by travelling farther to the south. Increasing nematode burden correlates with a significant decrease in Dolphin and Union caribou body weight.							
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								

9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents	Water pollution from new and old mines was a concern for Kugluktuk hunters. However, contaminants do not appear to be a threat. Currently very low and localized.							**Neg.**
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste	Hunters in Kugluktuk have noticed a shopping bag in a caribou stomach and have seen bulls tangled in wire during the rut. Garbage left out on the land; in particular plastic bags, was noted as a general threat to wildlife.							**Neg.**
9.5 Airborne pollutants	Dust pollution from new and old mines was a concern for Kugluktuk hunters. In Dolphin and Union caribou collected from the Kent Peninsula in November 1993, researchers found relatively low levels of organochlorine, heavy metal and radionuclide contaminants resulting from long-distance atmospheric transportation. Heavy metal concentrations from sampling in 2006 were also low and showed no trend over time. Evidence based on sampling in the 1990s and 2006 suggest that contaminants do not appear to be current threats to Dolphin and Union caribou health.							**Neg.**
9.6 Excess energy (noise/light pollution)	Participants in workshops said that some individual caribou can adapt to some types of noise quite well. It was also noted that their response to noise pollution can vary depending on the weather; for example, on still, clear and cold days the caribou tend to shy away, but on cloudy days, they allow people to drive closer. People indicated that all wildlife are less tolerant of noise when they are about to have their young.	L	U	C	N	M	L	**Low**
10. Geological events								
10.1 Volcanoes								**N/A**

10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Changing climate patterns have resulted in warming trends in Arctic regions at higher rates than other global ecosystems (over 4°C in some areas of Dolphin and Union caribou range). Global climate change acts indirectly through impacts to the habitat (e.g. changes to forage conditions and changes to factors that influence migration); these changes can impact caribou condition and survivorship. However, there is almost no assessment of trends in caribou habitat. FORAGE: An increase in plant productivity is measurable across the western Arctic islands, especially the interior of Banks Island. With an increase in summer temperatures, plant productivity has also increased. Extended periods of higher quality forage could improve the condition of caribou before the fall migration. It is unknown how the strongly regional effects of a warmer climate on plant growth could offset the greater ecological costs of parasites including gastro-intestinal nematodes. The annual variation and trends in the timing and amount of plant growth relative to weather are unknown for Victoria Island. Likewise, the effects of the timing of snow cover on foraging are unmeasured. For Svalbard reindeer, summer moisture can limit plant growth for the dry communities used in the winter, which may reduce caribou forage. This is likely also the case for Victoria Island as a large part of the Dolphin and Union caribou seasonal ranges has a continental climate, which means it is relatively dry. Changes to vegetation that result from climate change can cause a shift in migration patterns.	W	H	C	N	H	H	**High**

	SEA ICE: Later sea ice formation affects the fall migration and may also cause a longer staging time along the south coast of Victoria Island as the caribou wait for sea ice to form. This may increase foraging pressure on coastal plant communities and intra- and inter-specific competition for food. Dolphin and Union caribou may be especially vulnerable to the effects of a warmer climate if the current trend toward later formation of sea ice continues and leads to increased risk of drowning deaths as the caribou attempt to cross on thinner ice. If the ice is too thin to cross but other factors (like length of daylight, sun, or seasonal triggers) cause the caribou to migrate anyway, they may either waste energy by looking for a better place to cross, or attempt to cross on thin ice and possibly fall through the ice and drown. Additionally, in the spring, caribou may swim through channels of water in the ice and not be able to get out, leading to drowning. As a result, drowning events are seen as being on the increase. Sea ice and other ice crossings may have changed: leads in the sea ice open earlier, ice is thinner overall due to warmer temperatures and shorter winters and summer water levels are lower. ICING: Rain and icing events causing an ice crust to form over vegetation can prevent caribou from feeding effectively. Icing and crusting events could have potentially greater effects if warmer falls increase the frequency or severity of the events. There have been more cases of freezing rain and sporadic freeze-thaw cycles over the last 20 years. Years with increased freeze-thaw cycles have been associated with decreases in caribou populations since lichen and other plants can become covered in ice and unavailable as caribou forage, which can result in starvation. PARASITES: The warmer and longer summer weather may							

	increase the amount of harassment by oestrid flies; these trends might be already happening on Victoria Island. The trend toward warmer summers will modify conditions for parasites and diseases although the effects will be complex and are currently unknown. Warm and dry weather causes a more intense, longer insect season, especially in regards to mosquitoes, while warm and wet years produce more warble flies and nose bots. An increase in insect harassment for caribou has been seen since the 1970s. WARMER TEMPERATURES/PRECIPITATION: In general, Inuit state that earlier spring melt and much later fall freeze-up are causing longer summers, particularly since the mid-1990s. Temperatures are also warmer overall. Lower water levels cause creeks and lakes to dry out in late summer and shorelines to drop, exposing new areas. Early spring melts and increased snow can cause changes in break-up; streams and rivers may open earlier and the current may be very strong, sometimes carrying ice. While warm weather increases the likelihood of calf survival, changes to freeze-up, spring melt, ice thickness and water levels can also force caribou to migrate along different routes.							
11.2 Droughts								**N/A**
11.3 Temperature extremes	If it's too hot, the plants dry up, forcing caribou to feed on food of low value; likewise, if there's too much variation in the weather, the animals suffer. Freezing temperatures during calving may also result in the death of calves. Inuit interviewees have noted an increase in deaths from heat-related and insect-induced exhaustion.	W	U	S	N	H	L	**Low**
11.4 Storms and flooding	Declines in abundance in the early 20th century were possibly caused by a combination of icing storms and the introduction of rifles. Storms and hail in large amounts have been seen in summer time when this was not seen in the past.	L	U	S	N	M	M	**Low**

11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Eskimo Curlew (*Numenius borealis*)
Populations (if applicable): N/A
Percentage of North American population NWT is responsible for: 100% of breeding range in Arctic Canada. The current distribution is unknown and there have been only a few unconfirmed sightings over the last four decades in Canada: in the prairies, the the Maritimes. Historically, nests are known only from two areas of tundra in the NWT. By extension, it has been assumed that potential breeding habitat occurs between these two points. Breeding is suspected to have occurred elsewhere but has not been confirmed.
NWT General Status Ranks: At Risk
NatureServe Conservation Rank (NWT): SHB
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Endangered
Reasons for assessment or population trends: This bird is a species of shorebird with 100% of its known breeding range in Arctic Canada. Formerly abundant, the population collapsed in the late 1800s, primarily owing to uncontrolled market hunting and dramatic losses in the amount and quality of spring stopover habitat (native grasslands). The population has never recovered and there have been no confirmed breeding records for over 100 years, nor any confirmed records of birds (photographs/specimens) since 1963. As such, less than 50 years have elapsed since the last confirmed record. However, there are some recent sight records that suggest the possibility that a very small population (fewer than 50 mature individuals) may still persist in remote arctic landscapes. The primary factors limiting recovery are the very low population size, no known chance of rescue from outside populations and the historic and ongoing conversion of native grasslands on its spring staging areas in Canada and the US and on its wintering grounds in Argentina.
Sources used for assessments: COSEWIC (2009b), Borstad et al. (2008)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[133] = 2.5		
Dependence on habitats that are sensitive to climate change[134]	Limiting factors include such conservative life-history traits as dependency on a few restricted habitat types over the course of its annual cycle. Historically, nests are known only from two areas of tundra in the NWT.	4 – Depends on sensitive habitats that are rare

[133] Overall sensitivity score is based on the average of habitat, abioticand biotic factor scores.
[134] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	Eskimo Curlews nest in Arctic and subarctic tundra in the NWT. During fall migration, a wide variety of inland and coastal habitats may be used, including ericaceous heathland with crowberries, meadows, pastures, old fields, intertidal mudflats, salt marshes and sand dunes. In the Pampas of Argentina, where they historically spent the winter, eskimo curlews were found in treeless grasslands interspersed with wetlands. On spring migration, they were found in tall grass and eastern mixed grass prairies, often in areas that had been recently burned or disturbed by grazing bison and in cultivated fields. There are ongoing vegetation changes in the arctic tundra as a result of climate change in response to thawing permafrost and deepening soil active layer depths; advances in the timing and duration of the growing season; and changes in vegetation growth. However, climate-related habitat trends began occurring well after the initial collapse of the species.	
Sensitivity to climate-relevant abiotic factors[135]	None noted.	Unknown
Sensitivity to climate-relevant biotic factors[136]	If the species required social facilitation to find sporadic food on migration, then numbers would have been so reduced by the late 1800s that systems of social cohesion may have effectively collapsed. Berries were likely a critical food source for the eskimo curlew on fall migration, allowing it to accumulate fat stores for its non-stop migration over the Atlantic to South America. Likewise, grasshoppers and other invertebrates may have been vital for attaining spring body condition prior to breeding. However, the decline of food sources is not attributed to climate change.	1 – Not sensitive
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	A number of plausible non-climate factors may have been responsible for the overall decline of eskimo curlew. However, in the NWT, non-climate stressors are largely negligible and didn't contribute to the initial decline in this species.	1 – No pressures.
Adaptive capacity[137] = 2		

[135] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

[136] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

Reproductive capacity[138]	The eskimo curlew is a monogamous, long-lived shorebird (perhaps ten-30 years). It likely has delayed maturation (possibly three years) and a relatively low reproductive rate. Usually, four eggs are laid. Only one brood is probably laid per season. Generation time unknown.	3 – Late reproduction/many offspring
Dispersal capacity[139]	Long distance migrant. Like other shorebirds, young are precocial, departing the nest with parents one to two days after hatching.	1 - >10km
Genetic diversity	No genetic information is available for this species. The species occupies a single biogeographic region; and there is no known genetic differentiation.	N/A
Phenotypic plasticity		N/A

[137] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[138] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.
[139] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	**Overall level of concern**
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops	On northward migration, eskimo curlew distribution closely matched that of tall grass prairie and to a lesser extent, mixed-grass prairie. The main natural disturbance drivers in the original grassland ecosystems were drought, fire and grazing by large ungulates like bison. However, European settlement on the Great Plains precipitated major changes in landscape composition and arrested many natural disturbance factors; the intensity and magnitude of these changes were probably never greater than in the early 1870s, coinciding with the beginning of the precipitous decline in eskimo curlew numbers. During or shortly after the American Civil War (1861-1865), homestead acts in different states in the US precipitated dramatic increases in human populations from Texas to North Dakota. The increased population of homesteaders, both in the United States and Canada, caused large-scale landscape changes. Large areas of native prairie were ploughed and converted to cropland. By the mid-1990s, only 4% of the original 74 million							**N/A**

	hectares of native tall grass prairie remained, with much of it being lost during the late 1800s. In the case of eastern mixed grass prairie, which was historically less important to eskimo curlews, only 26% of the original 63 million hectares remained in the early 1990s. When eskimo curlews were forced to shift from exploiting native grassland areas disturbed by native grazing herbivores and recently burned areas to agricultural fields, they probably relied on spring cultivation for foraging. The widespread conversion from spring to winter wheat, which began around 1870, likely had negative effects on food availability for northward-bound eskimo curlews and perhaps meant that they could not attain body condition necessary for successful breeding. Moreover, reduction of suitable feeding habitat concentrated migrating birds further into fewer areas, which may in turn have increased ease of spring market hunting.							
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing	On the wintering grounds, overgrazing, soil compaction and fires resulted in tall grasses being replaced by shorter grass species. Such habitat changes would have placed an additional stress at a key time in the species' history. Considerable areas of grassland remain in Argentina, but it may not be optimal eskimo curlew wintering habitat (grassland type may be important as well as the spatial configuration of patches).							**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling	Some NWT breeding habitat is protected in the Kendall Island Bird Sanctuary. COSEWIC (2009) notes that most shorebird habitat there has been affected by overgrazing by geese and by major							**Neg.**

	impacts from oil and gas development. However, there is no evidence for over-grazing by geese at Kendall Island or Anderson and remnant effects of previous oil and gas exploration is likely rather limited (Woodard pers. comm. 2020).							
3.2 Mining and quarrying								**N/A**
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads								**N/A**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	The eskimo curlew was considered a delicacy, so its social habitat of aggregating in large, dense flocks during migration made it a popular commercial target for 19th century market hunters. Moreover, its habit of circling back within gun range of market hunters, when flock members were shot, made it particularly susceptible to over-exploitation. However, there is evidence for some declines in eskimo curlew populations prior to market hunting. Market hunters accounted for the shooting of huge numbers of curlews on spring migration through the Great Plains of the United States and the Canadian prairies; hunting intensity may have increased in the late 1870s and 1880s coinciding with the commercial collapse of the passenger pigeon hunt. Thousands of eskimo curlews were also shot on fall migration in Labrador and, when stormy weather forced birds to land, in New England. Relatively few are believed to have been exploited on the wintering							**N/A**

	grounds, but the extent of the hunt there is almost wholly undocumented. Given that the eskimo curlew population was probably much smaller than originally believed and given the importance of adult survivorship in this long-lived species, it is not hard to see why commercial 'harvesting' of thousands of pre-breeding adult birds per year could quickly result in a population crash, especially when combined with decreases in the supply of critical stopover habitats.							
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression	Foraging eskimo curlews and other shorebirds are attracted to recently burned areas. Declines in the frequency and extent of these burned areas due to fire suppression also likely reduced curlew foraging opportunities in the spring, by changing the quality, number, patch size and spatial arrangement of spring stopover sites.							**N/A**
7.2 Dams and water								**N/A**

management/use								
7.3 Other ecosystem modifications	Recently burned areas and those near water or disturbed by grazing American bison were preferred during spring migration. As these native prairie grasslands were broken up and fragmented, eskimo curlews probably relied more and more on cultivated fields, particularly freshly planted cornfields or wheat fields. Loss of native grassland may have also changed the dynamic population cycles of grasshoppers in the prairies, which staging eskimo curlews may have been pre-adapted to exploit. From an arthropod biodiversity perspective, cultivated fields were impoverished habitats and provided unsuitable substrates for most rangeland grasshopper species to lay their eggs. Thus, conversion of grasslands to croplands also resulted in a decrease of an important food source: grasshopper egg pods and young. Human interference in large-scale ecological processes (changes in natural herbivory and fire regimes) also had drastic repercussions on spring stopover habitat and foraging opportunities for eskimo curlews. The near-extinction of a keystone species, the American bison, had a huge impact on ecological succession in native grasslands, encouraging woody species encroachment and other marked changes in plant species composition. Because of unsustainable market harvest, the mid- to late 1880s saw the local extirpation and range retraction of bison throughout the eskimo curlew's spring migration route in North America. While the most serious population declines of eskimo curlew pre-date the use of chemical control for grasshoppers and other insects, the use of modern-day insecticides could also be viewed as a current limiting factor.							**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien								**N/A**

species/diseases								
8.2 Problematic native species/diseases	Some NWT breeding habitat is protected in the Kendall Island Bird Sanctuary. COSEWIC (2009) notes that most shorebird habitat there has been affected by overgrazing by geese and by major impacts from oil and gas development. However, there is no evidence for overgrazing at Kendall Island or the Anderson River and the remnant effects of oil and gas are likely rather limited (Woodard pers. comm. 2020).							**Neg.**
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents								**N/A**
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light								**N/A**

pollution)								
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	There are ongoing vegetation changes in the arctic tundra as a result of climate change in response to thawing permafrost and deepening soil active layer depths; advances in the timing and duration of the growing season; and changes in vegetation growth. Habitat degradation due to saltwater inundation as a result of coastal erosion has also occurred at the Anderson River Delta, a historical breeding site (Borstad et al. 2008). However, climate-related habitat trends began occurring well after the initial collapse of the species.	W	H	S	N	H	H	**High**
11.2 Droughts								**N/A**
11.3 Temperature extremes								**N/A**
11.4 Storms and flooding								**N/A**
11.5 Other								**N/A**
12. Other threats								

Species: Evening Grosbeak (*Coccothraustes vespertinus*)
Populations (if applicable): N/A
Percentage of North American population NWT is responsible for: The evening grosbeak breeds in Canada, the United States and Mexico. In Canada, its distribution includes all Canadian provinces and territories except NU. Fort Liard represents a portion of the known northern limit of the species. Based on the breeding bird survey, the NWT is estimated to host 0% of the global population. However, in the southwestern NWT, the evening grosbeak breeding population showed a non-significant declining trend between 1998 and 2011.
NWT General Status Ranks: Secure
NatureServe Conservation Rank (NWT): S4
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Under consideration
Reasons for assessment or population trends: This large finch is widely distributed across Canada's forests, but has exhibited significant long-term declines (77-90%) over most of its range, since 1970. Over the past decades, some data suggest a further decline of nearly 40%, while other data indicate stabilization at a lower level. Threats to the species include reduced availability of mature and old-growth mixed wood and conifer forests, collisions with windows and mortality associated with feeding on grit and salt along roads in winter.
Sources used for assessment: COSEWIC status report (2016b), ENR (n.d.), Zhang et al. (2019)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[140] = 2.5		
Dependence on habitats that are sensitive to climate change[141]	Optimal evening grosbeak breeding habitat generally includes open, mature mixed wood forests, where fir species and/or white spruce are dominant and spruce budworm is abundant. The distribution of evening grosbeak in Canada closely matches the limits of the boreal shield, boreal plain and mountain cordillera ecozones. These regions are generally dominated by fir, spruce, larch, pine and aspen.	3 – Depends on sensitive habitats that are not rare.

[140] Overall sensitivity score is based on the average of habitat, abioticand biotic factor scores.
[141] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	The climate in the boreal forest and in a large portion of the evening grosbeak's Canadian range will likely be warmer and drier in the 21st century. Over the long term, habitat loss due to the anticipated contraction in the area covered by balsam fir forests is expected as a result of climate change. Studies suggest that balsam fir-dominated forest and spruce budworms will be greatly reduced in the northeastern United States and possibly in the southern portion of the breeding range of evening grosbeak in eastern Canada due to a northward shift in balsam firs and budworms as a result of increasing temperatures. Models using climate, land use and topography variables on the projected density of evening grosbeak in the boreal and hemiboreal forest in North America, on the other hand, predict that the species will increase by 93% in density by 2100 in the northernmost areas of Canada. Other models using climate data predict that climatically suitable core habitat range for evening grosbeak will increase by 45% for the 2071-2100 period. During this period, grosbeak densities are predicted to increase particularly in northwestern BC and Alaska. These latter results have to be viewed with caution as they do not take into account changes in the distribution of forests associated with climate change.	
Sensitivity to climate-relevant abiotic factors[142]		Unknown
Sensitivity to climate-relevant biotic factors[143]	In summer, this species can be a major predator of the spruce budworm and helps in the natural control of this insect pest. A total of eight species and 11 subspecies of spruce budworm exist in North America. Factors that trigger outbreaks include generally consecutive dry summers or spring and autumn droughts. The 25-40-year natural cycle of spruce budworm (especially in eastern Canada) is likely to have a greater influence on evening grosbeak numbers than any threats and largely correlates with declines in evening grosbeak populations since the 1970s. As	2 – Somewhat sensitive or possibly very sensitive.

[142] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.
[143] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

	there are no reliable abundance data from periods prior to spruce budworm outbreaks (i.e., before 1970), it is not possible to determine whether the current population is depressed or at levels which are normal for non-outbreak periods; however, one study suggests that population levels observed since 1995 are representative of a normal predator-prey cycle. Several studies generally agree that climate change may negatively affect the distribution and abundance of spruce budworm in Canada, notably in eastern provinces. Climate change is predicted to increase the annual temperature average in the eastern boreal forest, fire ignition, area burned and length of the wildfire season and the average range of precipitation. A more humid climate in eastern Canada could decrease the abundance of spruce budworm, which usually requires extended periods of drought to reach epidemic levels. Moreover, climate change could negatively impact spruce budworm as they depend on timely availability of new foliage. In addition to temperature, the timing of insect life cycles and bud flushing is also affected by photoperiod. Thus, it is conceivable that, with rapid changes in climate, the synchrony between bud burst and the emergence of feeding stages could become decoupled because of subtle timing differences in responses to cues determining the seasonality of the insect species concerned, causing a negative effect on insect populations. To a lesser extent, evening grosbeaks also feed on other defoliating insects that occur across the boreal forest during the breeding season such as forest tent caterpillar, jack pine budworm, larch sawfly and large aspen tartrix. Outside the breeding season, the species seems to depend largely on seed crops from various trees such as firs and spruces in the boreal forest. One study found that evening grosbeaks irrupt out of normal winter range when the seed-crop productivity of coniferous trees is low, which happens every two to three years. A prevalent hypothesis is that widespread masting in the boreal forest at high latitudes is driven primarily by favourable climate during the two to three consecutive years required to initiate and mature seed	

	crops in most conifers. Seed production is usually much reduced in the years following masting, driving evening grosbeaks to search elsewhere for food and overwintering habitat.	
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	There are no known threats to evening grosbeak in the NWT.	1 – No pressures.
Adaptive capacity[144] = 1		
Reproductive capacity[145]	Evening grosbeak is socially monogamous. There is one clutch per year with an average size of three to four eggs; re-nesting may occur if initial clutch fails. The age at first breeding is one year. Generation time three to four years. The longevity record for evening grosbeak in the wild is 15 years and three months. The maximum recorded age in Canada is 14 years and nine months.	1 – Early reproduction/many offspring
Dispersal capacity[146]	Evening grosbeak migratory movements can reach up to 3,400 km. The species demonstrates little breeding site fidelity.	1 - >10km
Genetic diversity	There have been no molecular or genetic studies on the Canadian evening grosbeak population.	N/A
Phenotypic plasticity		N/A

[144] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[145] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.
[146] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas	The primary concern under this category is collision with buildings, given that evening grosbeak is among the ten species in North America most frequently killed by window strikes near feeding stations. The impact of this threat is expected to be low overall, given that it likely affects a minority of the population and of those colliding with windows, some may survive. Bird feeders also have beneficial aspects for the species by providing supplementary food during harsh winter conditions.							**Neg.**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops	Evening grosbeak is sensitive to forest fragmentation caused by agricultural activities carried out at the southern limit of the boreal forest where the species is more abundant in contiguous forest than in forest fragments surrounded by agriculture.							**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing	See 2.1.							**N/A**
2.4 Marine and freshwater								**N/A**

aquaculture								
3. Energy production and mining								
3.1 Oil and gas drilling								**N/A**
3.2 Mining and quarrying								**N/A**
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads	Mortality related to ingestion of sodium chloride along roadsides may be a threat. In winter, flocks of evening grosbeaks are often observed along roadsides ingesting salt particles and grit. It is during winter that evening grosbeak has the greatest need to ingest grit to aid in the digestion of seeds. Such collisions have been known to be important at least locally. Examples include 2,000 evening grosbeaks found dead along a 16 km stretch of highway in southern BC in the early 1980s and another 500 birds along the same stretch of highway in 1974. These two reports coincide with a spruce budworm infestation in this region, which suggests that this threat could be more important when the species is at high densities. Given that many road mortalities are unreported; this may be a larger factor than has been documented.							**Neg.**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals								**N/A**
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and	Reduction of mature and old-growth mixed wood forests due to							**Neg.**

wood harvesting	commercial forest management since the 1950s has likely resulted in some decline in habitat availability. For example, >20 million ha of boreal forest (mainly mature and old stands) were harvested in Canada between 1975 and 2010, with an additional six million ha predicted to be harvested by 2020. Clearcut logging can include a short rotation time (i.e., 40-70 years) between harvests, which limits forests from reaching maturity and achieving a dense forest structure, both of which are important for evening grosbeak. Moreover, the practice of harvesting balsam fir and replanting with faster-growing species such as black spruce or jack pine in eastern Canada may reduce availability of suitable habitat for evening grosbeak through changing forest composition in favour of tree species known to be less susceptible to spruce budworm outbreaks. In northwestern Canada, mature mixed wood forests are also managed using techniques that reduce tree diversity in favour of trembling aspen stands. However, increased use of natural regeneration and attempting to replant to maintain similar tree species composition post-harvest may reduce the impacts of forest harvesting in western Canada if forest rotation ages are sufficiently long for favourable evening grosbeak habitat to develop. The impact of forest harvesting on the evening grosbeak population in Canada is difficult to assess in part because of differences in management practices and disturbance history between eastern and western Canada and the lack of studies addressing the response of this species to forestry practices.							
5.4 Fishing and harvesting aquatic resources								**N/A**

6. Human intrusion and disturbance									
6.1 Recreational activities									**N/A**
6.2 War, civil unrest and military exercises									**N/A**
6.3 Work and other activities									**N/A**
7. Natural system modifications									
7.1 Fire and fire suppression	Habitat availability has likely increased since 1850 as the interval between forests fires in Canada lengthened, resulting in higher balsam fir abundance across the boreal forest.								**Neg.**
7.2 Dams and water management/use									**N/A**
7.3 Other ecosystem modifications	Chemical insecticides, such as DDT (now banned in North America) and fenitrothion were used extensively to control spruce budworm from the early 1950s to the 1980s. In the case of fenitrothion, although its effects on evening grosbeak are unknown, a decline in abundance and probably mortality in several passerine species feeding in the crowns of trees following the application of this insecticide have been reported. In ON, two studies have noted that fenitrothion did affect forest arthropod density and forest bird behaviour but had no long-term effect on populations. With organophosphate pesticides, such as trichlorfor and carbaryl, one study reported that the enzyme cholinesterase is suppressed in evening grosbeaks in treated forests. Since the early 1980s, *Bacillus thuringiensis* (BT), a biological pesticide and tebufenozide have been the main products used to control spruce budworm in Canada. BT has very low toxicity to vertebrates, including birds and the toxin is specific to Lepidoptera larvae. However, the latter are an important food source for								**N/A**

	insectivorous forest birds and their control can have adverse effects on chick development and adult behaviour and energetics. The effects on evening grosbeak may therefore be negligible, but should be studied in more detail. The intensity of spruce budworm outbreaks is likely to be reduced in the near future in the commercial forests due to new approaches that are currently being assessed to control spruce budworm, such as remote sensing techniques to detect forest stands that are vulnerable to budworm defoliation (i.e., old and mature balsam fir stands). These techniques will be used to perform preventative logging well before outbreaks occur in such a way that fir forest density will be reduce and forest composition will be changed in order to produce unsuitable habitat for budworms. The impacts of these techniques of budworm prevention on evening grosbeak habitat are currently unknown but will likely reduce the amount and quality of habitat available for this species.							
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases								**N/A**
8.2 Problematic native species/diseases	In portions of the Atlantic provinces (especially NL and Cape Breton), over-browsing by moose and deer may limit regeneration of suitable habitat. The 25-40-year natural cycle of spruce budworm (especially in eastern Canada) is likely to have a greater influence on evening grosbeak numbers than any threats and largely correlates with declines in evening grosbeak populations since the 1970s. As there are no reliable abundance data from periods prior to spruce budworm outbreaks (i.e., before 1970), it is not possible to determine whether the current population is depressed or at levels which are normal for non-outbreak periods; however, one study							**N/A**

	suggests that population levels observed since 1995 are representative of a normal predator-prey cycle.							
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin	Various types of diseases have been reported as causing mortality in evening grosbeak in Canada. They include conjunctivitis caused by *Mycoplasma gallisepticum*, salmonellosis and infections by a parasitic mite, *Knemidokoptes jamaicensis*, which causes lesions to the feet and bill. At a local scale, the West Nile virus has also caused mortality in evening grosbeak in the eastern United States. The impacts of these diseases on evening grosbeak remain unknown, but could be significant given that a number of them are contracted in winter when the species adopts a gregarious behaviour and feeds with other potentially contaminated granivorous species at feeding stations.							**Neg.**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents	Among the different types of road salt used in Canada, sodium chloride and calcium chloride are the most widely used on paved roads and are known to be toxic to birds when taken in excess, because the kidney of terrestrial birds is not efficient at removing excess sodium. Evening grosbeak has a particularly strong attraction to salt, frequently consuming sodium chloride or calcium chloride along roadsides. Detailed data on acute toxicity of salt on evening grosbeaks and other songbird species is currently lacking, but exposure modeling studies on other birds (e.g. house sparrow), indicate that overconsumption of sodium chloride could cause a series of symptoms, including reduced vigilance and motor							**Neg.**

	function, which might be linked to the likelihood of motor vehicle strikes when flocks of evening grosbeaks feed on roadsides. When taken in excess, sodium chloride could also cause direct mortality due to dehydration if water is not available near feeding sites. Moreover, when evening grosbeaks eat snow and water containing high concentrations of salt on roadside for hydration, sodium chloride toxicity could cause direct mortality. Although the amount of salt used in Canada was higher prior to 1990 compared to modern techniques, the impact of this threat to evening grosbeaks needs further investigation as road salt is still widely and intensively used across parts of the species' winter range.							
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	The climate in the boreal forest and in a large portion of the evening grosbeak's Canadian range will likely be warmer and drier in the 21st century. Over the long term, habitat loss due to the	W	M	S	LT F	M	M	**Low**

	anticipated contraction in the area covered by balsam fir forests is expected as a result of climate change. Studies suggest that balsam fir-dominated forest and spruce budworms will be greatly reduced in the northeastern United States and possibly in the southern portion of the breeding range of evening grosbeak in eastern Canada due to a northward shift in balsam firs and budworms as a result of increasing temperatures. Moreover, with climate change, fire frequency is expected to increase, especially in central and western Canada, which could result in a decrease in the quantity of suitable habitat for evening grosbeak. In the northern portion of the species' range in eastern Canada, a contraction is also predicted to occur as fire will be more frequent and more intense due to a warmer and drier climate which in turn will negatively affect the capacity of fir to survive. Models using climate, land use and topography variables on the projected density of evening grosbeak in the boreal and hemiboreal forest in North America, on the other hand, predict that the species will increase by 93% in density by 2100 in the northernmost areas of Canada. Other models using climate data predict that climatically suitable core habitat range for evening grosbeak will increase by 45% for the 2071-2100 period. During this period, grosbeak densities are predicted to increase particularly in northwestern BC and Alaska. These latter results have to be viewed with caution as they do not take into account changes in the distribution of forests associated with climate change. Climate change may also directly impact food sources of evening grosbeaks such as spruce budworm. Several studies generally agree that climate change may negatively affect the distribution and abundance of spruce budworm in Canada, notably in eastern provinces. Climate change is predicted to increase the annual							

	temperature average in eastern boreal forest, fire ignition, area burned and length of the wildfire season and the average range of precipitation. A more humid climate in eastern Canada could decrease the abundance of spruce budworm, which usually requires extended periods of drought to reach epidemic levels. Moreover, climate change could negatively impact spruce budworm as they depend on timely availability of new foliage. In addition to temperature, the timing of insect life cycles and bud flushing is also affected by photoperiod. Thus, it is conceivable that, with rapid changes in climate, the synchrony between bud burst and the emergence of feeding stages could become decoupled because of subtle timing differences in responses to cues determining the seasonality of the insect species concerned, causing a negative effect on insect populations.							
11.2 Droughts	Increased frequency of droughts and wildfires in the NWT are expected, which may affect evening grosbeak habitat (ENR n.d.). However, species may shift northwards with climate change.							**Neg.**
11.3 Temperature extremes	There is an expected increase in the number of extreme heat events and a decrease in extreme cold events projected for the NWT. However, minimum and maximum temperature tolerance limits for this species are not known and a northward shift in this species is expected.							**Neg.**
11.4 Storms and flooding	An increase in precipitation events is projected for the NWT, which may impact spruce budworm availability. Impacts to evening grosbeaks are uncertain though (Zhang et al. 2019).							**Neg.**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Grey whale (*Eschrichtius robustus*)
Populations (if applicable): Northern Pacific Migratory (DU1)
Percentage of North American population NWT is responsible for: Small numbers of long-distance migrants reach the Canadian Beaufort Sea off the YT and NWT in the summer and autumn.
NWT General Status Ranks: Undetermined
NatureServe Conservation Rank (NWT): SNR
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Special Concern
Reasons for assessment or population trends: Grey whales migrate each year from their winter calving grounds in Mexico to their summer feeding areas in northern Alaska, Russia and Canada. The population increased by 2.5%/year following the cessation of whaling and peaked, within the range of pre-exploitation estimates, at about 27,000 animals in 1998. The extent of recovery of the summer resident group is unknown. However, over 1/3 of the population died from 1998-2002 (possibly due to a lack of food in Alaska). Birth rates, survival rates and other indicators suggest that the decline has ceased and that the population is stable or increasing since 2002. The whales are susceptible to human activities in their four breeding lagoons in Mexico, as well as to entanglement in fishing gear and collisions with boats throughout their range. Underwater noise associated with proposed oil development in BC could alter migration patterns. The small group of summer-resident whales could also be threatened by subsistence whaling in the USA.
Sources used for assessments: COSEWIC (2017d)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[147] = 1.5		
Dependence on habitats that are sensitive to climate change[148]	Extreme dependence on specific lagoons and embayments along the outer (Pacific Ocean) coast of Baja California, Mexico, for reproduction (Laguna Oja de Liebre, Guerrero Negro, Bahia Magdalena, Laguna San Ignacio). Grey whales have strong site fidelity, at least in regard to feeding areas.	2 – Generalist, but some sensitive habitats are important.

[147] Overall sensitivity score is based on average of habitat, abiotic and biotic factor scores.
[148] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

Sensitivity to climate-relevant abiotic factors[149]	Nothing noted.	Unknown
Sensitivity to climate-relevant biotic factors[150]	Best known as benthic foragers that rely heavily on amphipod crustaceans and other swarming organisms found in or on soft bottom sediment. Flexibility in prey choice may have been underappreciated at the northern feeding sites. Recent research has shown that they feed on a much broader range of organisms, suggesting that they are better characterized as opportunists. It remains true nonetheless that there is a close link between the productivity of benthic habitats in cold temperate to Arctic waters and the overall size and health of grey whale populations. The only significant predators of grey whales are killer whales, which take a particularly significant toll on young of the year during the spring northbound migration. Nearly all adults are heavily infested with ectoparasites and epizoites, including the barnacle *Cryptolepas rachianecti* and up to three species cyamids, or whale lice (*Cyamus scammoni*, *C. ceti*and *C. kessleri*).	1 – Not sensitive.
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	Noise from human activities is likely the most significant threat. This is considered a larger concern along the migratory corridor. Harvesting was a significant historical threat, but is generally accepted to be sustainable now. From an NWT perspective, there are few/minor non-climate threats.	1 – No pressures.

[149] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.
[150] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

Adaptive capacity[151] = 2.5		
Reproductive capacity[152]	Gestation period is 13-14 months and females give birth to a single calf at intervals of at least two years. Lactation lasts for about six months. The average age at sexual maturity is eight years and grey whales continue to grow until they are ~40 years old. The generation time for assessment purposes is estimated as 23.3 years.	4 – Late reproduction/few offspring
Dispersal capacity[153]	Strongly migratory animals, which winter and breed in warm temperate or subtropical waters and then migrate to cold temperate, subarctic and Arctic waters where they feed intensively through the summer and autumn. Annual migration distance of more than 18,000 km. Strong site fidelity, at least in feeding areas.	1 - >10km
Genetic diversity		N/A
Phenotypic plasticity		N/A

[151] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[152] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.
[153] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas	Grey whales are a major attraction in recreational whale-watching along the west coast of North America. Most whale-watching activity takes place during the summer months. No mention of such activity occurring in or planned for the NWT.							**Neg.**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling								**N/A**
3.2 Mining and								**N/A**

quarrying								
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads								**N/A**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes	Small numbers of grey whales (probably tens/years) from throughout the species' range (all DUs) die or are seriously injured as a result of entanglement or entrapment in fishing gear and due to ship strikes. A potential threat is degradation of prey as a result of dredging, dumping, or oiling, ocean acidification and climate change.	L	L	S	LTF	L	H	**Low**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals								**N/A**
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources	Whaling was the most obvious threat to grey whales historically but it is generally accepted that recent and current removals are adequately monitored, reported and at sustainable levels. Historically important to Indigenous people as subsistence and cultural resources. Removals by subsistence whalers in Russia (reportedly averaging 127/year from 2008-2012 from DU1) are considered sustainable. In addition, small numbers of grey whales (probably tens/years) from throughout the species' range (all DUs) die or are seriously injured as a result of entanglement or entrapment in fishing gear and due to ship strikes.							**Neg.**

6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression								**N/A**
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications								**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases								**N/A**
8.2 Problematic native species/diseases								**N/A**
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**

9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents	A potential threat is degradation of prey as a result of dredging, dumping, or oiling, ocean acidification and climate change. Their largely near-shore distribution and benthic or epibenthic feeding mode exposes grey whales to environmental toxins (e.g. from harmful algal blooms). However, there is no evidence, to date, that they have been seriously affected by such exposure. Since they regularly disturb and forage in bottom sediments, grey whales are clearly exposed to various contaminants. However, with one individual exception, no alarming levels of organochlorines or heavy metals have been detected.							**Neg.**
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)	Increased human activity is probably the main factor affecting grey whale habitat along the migratory corridor. This includes increased industrial noise and increased vessel traffic for shipping, resource extraction and recreation. Grey whales have been shown to avoid loud sources of industrial noise. Behavioural responses to boats range from actively seeking contact with boats to active avoidance. Although the importance of acoustic signals for communication and orientation in grey whales is poorly understood, it is known that they produce a variety of communicative sounds on both the breeding and feeding grounds and also during migration. An increase in anthropogenic noise in							**Neg.**

	grey whale habitat could negatively affect this acoustic communication. No mention of activities in Canadian Beaufort Sea.							
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Grey whales have been proposed as 'sentinels' of large-scale ecosystem change. The delay in the timing of their southbound migration, expansion of their feeding range along the migration route and northward into Arctic waters and the apparently growing tendency of some individuals to remain in polar waters throughout the winter months are probably all indications that North Pacific and Arctic ecosystems are in transition. In response to changing climatic conditions and sea level, grey whales have moved between the Atlantic and Pacific oceans multiple times over the last 100,000 years. The role of the Canadian Beaufort Sea as a summer and autumn feeding ground for grey whales remains poorly understood. However, it is clear that with the dramatic changes in ice conditions in this region, significant changes are occurring in the geographical extent and duration of grey whales' present. It seems likely that at least some individuals are moving farther east into Canadian waters and remaining there longer than was true as recently as a few decades in the past. It has also been suggested that remaining in the Beaufort Sea for the winter might offer grey whales (at least a few of them) a net metabolic advantage whereby the energetic costs of thermoregulation in cold water are offset by not undertaking the 10,000 km round trip migration and							**Neg.**

	remaining in northern seas to take advantage of spring forage. Years with low calf production may be associated with feeding seasons effectively shortened by extensive seasonal ice and suboptimal nutritive condition in pregnant females. The recent trend towards light ice conditions in the Bering Sea and increasing availability of grey whale foraging habitat in the Arctic may have a compensatory or offsetting effect. The effects of climate change, which are especially obvious and pronounced in high-latitude environments including the Arctic, where the sea ice regime has shifted dramatically in recent decades, are generally viewed as more positive than negative for grey whales, at least in the immediate future.							
11.2 Droughts								**N/A**
11.3 Temperature extremes	Increase of extreme heat events impact species that the grey whale feeds on, though the effects are unknown (Lee pers. comm. 2020).							**N/A**
11.4 Storms and flooding	Increase of storms and flooding events impact species that the grey whale feeds on, though the effects are unknown (Lee pers. comm. 2020).							**N/A**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Grizzly bear (*Ursus arctos horribilis*)
Populations (if applicable): Population groups (i.e., Delta grizzly bears, mountain grizzly bears and barren-ground grizzly bears) are not considered distinct.
Percentage of North American population NWT is responsible for: 7-9%
NWT General Status Ranks: Sensitive
NatureServe Conservation Rank (NWT): S3
***Species at Risk (NWT) Act*:** No status
***Species at Risk Act* (Canada):** Special Concern
Reasons for assessment or population trends: Of the overall population estimate of 4,000-5,000 grizzly bears in the NWT, only an estimated 2,000-3,000 are mature individuals. This is considered a small population. There is evidence of population stability or increase in some areas, but density throughout the NWT is naturally low and outside the Richardson and southern Mackenzie mountains is very low. Long-lived, low reproductive output, delayed age at maturity also contribute to vulnerability of this species. Although their range is apparently expanding, the reasons behind this expansion are not well understood.
Sources used for assessments: SARC (2017a, d)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[154] = 1		
Dependence on habitats that are sensitive to climate change[155]	Hibernation is one of the most notable aspects of grizzly bear life history. This is a key time for grizzly bears during which they are more vulnerable to disturbances and habitat changes (e.g. climate change altering timing of seasons). All grizzly bears in the NWT are expected to den for several months, unlike bears in southern North America. Grizzly bears prefer certain kinds of habitat. They prefer areas that are open, have abundant food resources and are not too warm during the summer months. Females with cubs may choose brushier areas however, to provide cover for the cubs. Shade and the particular habitat created by eskers on the barrenlands appear to be important in the summer.	1 – Broad generalist. Habitats that are important are not considered limiting.

[154] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.
[155] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	Eskers are also noted for supporting varied forage, which attracts animals such as caribou and grizzly bears. The wide distributional range of the species reflects their generalist approach to both habitat selection and diet.	
Sensitivity to climate-relevant abiotic factors[156]	Physiologically adapted to environmental stochasticity.	1 – Not sensitive.
Sensitivity to climate-relevant biotic factors[157]	It is likely that we can anticipate a lengthening of the growing season at higher latitudes, which may improve bear habitat in the north and allow the species to expand its range into the Arctic archipelago. Changes to habitat and vegetation, such as an expected increased range expansion of shrub species and concomitant declines in lichen abundance in the western Arctic tundra, may affect community dynamics including potential changes in food availability. However, grizzly bears are considered physiologically adapted to surviving long periods without food.	1 – Not sensitive.
Non-climate stressors = 2		
Sensitivity to potentially interacting non-climate pressures	The biggest threat to grizzly bears in the NWT is human-caused mortality. However, known mortality from all sources is at or near sustainable levels within the NWT. There is some concern regarding the mortality rate in the central/eastern barrens, which is impacted by harvesting from the Kitikmeot region in NU. Decreasing population trends in food sources (e.g. BGC, berries, sheep, and muskrat) is also of concern. Quarrying, roads and fire are less significant threats.	2 – Moderate pressures.
Adaptive capacity[158] = 2.5		
Reproductive capacity[159]	Although grizzly bears are long-lived, their reproductive output is very low. A female grizzly	4 – Late reproduction/few

[156] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.
[157] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).
[158] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.

	bear becomes sexually mature at four to five years, but most reproduce later (e.g. eight years). Litters of one to three cubs are produced approximately every four years. Mean age at first reproduction in the eastern barrens (8.1 years) is late compared to other grizzly bear populations. Age at first reproduction and interbirth interval for females is variable and influenced by habitat. Age at first reproduction is also related to body size and body size is predicted from environmental factors such as primary productivity.	offspring
Dispersal capacity[160]	Home ranges of grizzly bears in the NWT include the largest ranges reported for the species. They move quickly for their size (reaching speeds up to 90 km/hr). Especially impressive are the wide-ranging movements of subadult male grizzly bears in the central barrens, where movements between the Lac de Gras area and the Coronation Gulf can result in ranges exceeding 32,000 km^2 in a single year. Grizzly bears move widely across their habitat. They have the ability to travel by walking great distances without stopping. They are noted to be excellent swimmers and adept at maneuvering in the mountains, including scaling steeper slopes. Grizzly bears seem adept at moving between habitat types with ease. Dispersal in grizzly bears is a gradual process, taking one to four years.	1 - >10km.
Genetic diversity		N/A
Phenotypical plasticity	This species, like polar bears, have gone through genetic bottlenecks before and survived (Gau pers. comm. 2020).	N/A

[159] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.
[160] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling	The Inuvialuit have expressed concern about the Mackenzie Gas Project pipeline running through the Inuvik Grizzly Bear Management Area. It is thought that the presence of a pipeline would affect grizzly bear harvesting by causing grizzly bears to	L	L	S	LTF	L	L	**Low**

	move out of the area. Development may also function as a barrier to movement. However, in late 2017, the joint venture project was dissolved. The project certificate remains in place until 2022.							
3.2 Mining and quarrying	Because individual grizzly bears need large home ranges, avoidance of industrial projects and increased future resource development could potentially pose a significant threat by the removal of a large portion of effective habitat. The same loose gravel esker sites that bears would use for denning are also the same areas that would serve as borrow sources (i.e., sources of gravel for construction of roads and other infrastructure). However, mining and exploration activities, which may be intense in localized areas (e.g. immediately around diamond mines), are not expected to represent significant barriers to dispersal for grizzly bears at the population level. Permanent removal of suitable habitat by human activity within grizzly bear range remains relatively small in terms of the species' overall range in the NWT. The total land under mineral leased claims, typically for active mines and development activities, was approximately 8,700 km^2 in 2007, or about 0.7% of the NWT. Future development includes Prairie Creek lead/zinc mine (in grizzly habitat; builds on existing infrastructure and right of ways) and the Selwyn Project (in grizzly habitat; including mine construction, associated infrastructure and an access road). Environmental assessments (EAs) for both mines are complete. The NICO Project and the Nechalacho Rare Earth Element Project are not in grizzly bear habitat, but are within the summer range of the Bathurst herd, which is a key prey species. EAs for both these projects are complete. The proposed Izok Corridor Project (includes mine construction, all season access road and a port facility) is in the Kitikmeot region of NU and could have an impact on NWT grizzly bears.	L	L	C	N	M	L	**Low**

	There is some concern that grizzly bears range expansion north and east was the result of habitat loss from industry (along with forest fires and climate change) in other areas.							
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads	It is well-known that grizzly bear populations in areas of high road densities generally decline in distribution and abundance. Avoidance tends to be triggered at traffic volumes of more than ten vehicles/day, with most bears avoiding roads with a volume of 30 vehicles/day and all bears avoiding roads with a volume of 60 vehicles/day. CZC's all-season access road for Prairie Creek mine is anticipated to host 30 truck trips/day. Permanent removal of suitable habitat by human activity within grizzly bear range remains relatively small in terms of the species' overall range in the NWT. Average road density in the NWT, including all-season roads, is very small at 0.22 km/100 $km^2$and largely exists outside of grizzly bear range. Where roads have been established, road density remains much less than in other areas of Canada. Future projects of note include the proposed extension of Highway 4 into the Slave Geological Province and the development of the Mackenzie Valley Highway from Wrigley to Tuktoyaktuk. A 28 km all-weather haul road in the central barrens is currently under construction (Jay Pipe expansion) and there are regular discussions of an all-weather road to connect a deep-water portion of the Arctic coast to interior resource development. Regardless, grizzly bears are generally believed to have considerable plasticity in their foraging patterns, which allows for adaptation to altered environments. Grizzly bears can become habituated to human settlements and roads, even busy ones like the Dempster Highway, thus they may not act as	L	L	C	N	H	L	**Low**

	barriers/deterrents after some time has passed. Man-made trails and seismic lines can also be used by grizzly bears to move from place to place.							
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths	Helicopter traffic, for example for scientific and exploration purposes, was also thought to negatively affect bears and Inuvialuit hunters' ability to hunt bears.	L	L	C	N	H	L	**Low**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	Human-caused mortality is observed throughout all parts of the species' range in the NWT and can be a significant component of survival. Recent behavioural changes in grizzly bears (e.g. attraction to hunting activities) have been noted in the Mackenzie Mountains and there are already indications of increasing instances of human-grizzly bear interactions. Over the course of the last decade, hunters have observed that grizzly bears have gone from being deterred by the sound of gunshots to being attracted to them. Some hunters feel that grizzly bears have lost their fear of humans as the grizzly bear harvest has decreased, resulting in a human safety issue. Bears receiving anthropogenic food rewards in response to particular behaviours tend to quickly become food-conditioned. Habituation, by contrast, is the loss of fear of humans as a result of a lack of negative reinforcement. Both processes can contribute to negative bear-human interactions. For human-grizzly bear interactions, non-lethal removals are often not effective and management kills of grizzly bears are generally the outcome of conflicts where they occur in the NWT. Defence of life and property (DLP) kills remain a substantial proportion of all known human-caused mortalities in the NWT (~28% of the total; 171/614 since 2001).	W	M	C	N	H	M	**Low**

	Overall rate of known human-caused mortalities is 42.2 bears/year throughout the NWT. A human-caused mortality rate of less than 1.0% seems likely. 2.8% is suggested as the sustainable kill rate where conditions are less than ideal (i.e., in areas where primary productivity is <1,000 g/m^2/year) and only 1.1% in low quality habitats where primary productivity is very low, such as the central barrens of the NWT/West Kitikmeot (primary productivity is <600 g/m^2/year). Bears in this area will be most vulnerable to over-harvest. In the NWT, kill is likely sustainable, even in these areas. That being said, grizzly bears of the North Slave region move freely between this region and the Kitikmeot region of NU. Combining the Kitikmeot and North Slave harvests would result in an annual harvest closer to 3% in this region, which is higher than the 1.1% sustainable rate for this habitat. In the ISR, grizzly bears are managed under a co-management system that includes provisions for quotas (62/year) in established community hunting areas, which are incorporated into community bylaws and regulations under the NWT's *Wildlife Act*. A similar quota system is in place in the Gwich'in Settlement Area (12/year) although this quota is not legally binding. Both quotas are male-biased and include subsistence harvest, DLP kills, sport hunting and illegal kills. Outside of the Inuvialuit Settlement Region and Gwich'in Settlement Area, grizzly bear harvest falls under the *Wildlife Act.* There is a lifetime harvest maximum of one grizzly bear/resident hunter in the Mackenzie Mountains. All non-resident and non-resident alien harvest is restricted to the Inuvialuit Settlement Region, must be undertaken through an outfitter and is subject to quotas. With the exception of the Inuvialuit Settlement Region and Gwich'in Settlement Area, there are no limits on subsistence harvest in the NWT. Additionally, the *Big Game Hunting Regulations* prohibit hunters from hunting							

	grizzly bears in dens or any grizzly bear accompanied by a cub. The *Wildlife Act* prohibits breaking into, damaging, or destroying dens. Aversive conditioning programs have been implemented throughout the NWT to take advantage of bears' ability to modify their behaviours. The current level of harvest in the NWT is also likely to be sustainable because of the overall male-biased kill ratio. There may be some unanticipated changes to local population dynamics with sex-biased harvested though (shift in age structure, smaller-sized bears, lower reproductive rates, lower mean litter size, lower age at first reproduction).							
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression	Stochastic natural events such as forest fires are a threat to grizzly bear, both as a mortal danger and through loss of habitat and food resources. Traditional knowledge indicates that grizzly bears will leave an area if they spot forest fire smoke, especially mothers with cubs. Bears will return to the area eventually, but it may take	W	L	S	N	M	L	**Low**

	some time. The impact at a population level is unclear though. Grizzly bears tend to favour open habitat and in this context, the absence of regular fires may adversely impact grizzly bears that occur in the forested areas of the NWT. In contrast, wildfires that remove habitat for key prey species such as BGC may be detrimental.							
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications	Generally declining trends in BGC have been documented throughout North America; the Porcupine herd appears to be the only exception. The potential for this to influence grizzly bear numbers in the NWT is not yet known; however, the loss of this major food source could place a significant burden on the grizzly bears of the NWT. Further, the Gwich'in Renewable Resources Board has noted declines in berries over the past three years, a steep decline in the muskrat population, low numbers of dall's sheep in the Richardson Mountains (<500 animals) (2016), as well as declines in the ground squirrel and rabbit populations in the Gwich'in Settlement Area, the last of which they attribute to an increase in predator species, including grizzly bears.	W	M	C	N	M	M	**Medium**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases	Potential for northward expansion of pathogens due to climate change (GNWT pers. comm. 2020).							**Neg.**
8.2 Problematic native species/diseases								**N/A**
8.3 Introduced genetic material	Grizzly bears and polar bears interact in the northern part of the grizzly bears' range and this sometimes results in hybridization. Instances of hybridization should perhaps not be surprising, as the polar bear evolved from the grizzly bear. The extent to which hybridization poses a conservation risk to either grizzly bears or							**Neg.**

	polar bears is unknown.							
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents								**N/A**
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste	Waste dumps may attract grizzly bears. Ineffective waste management practices that attract bears to areas inhabited by people (e.g. communities, human camps) may ultimately result in bears needing to be destroyed to maintain human safety. This may also result in habituation and increase the potential for encounters with humans. As noted above (threat 5.1), DLP kills remain a substantial proportion of all known human-caused mortalities in the NWT (~28% of the total; 171/614 since 2001), although total known human-caused mortality within the NWT is thought to be sustainable at this time. Changing behaviour of bears has already been noted in some regions (e.g. the Mackenzie Mountains); although it's unclear whether or to what degree this is attributable to waste management practices at camps and settlements. However, after internal discussions with Municipal and Community Affairs (MACA), steps towards implementation of the	L	M	C	N	H	M	**Medium**

	joint ENR/MACA strategy and a dramatic increase in 2019 bear mortalities at landfills across the NWT, there is heightened awareness of the landfill-wildlife interface, in particular for bear (Gau pers. comm. 2010).							
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)	Development activity may spook either grizzly bears or potential prey with noise. However, grizzly bears may become habituated to human presence and human noise after some time and man-made noises may even attract bears. However, loud noises such as a generator and engine noises such as skidoos, helicopters, or airplanes, may spook bears and cause them to leave an area. In addition, construction and construction noise has the ability to threaten bears that are denning or cause harassment.	L	L	C	N	H	L	**Low**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides	Slumping may increase with climate change (GNWT pers. comm. 2020).							**Neg.**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	It is likely that we can anticipate a lengthening of the growing season at higher latitudes, which may improve bear habitat in the north and allow the species to expand its range into the Arctic archipelago. Changes to habitat and vegetation, such as an expected increased range expansion of shrub species and concomitant declines in lichen abundance in the western Arctic tundra, may affect community dynamics including potential changes in food availability (note: changes in food availability not clearly linked to climate change are covered in threat 7.3). Members of the Łutsel K'e Dene First Nation have observed fewer berries (cranberries and blueberries) in recent years (2010-2015).	W	U	C	LTF	L	M	**Low**

	Blueberries also appear to be smaller in size than in earlier years. In 2014, members observed later than usual emergence of raspberries. These trends are associated with lower rainfall (2012-2014) and increasing fire frequency. Climate change may contribute to dry or bad berry years, forest fires, flooding, as well as delayed freeze-up, earlier spring, hotter summers, rainy years or other extreme/unusual climatic conditions. These changes could affect the seasonal behaviour or food supply of grizzly bears. For example, an earlier spring may result in grizzly bears exiting their dens too early, before adequate food is available. Rainy years, along with other conditions, can change river banks through erosion, making it difficult for bears to travel. Climate change may also be resulting in an increase in brush, making it difficult for all animals to travel, including grizzly bears. In general, the impact of climate change on grizzly bears in the NWT is speculative.							
11.2 Droughts	Increased droughts and resultant forest fires are expected. The effects of these events on grizzly bears remain uncertain. However, it is possible that the resultant habitat loss could limit the northward shift of grizzly bears (Lee pers. comm. 2020).							**Low**
11.3 Temperature extremes	The impact of warmer summer temperatures is noted as being partially responsible for the north-eastward expansion of grizzly bears.							**Neg.**
11.4 Storms and flooding	Stochastic natural events such as floods are a threat to grizzly bear, both as a mortal danger and through loss of habitat and food resources. It is thought that flooding in the Mackenzie Delta may have reduced the grizzly bear population in the last several years, either through drowning, starvation (the flooding having affected the food supply), or through emigration to the mountains.	L	U	S	STF	M	L	**Low**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Hairy braya (*Braya pilosa*)
Populations (if applicable):
Percentage of North American population NWT is responsible for: The entire known/confirmed population of this species occurs in the NWT.
NWT General Status Ranks: At Risk
NatureServe Conservation Rank (NWT): S2
***Species at Risk (NWT) Act*:** Threatened
***Species at Risk Act* (Canada):** Endangered
Reasons for assessment or population trends: Range is severely limited. There are only five known locations, but may be more on Cape Bathurst and Baillie Islands. Coastal habitat is declining (ten m/yr. erosion) and this is expected to increase. Hairy braya only exists on Cape Bathurst peninsula and Baillie Islands in the NWT, so there is no possibility of rescue from outside populations. The ability to expand its range is limited. Hairy braya has specialized habitat requirements. It does not compete well with other plant species when establishing or colonizing new areas.
Sources used for assessments: SARC status report (2012b)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[161] = 3		
Dependence on habitats that are sensitive to climate change[162]	Hairy braya is restricted to the NWT. Its current range is limited to an area that escaped Pleistocene glaciation. The plant occurs on bluffs and dry uplands composed of calcareous sandy loam and silty clay soils. These areas of suitable habitat are separated from other suitable habitat by large areas of wet tundra. In addition, strips of potential habitat along the coast are often fragmented by erosion or salinization due to sea spray and storm waves overtopping coastal bluffs. Hairy braya may require stable habitats over long periods of time (i.e., longer than the 15,000 years that have elapsed since the last glacial maximum) in order to establish and maintain viable populations. Erosion is occurring (currently at ten m/year) and this	4 – Depends on sensitive habitats that are rare.

[161] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.
[162] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	is expected to increase due to rising sea level. There is a possibility of random events such as storm surges flooding low-lying areas where the bulk of the population occurs, leading to salinization and erosion.	
Sensitivity to climate-relevant abiotic factors[163]	Salinization is affecting coastal habitat, resulting in population decline. No other information on abiotic factors noted.	3 – Likely very sensitive.
Sensitivity to climate-relevant biotic factors[164]	Like other *Braya* species, hairy braya appears to be a poor competitor, requiring bare soil to become established. In some cases, areas of bare soil occupied by hairy braya were the result of the erosion of coastal bluffs and in other cases they were caused by disturbance due to caribou hooves. However, most commonly bare soils supporting hairy braya subpopulations appear to be the result of seasonal periods of standing water that eliminate most other plant species from small depressions in otherwise dry habitats. Once established, mature hairy braya plants can withstand some encroachment by other plant species.	2 – Somewhat sensitive or possibly very sensitive.
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	The extremely remote location means there is currently little human disturbance. Climate change is the most significant plausible threat for this species.	1 – No pressures.
Adaptive capacity[165] = 3.5		
Reproductive capacity[166]	Generation time is unknown. The species appears to be a long-lived perennial (of at least ten-15 years). The life cycle and reproduction of hairy braya have not been studied. Hairy braya is likely cross-pollinating. Since the seeds of hairy braya are neither more nor less adapted for dispersal than those of other *Braya* species that are more widely distributed, the narrow distribution of hairy braya is probably due to the fact that out-crossing plants, as hairy braya is presumed to be, are not able to generate new populations from the establishment of a single individual in a new area.	3 – Late reproduction/many offspring

163 For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.
164 Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).
165 Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
166 Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.

Dispersal capacity[167]	The only known populations of the plant are limited to an area that escaped Pleistocene glaciation and is surrounded by glaciated lands. As such, range expansion is unlikely. The ability of hairy braya to disperse between patches of suitable habitat is unknown, but neither the fruits nor the seeds of the plant are adapted for long-distance dispersal.	4 – <0.25km
Genetic diversity		N/A
Phenotypic plasticity		N/A

[167] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling								**N/A**
3.2 Mining and quarrying								**N/A**
3.3 Renewable								**N/A**

energy								
4. Transportation and service corridors								
4.1 Roads and railroads								**N/A**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals								**N/A**
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression	Loss of habitat due to soot deposits (together with coastal erosion) from oil shale fires that have been burning along the eastern banks of the peninsula at least since 1826 may have eliminated hairy braya from some areas of potential habitat.							**Neg.**
7.2 Dams and								**N/A**

water management/use								
7.3 Other ecosystem modifications	The recent decline of caribou in the Cape Bathurst region may have also reduced hairy braya habitat, since at least some habitat is associated with disturbance due to caribou hooves; caribou numbers are now low but stable.							**Neg.**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases								**N/A**
8.2 Problematic native species/diseases								**N/A**
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents								**N/A**
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and								**N/A**

solid waste								
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	The well-documented decrease in arctic sea ice over the past few decades has increased the duration and severity of storm surges that are likely hastening the erosion of hairy braya habitat along the coast. Recent erosion rates have been approximately nine to ten m/yr. over the past 38 years for some coastline areas of Cape Bathurst peninsula. The total number of individuals in the one coastal subpopulation that was visited in both 2004 and 2011 has plummeted from several hundred to approximately 100 individuals over that seven-year period because of erosion of habitat. Due to warming of the earth's atmosphere, which is expected to continue into the foreseeable future, it is expected that sea levels in the region will increase by 0.2-1.0 m over 100 years and protective sea ice will continue to decline, so coastal erosion rates will likely increase and the probability of storm surges will likely also increase. Sites along the coast are also destroyed by salinization, potentially at a greater rate than erosion itself. The complete loss of all at risk coastal subpopulations would reduce the total number of mature individuals by approximately	L	H	S	N	H	H	**High**

	15%. When the at risk subpopulations are gone the number of mature individuals may stabilize. Habitat loss due to coastal erosion is clearly understood. Based on estimated rates of coastal erosion, all subpopulations within one km of rapidly eroding northwest-facing shorelines face extirpation within about 100 years. The rates of coastal erosion were estimated based on current sea level in the Beaufort Sea and on current frequencies of storms.							
11.2 Droughts								**N/A**
11.3 Temperature extremes								**N/A**
11.4 Storms and flooding	See 11.1.	L	M	S	N	H	H	**Med.**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Harris' Sparrow (*Zonotrichia querula*)
Populations (if applicable): N/A
Percentage of North American population NWT is responsible for: The species breeds along the treeline in northern Canada (NWT, NU, SK, Manitoba and irregularly ON) and winters in the central midwest region of the United States.
NWT General Status Ranks: Undetermined
NatureServe Conservation Rank (NWT): S3
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Special Concern (listing under consideration)
Reasons for assessment or population trends: This northern ground-nesting bird is the only songbird that breeds exclusively in Canada. Data from Christmas bird counts in the United States midwest wintering grounds show a significant long-term decline of 59% over the past 35 years, including 16% over the past decade. The species may be affected by climate change on the breeding grounds, while the threats on the wintering grounds include habitat loss, pesticide use, road mortality and predation by feral cats.
Sources used for assessments: COSEWIC (2017c), ENR (n.d.)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[168] = 1.7		
Dependence on habitats that are sensitive to climate change[169]	Harris' sparrow favours a mosaic of upland and tundra, with scattered lakes. Breeding territories typically include coniferous trees; densities are highest where forest stands are dominated by spruce or tamarack, interspersed with shrubs typically <1 m tall. Densities have been observed to decline with decreasing tree and understory vegetation abundance. The species infrequently nests in areas where trees are absent; in these cases, shrub cover is particularly important for nest placement and concealment. Favoured breeding habitat typically has small, isolated forest stands (ranging from a small clump of trees to 12 ha) interspersed throughout the breeding territory. In winter and during migration, the species frequents a variety of habitats, with riparian thickets, grasslands,	2 – Generalist, but some sensitive habitats are important.

[168] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.
[169] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	woodland edges, hedgerows and willow thickets commonly used.	
Sensitivity to climate-relevant abiotic factors[170]	In the NWT, mean nest entrance orientation is at 140.5°, which is 170° away from the direction of prevailing storms. Relatively little information on the species physiology exists. Optimum temperature for Harris' sparrows during incubation was between +10°C and +20°C, allowing females to leave the nest for longer periods to forage and to return less frequently to tend to eggs. Temperatures above +20°C have resulted in adults attending the nest more frequently in an effort to provide shade and to help regulate fledgling body temperature. Harris' sparrows were also found to be poorly adapted to extreme temperatures during nesting, specifically when temperature reached above +30°C and below -10°C. During periods of inclement weather, birds abandon newly acquired breeding territories, returning to resume nesting after the inclement weather has passed. This strategy is beneficial when birds have not initiated egg-laying; however, it is detrimental and can be fatal to young birds or eggs recently laid.	2 – Somewhat sensitive or possibly very sensitive.
Sensitivity to climate-relevant biotic factors[171]	Harris' sparrows consume a wide variety of plant species, including sedges, bulrushes, birch, pigweed, lamb's quarters, blueberry, crowberry and bearberry. Berries are particularly important to Harris' sparrow when the birds first reach the breeding grounds and insects have not yet emerged.	1 – Not sensitive.
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	In the NWT, threats are primarily related to climate change (changing distribution of pest/predator ranges, habitat shifting and temperature extremes). Other factors are considered negligible at this time.	1 – No pressures.
Adaptive capacity[172] = 1		
Reproductive capacity[173]	Average clutch size is 4.07 eggs, with a range of three to five. Research on the Thelon River, NWT,	1 – Early reproduction/many

[170] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.
[171] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).
[172] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.

	documented a hatching rate of 76%, fledging rate of 62.5%and overall nest success rate of 47.5%, with 2.07 fledged young per pair. Generation time is two to three years. There is a clinal increase in clutch size as latitude increases. The species only initiates second broods if the first brood has failed before the eggs have hatched. The age for birds to first breed is not known; however, it is believed to be one year. The longevity record is 11 years, eight months.	offspring
Dispersal capacity[174]	Medium-distance temperate migrant. No significant barriers to dispersal and movement have been identified. After fledging, juveniles disperse up to 500 m from natal sites. Fidelity to breeding sites is not noted.	1 - >10km
Genetic diversity		N/A
Phenotypic plasticity		N/A

[173] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.
[174] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas	Residential and, to a lesser extent, commercial developments may be removing suitable wintering habitat for Harris' sparrow; however, development is largely confined to the fringes of existing urban areas. Window kills may represent the greatest concern with respect to this threat; however, no studies have specifically documented the frequency of window kills of Harris' sparrow. Overall low human population within the breeding grounds not expected to affect the species.							**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas	May be some slight impact through the breeding grounds associated with lodges; unknown to what extent, however.							**Neg.**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops	Throughout the wintering grounds in the midwestern US, the conversion of grassland and fringe lands for agricultural purposes is thought to be a factor in the decline of Harris' sparrow, though it is unknown to what extent. Within the species' northern wintering range limit (i.e., Nebraska, South Dakota, Iowa, Missouri and Kansas), approximately 530,000 ha of grass-dominated land cover was converted to cropland between 2006 and 2011; similar changes have been documented in the core wintering range in Texas, Nebraska, Kansas and Oklahoma and are negatively affecting a suite of grassland species in this region. Clearing of hedgerows and other shelterbelts in association with agricultural							**N/A**

	intensification and the reduction of fringe lands may be particularly detrimental towards the species. However, because Harris' sparrow uses open habitat and may feed on waste grain, the net effect of agriculture is unknown at this time. Threat applies primarily to winter range and to a lesser extent migratory route, but not breeding range.							
2.2 Wood and pulp plantations	This threat could be present in the wintering range to a minimal extent.							**N/A**
2.3 Livestock farming and grazing	Pasture land may provide good habitat, with a mix of grassy and shrubby areas.							**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling	Oil and gas and renewable energy developments may represent potential threats to a wide group of species, including Harris' sparrow, given the large areas required for infrastructure placements and potential causes of mortality, especially at wind energy facilities. However, these potential impacts have not been studied with respect to Harris' sparrow in particular and it has been noted that right of way areas may actually be beneficial for the species. Minimal scope within breeding range; somewhat more within wintering range, but severity is unclear because pipeline right of way habitat can be attractive for this species and disturbance would be limited to development periods. Fracking is occurring in parts of the wintering grounds, but effects on Harris' sparrow have not been documented.							**Neg.**
3.2 Mining and quarrying	Within the breeding range, concerns include habitat loss linked to deforestation near the northern edge of the species' range							**Neg.**

	associated with quarries and mine development. Some mining and exploratory quarries expected to be developed within the breeding range in the near future. With a conservative 10 km buffer around each proposed mine, this could account for 2.8% of the breeding range, but the primary effect of direct habitat loss would be limited to a fraction of this area, although some less intense effects of noise and dust may extend farther. This threat does not apply to the wintering grounds.							
3.3 Renewable energy	See 3.1. Some solar and wind energy developments exist within the wintering range and more are likely to be built, but effects on this species are unclear.							**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads	Human activities such as mining and road construction occur within the breeding range; the extent to which they affect breeding habitat remains unclear, but overall rate of change to breeding habitat is likely to be low. Most Harris' sparrows are exposed to roads on their wintering grounds and as terrestrially foraging birds, they may be at risk of vehicle collisions, though only a small percentage of individuals are likely to be affected and the overall effect is likely low. Few roads and railroads exist on breeding grounds, though this is increasing somewhat.							**Neg.**
4.2 Utility and service lines	Transmission and distribution lines are unlikely to pose more than a negligible collision risk and may actually be neutral or beneficial to Harris' sparrow on the wintering grounds by providing suitable habitat.							**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals								**N/A**
5.2 Gathering terrestrial plants								**N/A**

5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities	Very low human population throughout the breeding range and even on wintering range, effects of recreational activities expected to be negligible.							**Neg.**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression	Within the breeding range, concerns include habitat loss linked to deforestation near the northern edge of the species' range associated with forest fires. Within breeding range, fire has potential to negatively affect nesting success in a given year, but also to positively affect the species through creating habitat openings suitable for nesting.							**Neg.**
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications								**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases	Cat predation is a possible threat on wintering grounds, given the overall extent of this issue and the particular vulnerability of birds that forage terrestrially; while no reports have specifically addressed cat predation on Harris' sparrow to date and it is nonetheless likely a credible concern.							**N/A**

8.2 Problematic native species/diseases	Habitat loss linked to deforestation and climate change near the northern edge of the species' range may reduce suitable breeding habitat while allowing ectoparasites (e.g. biting midges) and mosquitoes and mammalian predators, such as red fox, to spread north, negatively impacting nestling Harris's sparrows. Fledging mortality in the NWT has been noted to be primarily due to predation, with Arctic ground squirrels and, to a lesser extent, short-tailed weasels, as the principal predators of young. Increases in the population of various raptors (e.g. sharp-shinned hawk, Cooper's hawk and peregrine falcon) may be resulting in greater predation risk on Harris' sparrow through its annual cycle, although it is unclear to what extent.	W	U	S	ST F	H	L	**Low**
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents								**N/A**
9.3 Agricultural and forestry effluents (including erosion)	Pesticide use throughout the wintering grounds has been linked to declines in grassland birds. Neonicotinoids in particular have been implicated in widespread declines of a variety of taxa in the last decade. The degree to which pesticides have historically or are currently affecting Harris' sparrow is unclear.							**N/A**
9.4 Garbage and								**N/A**

solid waste								
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Within the breeding range, concerns include habitat loss linked to deforestation near the northern edge of the species' range associated with climate change and forest fires. Quantitative effects of climate change are not known; however, anecdotal evidence suggests that shifting of the treeline north may affect the species, potentially both positively (e.g. increased abundance of shrub species beneficial for foraging and nesting) and negatively (e.g. reduced suitable habitat at the southern edge of the species' range; i.e., northern Manitoba). Climate change may reduce the forest-tundra zone located along the southern edge of the species' breeding range and potentially result in a geographic shift northwards. The species' response to treeline shifts northward is supported through the change in observations of the species in the Churchill, Manitoba region dating back to the 1930s, when the species was more common, compared to the present day.	W	U	S	LTF	M	L	**Low**
11.2 Droughts	An increase in drought and forest fires are projected in the NWT that may alter the breeding habitat of Harris' sparrows. It is uncertain how this would impact the breeding range. The treeline is also expected to respond (higher or lower) depending on the current condition of the forest (ENR n.d.).	W	U	S	LTF	L	L	**Low**

11.3 Temperature extremes	Relatively little information on the species physiology exists. Optimum temperature for Harris' Sparrows during incubation was between +10°C and +20°C, allowing females to leave the nest for longer periods to forage and to return less frequently to tend to eggs. Temperatures above +20°C have resulted in adults attending the nest more frequently in an effort to provide shade and to help regulate fledgling body temperature. Harris' sparrows were also found to be poorly adapted to extreme temperatures during nesting, specifically when temperature reached above +30°C and below -10°C. The species is vulnerable to extreme temperature fluctuations during nesting, when chicks are unable to cope with body heat regulation. It is possible that climate change may bring greater temperature fluctuations, but likely only in the longer term and severity is difficult to predict at this point.	L	U	S	LTF	M	L	**Low**
11.4 Storms and flooding	During periods of inclement weather, birds abandon newly acquired breeding territories, returning to resume nesting after the inclement weather has passed. This strategy is beneficial when birds have not initiated egg-laying; however, it is detrimental and can be fatal to young birds or eggs recently laid. Climate change may result in more severe weather events which could have negative impacts on survival rates of nestlings.	L	U	S	STF	M	L	**Low**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Horned Grebe (*Podiceps auritus cornutus*)
Populations (if applicable): Western population
Percentage of North American population NWT is responsible for: ~92% of breeding range in Canada. Based on available breeding bird survey data, the highest nesting densities are located in the Prairie Pothole Region of southern AB, SK and Manitoba. The species also breeds at unknown densities in boreal and subarctic zones, including the YT, southern parts of NU. High densities have been recorded near Yellowknife; however, these densities are not representative of a broad area of Taiga Shield/Taiga Plains habitat (ECCC 2020).
NWT General Status Ranks: Sensitive
NatureServe Conservation Rank (NWT): S3
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Special Concern
Reasons for assessment or population trends: Approximately 92% of the North American breeding range of this species is in Canada and is occupied by this population. It has experienced both long-term and short-term declines and there is no evidence to suggest that this trend will be reversed in the near future. Threats include degradation of wetland breeding habitat, droughts, increasing populations of nest predators (mostly in the prairies) and oil spills on their wintering grounds in the Pacific and Atlantic Oceans.
Sources used for assessments: COSEWIC (2009c), ECCC (2020)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[175] = 2.3		
Dependence on habitats that are sensitive to climate change[176]	The horned grebe breeds primarily in temperate zones such as the prairies and Parkland Canada, but can also be found in more boreal and subarctic zones. It generally breeds in freshwater and occasionally in brackish water on small semi-permanent or permanent ponds, but it also uses marshes and shallow bays on lake borders. Breeding areas require open water rich in emerging vegetation, which provides nest materials, concealment and anchorage and protection for the young. The horned grebe primarily uses eutrophic environments, although it is also able to	3 – Depends on sensitive habitats that are not rare.

[175] Overall sensitivity score is based on the average of habitat, abiotic and biotic factors.
[176] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	breed successfully on oligotrophic ponds. The breeding range of the western population covers most of the Prairie, Boreal Plains, Taiga Plains, Taiga Cordillera, Montane Cordillera and Boreal Cordillera ecozones. Wetlands account for approximately 25% of the area of these ecozones (3.5-45.7%, depending on the ecozone). Near Yellowknife, nests occurred primarily in cattail or flooded willows and sedge. Cattail and sphagnum species were present in 83%, 75%and 41% respectively of all horned grebe nests. Little information is available on the particular requirements of the horned grebe during migration, but it has been observed on lakes, rivers and marshes. Some birds follow coastlines as part of their migration. Horned grebes generally winter in marine habitats, mainly estuaries and bays. Birds are found in greatest numbers in coastal habitats, including areas that offer some degree of protection. Site and mate fidelity have been observed in horned grebes. In Alaska, horned grebes show fidelity to certain lakes or to the region in which they were banded during the moulting periods (July and August). Temporary loss of wetlands during droughts can negatively impact horned grebe populations. All of their life stages are tied to water.	
Sensitivity to climate-relevant abiotic factors[177]	The dates of nest-building and egg-laying initiation can vary considerably from year to year depending on weather conditions. High spring temperatures favour early egg laying. The horned grebe is vulnerable to changes in water quality near its breeding sites. In particular, it generally occupies small, shallow ponds that are sensitive to eutrophication, drainage and drought. Some birds winter on inland lakes and rivers in areas where the minimum temperature in January is higher than -1°C.	3 – Likely very sensitive.
Sensitivity to climate-relevant	The horned grebe is aggressive when defending its territory, rarely leaving its nest unguarded.	1 – Not sensitive.

[177] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

biotic factors[178]	Its diet consists primarily of aquatic insects and fish in the summer and fish, crustaceans and polychaetes in the winter. The horned grebe is a diver that catches and eats most of its prey underwater, bringing larger prey items, such as certain fish and amphibians, to the surface before swallowing them. It also picks insects from the water surface and from aquatic plants.	
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	Threats in the NWT are not explicitly identified in the status report. It is plausible the increasing populations of magpies in and around Yellowknife could pose a threat, as could the development of drought conditions, but these have not been examined in the NWT.	1 – No pressures.
Adaptive capacity[179] = 1.5		
Reproductive capacity[180]	The horned grebe generally breeds in its first year. It can rebuild its nest and lay up to four replacement clutches if previous clutches are destroyed. In the western population, reported clutch sizes vary from an average of 5.3-5.9 eggs/clutch and hatching success from 30.3-60%. The average number of young produced has been reported at 2.2/successful nest (i.e., those fledging at least one young, range 1.6-2.6) and 1.4/breeding pair (range 0.6-2.0). Generation time is four years.	1 – Early reproduction/many offspring
Dispersal capacity[181]	Long-distance migrant. Site fidelity has been observed. In Alaska, horned grebes show fidelity to certain lakes or to the region in which they were banded during the moulting period. The size of the area defended may range from 0.05-2.70 ha.	2 – 1-10km
Genetic diversity	The birds of the two populations in Canada show some genetic differences. According to phylogenetic analyses based on mtDNA, the horned grebe of Iceland and North America (including the Magdalen Islands) form a single phylogenetic group. The mtDNA haplotypes form a classic 'star-shaped' haplotype network, the	N/A

[178] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenologyand disease).
[179] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[180] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.
[181] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

	pattern expected if all populations descended from a single ancestral population that grew fairly rapidly (or alternatively that experienced a selective sweep in mtDNA). The horned grebe nonetheless demonstrates significant differentiation in its global population at the mtDNA level and in amplified fragment length polymorphism (AFLP). Moreover, the moderate but significant genetic differentiation observed in mtDNA is well distributed between the two subspecies (i.e., between Iceland and other North American sites) and among the three disjunct parts of the range that were analyzed separately (western North America, Quebec, Island). Conversely, no significant genetic variation has been observed among sites located in western North America. Results from the AFLP analysis suggest four distinct groups: Iceland, Quebec, the west central sites (AB, Manitoba, YT and NWT).	
Phenotypic plasticity		N/A

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas	See 2.1.							**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops	In the prairies, wetlands have been impacted severely by conversion of grassland to cropland and wetland drainage. Gross wetland loss over the period 1985-2001 was 5% and the results for all ecoregions indicate a declining trend in wetland areas. Low prairies, wet meadows and shallow marshes made up 50% of the total loss, cultivated wetland cover 40% and deep marsh and open water habitats combined almost 4% of lost wetland areas. The annual rate of net wetland loss (number of wetlands) between 1985-1999 for the three prairie provinces is 0.48% (AB), 0.24% (SK), and 0.32% (Manitoba). There has been little change in the rate of wetland loss in recent decades. The main causes of loss include agriculture (67%), rural development (10.3%) and other uses (22.7%). The massive destruction and drainage of wetlands on the prairies primarily occurred before the recent decline in grebe numbers. Nevertheless, the permanent loss of wetlands continues, mainly because of agricultural activity and rural development.							**N/A**

2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling								**N/A**
3.2 Mining and quarrying								**N/A**
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads								**N/A**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals								**N/A**
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources	Horned grebes become entangled and drown in nets in some commercial fishing areas. This is most likely to occur on large lakes during migration. Commercial fisheries occur on large lakes in							**N/A**

	Manitoba, but bycatch data are not available for horned grebes. On the Great Lakes, birds are killed annually in fishing nets during both spring and fall migrations. There is little evidence of fishing net mortality occurring at sea in North America. Grebes were not reported from a seabird bycatch assessment of salmon gill net fisheries in BC; however, grebe species have been reported as bycatch in angel shark/halibut set gillnet fisheries in California.							
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression	With climate change, frequency and intensity of forest fires is predicted to increase. Forest fires can have a profound impact on the boreal forest (e.g. habitat destruction, changes in vegetation, run-offs of sediments, changes in nutrient cycles and hydrological processes). Specific impacts of forest fires on horned grebes have not been studied and are likely the result of several indirect and cumulative impacts over the long-term (ECCC 2020).							**Neg.**
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications								**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases								**N/A**

8.2 Problematic native species/diseases	Horned grebe eggs are taken by raccoons, American crow, common raven, black-billed magpie and various gull species. Chicks can be subject to predation by the northern pike and by gulls. Adults may be taken by mink and possibly foxes. In the prairies, predation problems are often related to large-scale habitat degradation coupled with changes in predator communities. The major expansion of some predators in the prairies could be a possible limiting factor and cause of population decline in the western population of grebes. Breeding bird surveys trends show a substantial increase in common raven and black-billed magpie since the 1970s. Raccoons have also expanded their range in the prairies during the 1900s.							**Neg.**
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin	Type E botulism has been reported in the Great Lakes since the later 1990s and may be an important source of mortality for both resident and migrating waterbirds. Horned grebes were one of the top five affected species of those collected in 2007, with 354 birds affected by botulism.							**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents	At sea, this species is vulnerable to oil pollution, since it spends most of its time on the water. Of 34,717 birds killed in eight spills in the southern US, 12.3% were horned grebes. There are a number of other examples. The large wintering area of this species in North America partially protects this population from catastrophic losses due to isolated oil spills.							**N/A**

	Grebes occupy the upper trophic levels of the food chain and are therefore more susceptible to contamination, especially in the case of bioaccumulatable toxic substances. Significant concentrations of DDE (dichlorodiphenyldichloroethylene) and PCB were detected in horned grebe eggs collected in Manitoba in 1986 and 1987. In BC, elevated levels of dioxins and furans have been detected in the liver of horned grebes collected downstream from a pulp and paper plant outfall.							
9.3 Agricultural and forestry effluents (including erosion)	Eutrophication and degradation of nesting sites from the accumulation of fertilizers used in agriculture can negatively impact horned grebe populations.							**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Like other northern areas, the 38km² study area near Yellowknife has relatively stable water conditions compared to some other parts of the horned grebe range.							**N/A**
11.2 Droughts	A warmer and drier climate could increase the frequency and intensity of forest fires, cause the melting of the permafrost and the desiccation of wetlands (ECCC 2020). Temporary loss of wetlands	W	H	S	LTF	L	M	**Medium**

	during droughts can negatively impact horned grebe populations. Horned grebes are facing more short-term or medium-term habitat loss due to drought. Dry conditions on the prairies are not restricted to a particular area and were concentrated in southern regions in 1971, 1973, 1977, 1984, 1985, 1988, 1996, 1997, 2001 and in northern regions in 1968, 1969, 1970, 1972, 1981, 1990, 1992, 1998 and 2002. The number of May ponds, which are used to assess breeding habitat for waterfowl in the prairies and parklands, shows no significant long-term trends for the Canadian prairies. It is not clear, however, that the estimated number of May ponds is a good indicator of horned grebe breeding habitat availability. Habitat loss can also be temporary. The prairie region undergoes cycles of drought followed by heavier rainfall, which can result in temporary loss of breeding ponds. The length and frequency of droughts in the prairies is expected to increase in the future, due to climate change. According to the Canadian Global Climate Model, the southern prairies could experience serious summer deficiencies in soil moisture by the end of this century. Higher temperatures will intensify drought conditions and also bring about wetter periods, but overall, the prediction is that soil moisture will become more variable.							
11.3 Temperature extremes	Projected increases in extreme heat events and decrease in extreme cold events. It is uncertain how the horned grebe will respond to these changes (Lee pers. comm. 2020).							**Neg.**
11.4 Storms and flooding	Weather conditions can also significantly affect water levels. Heavy rainfall combined with wind and waves during storms can flood nests. Storms encountered during migration can also affect the horned grebe.							**Neg.**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Ivory Gull (*Pagophila eburnea*)
Populations (if applicable):
Percentage of North American population NWT is responsible for: Until recently, the Canadian Arctic was thought to support 20-30% of the global breeding population of ivory gulls and to contain colonies of global importance; however, this may have declined. From September to May they winter in Davis Strait, NU. In Canada, ivory gulls currently only nest in NU. They once nested on Prince Patrick Island in the NWT, but this site has been abandoned since its initial discovery in the 1800s. In the NWT, ivory gulls are uncommon migrants in the Beaufort Sea.
NWT General Status Ranks: At risk
NatureServe Conservation Rank (NWT): SHB, S1N
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Endangered
Reasons for assessment or population trends: Aboriginal traditional knowledge and intensive breeding colony surveys over the last four years indicate that the Canadian breeding population of this long-lived seabird has declined by 80% over the last 20 years. This bird feeds along ice-edge habitats in the high Arctic and breeds in very remote locations. Threats include contaminants in food chains, continued hunting in Greenland, possible disturbance by mineral exploration at some breeding locations and degradation of ice-related foraging habitats as a result of climate change.
Sources used for assessments: COSEWIC (2006)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[182] = 3		
Dependence on habitats that are sensitive to climate change[183]	This bird feeds along ice-edge habitats in the high Arctic and breeds in very remote locations. Small, scattered colonies occur in Arctic Canada, Greenland, Spitzbergen and the northern islands and archipelagos of Russia in the Kara Sea. Unlike most other Arctic-breeding seabirds, ivory gulls spend the entire year at high latitudes, where they rarely range far from pack ice. The wintering distribution is poorly known but is generally along the southern edge of pack ice in waters of the north Atlantic Ocean	4 – Depends on sensitive habitats that are rare.

[182] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.
[183] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	(Davis Strait and Labrador Sea) and the north Pacific Ocean (Bering, Chukchi and perhaps Beaufort Seas), although some may remain in northern areas near polynyas. In Canada, the ivory gull has a highly restricted range while breeding, nesting exclusively in NU. Ivory gulls require breeding sites that are safe from terrestrial predators, particularly the Arctic fox. They nest near marine waters that are partially free of ice in late May and early June; colonies are found concentrated around Jones and Lancaster Sounds, with colonies occurring on southeastern Ellesmere Island, eastern Devon Island and the Brodeur Peninsula of northern Baffin Island. This latter factor is particularly important in the high Arctic, where the sea is ice-covered in May, June and in some areas, well into July. Thus, most known nesting locations are associated within 100 km of nearby polynyas and/or recurring leads. Collectively, the fact that most known nesting sites are located in regions that are both free of predators and in proximity to early season open water restricts the possible breeding locations of ivory gulls in the Canadian Arctic. A recent review which related the geomorphology of NU with colony locations of ivory gulls indicates that there are two predominant habitat types that are consistently used as colony locations; sheer granite cliffs found in glacial terrain of southeast Ellesmere and Devon Islands and vast gravel limestone plateaus devoid of vegetation on the Brodeur Peninsula of Baffin Island, parts of Cornwallis Island, west Devon Island and northeast Somerset Island. These sites are largely devoid of predators. Large expanses of the western Arctic and Ellesmere Island are apparently unsuitable for nesting ivory gulls because there is no ice-free ocean regularly available in these regions in late May and early June when ivory gulls arrive to breed. Furthermore, the flat vegetated landscape of these islands supports lemmings and Arctic foxes. Consequently, evidence is growing that the decline in the breeding population of ivory gulls detected in Arctic Canada cannot be simply attributed to movement of nesting ivory gulls into other alternative nesting areas elsewhere in	

	Arctic Canada.	
Sensitivity to climate-relevant abiotic factors[184]	None noted.	Unknown
Sensitivity to climate-relevant biotic factors[185]	Opportunistic feeder. At sea, it is a surface-feeder, foraging primarily on small fish, such as lantern-fish and juvenile Arctic cod and macro-zooplankton, such as amphipods and euphausiids. Pellets found near nests and containing small bones and hair suggest that, at least during breeding, they also catch small mammals. Ivory gulls are also scavengers of marine mammals killed by large predators and are reported to forage on marine mammal feces and placentae. In doing so, they are potentially subject to high toxic chemical loading. It is assumed that ivory gulls nest in extremely remote locations (often 20-30 km inland) to avoid interactions, particularly with species that could prey on their eggs and chicks.	2 – Somewhat sensitive or possibly very sensitive.
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	In general, high-latitude seabirds have much higher metabolic rates and daily energy expenditure than expected. Due to their high metabolic rates, Arctic-breeding seabirds exhibit high energetic requirements and, therefore, have a greater potential for the bioaccumulation of persistent organic pollutants than other species, even when compared to marine mammals. However, ivory gulls are an infrequent migratory visitor to the NWT's Beaufort Sea area. A historical breeding colony on Prince Patrick Island has been abandoned for some time. In that context, the only known threat to ivory gulls in the NWT is climate change.	1 – No pressures.
Adaptive capacity[186] = 2.5		
Reproductive	Ivory gulls have an adult survival rate comparable	4 – Late

[184] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.
[185] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).
[186] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.

capacity[187]	with other gulls (0.86) and may experience high post-fledging mortality. Like most gull species, the ivory gull displays delayed sexual maturity and is believed to breed for the first time when two to three years old, although data are lacking. They also show a relatively low productivity rate, with a clutch size of normally two eggs, compared with the more usual three-egg clutch seen in most other gulls. In Canada, colony surveys indicate that ivory gulls fail to produce any young in some years due to intermittent breeding and sometimes, predation. Generation time is estimated at seven years (adults can live 20 years).	reproduction/few offspring
Dispersal capacity[188]	Ivory gulls are known to leave their colonies immediately after breeding and disperse to offshore foraging zones. However, the timing and scale of these movements is highly dependent on inter-annual changes in the extent, location and movement of sea ice. Annual migration between breeding and wintering habitats. Traditional breeding grounds that are limited in availability appear to be used regularly/intermittedly over time (accounting for years of skipped breeding and potential interchange between sites).	1 - >10km.
Genetic diversity		N/A
Phenotypic plasticity		N/A

[187] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.

[188] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling	The colony on Seymour Island, while protected as a migratory bird sanctuary, lies just south of the Sverdrup Basin, a marine area known to contain significant oil and gas reserves that may be exploited in the future.							**N/A**
3.2 Mining and	The Brodeur Peninsula of Baffin Island (one of the key breeding							**N/A**

quarrying	locations of the species in Canada) has experienced significant and accelerating human activity related to diamond mining exploration in the last three years. Various mining companies have staked almost the entire peninsula in search of diamonds. These activities include aerial surveys and sampling on the ground, the establishment of at least one drilling site, a fuel cache (over 400 drums in 2003) and a summer field camp. The effects of this activity on the three remaining Ivory Gull colonies are unknown; however, the fuel cache is located centrally within 2 km of previously known, but abandoned colonies. Moreover, the drilling camp is located within 4 km of the largest remaining ivory gull colony on the peninsula (56 birds in 2004), which supported no gulls in July 2005. In fact, no ivory gulls were found to nest at any of the known colony locations on the Brodeur Peninsula of Baffin Island in 2005. Human activities in the vicinity of an ivory gull colony may play a significant role in habitat degradation, particularly activities related to resource exploration and extraction. The extreme climate, topography and isolation of the Arctic require that these activities rely on helicopter, fixed-wing aircraft and in some cases, the use of ATVs. This generates noise and pollution. One study suggested that colonies were quite sensitive to disturbance; although recent information from a number of sources in Canada and Norway contradicts this. Furthermore, the presence of semi-permanent drilling camps may attract mammalian and avian predators and scavengers to remote areas where they were previously absent. For example, the diamond mines established recently in the NWT are known to have attracted predatory birds (e.g. black-billed magpies, common ravens) and mammals (red foxes) to the region where they were previously rare or entirely absent. These changes have occurred despite concerted efforts by industry to manage waste and potential food sources for wildlife.							

	In general, ivory gulls are most vulnerable to direct human activities during breeding.							
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads								**N/A**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	A recent analysis of ivory gulls banded in Canada indicates that they are still at considerable risk of mortality due to hunting. Canadian Inuit are permitted to harvest ivory gulls throughout the year pursuant to their land claim agreements, but this is rarely done. In contrast, residents of west Greenland apparently harvest ivory gulls regularly, particularly during spring and fall migration. It is also worth noting that 35 ivory gulls were easily purchased from hunters in 1984-1986 in western Greenland with no advance notice, as part of a contaminants study of Arctic seabirds. This is despite the fact that ivory gulls have been fully protected in Greenland since 1978. Of 1,526 bands placed on ivory gulls between 1971 and 1999 in Canada, 26 have been recovered. Most of those recovered were shot in northwest Greenland (17) while others were shot in Canada (5). These band recovery rates in west Greenland are comparable to those reported for legally harvested thick-billed murres and common eider ducks. This suggests that harvest in west Greenland could have negatively affected ivory gulls breeding in Canada in the past and that it may continue to do so. Although new harvest regulations established in 2002 have apparently reduced harvest of							**N/A**

	murres and eiders in Greenland, they may have had little direct influence on ivory gull harvest because ivory gulls were already fully protected under the law prior to that.							
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities	It is worth noting that local residents believe that the ivory gull decline is related to the banding efforts near those communities (Arctic Bay, Grise Fiord, Resolute Bay and Pond Inlet) in the 1970s and 1980s, because they observed far fewer birds near the community in the years following banding work. They contend that disturbing and especially handling wild birds (gulls, eiders) leads to population declines. It is possible that annual visits to ivory gull colonies (although extremely brief, <5 minutes in most cases) have resulted in recent colony abandonment or intermittent breeding at some sites in Canada. However, this is considered unlikely (available information on sensitivity to helicopters is contradictory; the largest active colonies have supported breeding ivory gulls in consecutive years despite annual colony visits; intermittent breeding in response to surveys cannot explain the low numbers of ivory gulls detected in the first year of the survey (2002) nor the continued absence of							**N/A**

	nesting ivory gulls from several historical colonies which have not experienced helicopter visits).							
7. Natural system modifications								
7.1 Fire and fire suppression								**N/A**
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications								**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases								**N/A**
8.2 Problematic native species/diseases	Arctic foxes are well-known nest predators and can destroy entire ivory gull breeding colonies found on flat ground in some years. Polar bears will take eggs and young on occasion. Avian predators such as common ravens and glaucous gulls are known to depredate the eggs of young of ivory gulls, but little is known about the frequency or population-level effects and how predation rates vary by nesting habitat. They appear vulnerable to factors that increase the number of predators near colonies.							**N/A**
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								

9.1 Domestic and urban wastewater								N/A
9.2 Industrial and military effluents	Chronic oil pollution is a serious conservation concern in Atlantic Canada, where about 300,000 murres (mostly thick-billed) and dovekies are estimated to be killed every winter. Mortality estimates are not available for other species due to smaller numbers of corpses found and/or imprecise knowledge of their wintering range, but well over 20 species, including a number of gull species, have been found oiled on the beaches of NL. Gulls are also considered to be highly vulnerable to oil pollution. Ivory gulls, a species which is more pelagic than most other gull species, may be particularly vulnerable, although they tend to range farther north than most shipping lanes. Currently, incidences of oiled ivory gulls have not been noted, but given the offshore range of this species along eastern Canada, oiled ivory gulls would not be expected to reach land and/or be recovered. Toxic pollutants that bioaccumulate at high trophic levels are known to occur among ivory gulls breeding in Canada. Ivory gulls are also scavengers of marine mammals killed by large predators and are reported to forage on marine mammal feces and placentae. In doing so, they are potentially subject to high toxic chemical loading. Given their position in marine food webs, contaminants have been proposed as one stressor which could be affecting this species. Although levels of DDE, PCBs, oxychlordane, dieldrin, heptachlor epoxide and 2,3,7,8-TCDD increased between 1976 and 1987 in eggs of ivory gulls collected from Seymour Island, data from 2004 seem to indicate no significant changes or significant decreases (DDE, chlordanes) during 1976-2004. Current concentrations of the legacy organochlorines in ivory gulls from the Canadian Arctic do not appear to exceed toxicological threshold levels reported in the literature. Mercury concentrations in livers and kidneys of ivory gulls collected off the coast of western							N/A

	Greenland during 1984-1986 also did not exceed toxicological threshold levels reported in the literature. Concentrations of total mercury in eggs of ivory gulls collected from Seymour Island in the western Canadian Arctic, however, have steadily increased between 1976 and 2004 to levels which are now among the highest measured in seabird eggs as well as piscivorous avian species including raptors. Based on a review of the literature, one study suggested that concentrations in eggs of 0.5-2.0 μg/g wet weight were sufficient to induce detrimental effects including impaired reproductive success in birds, although pelagic seabirds appear to have a higher tolerance to mercury. Five of the six ivory gull eggs collected in 2004 exceeded 0.5 μg/g wet weight and two out of the six eggs collected exceeded 2 μg/g wet weight. This would suggest cause for concern and further investigation.							
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)	See 3.2. Generally, it is considered to be sensitive to disturbance by air and ground traffic near breeding colonies. However, this is based largely on a single source which reported that a single low flying aircraft caused the complete abandonment of a colony. In contrast, several independent observations by seabird researchers in Canada and Norway suggest that ivory gulls may be more tolerant of disturbance than many other seabirds.							**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/								**N/A**

tsunamis								
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Climate change is altering ice conditions in the circumpolar Arctic. In Arctic regions, considerable data now suggest that sea-surface temperatures are increasing, while sea ice thickness and distribution are diminishing. The distribution of sea ice and the duration of the open water season are critically important to the annual cycle of Arctic marine wildlife and thus changing sea ice conditions are expected to have a variety of effects on marine birds and other biota. Indeed, several studies have found that reproduction of polar marine birds varies in response to annual ice conditions. Recent evidence also indicates that conditions on north Atlantic wintering grounds of thick-billed murres, which may be similar to that of ivory gull, can influence the numbers of birds returning to breeding colonies synchronously, even though breeding colonies may be distant from each other and experience different climatic conditions during the breeding season. During the breeding season, marine birds should incur higher energetic costs in years with more extensive sea ice due to higher commuting costs to and from the colony to feeding areas and perhaps increased costs of finding food during less productive seasons (i.e., increased ice cover and reduced light penetration resulting in lower productivity in the marine zone). Given the ivory gull's strong and year-round association with pack ice, it is possible that some large-scale ecological perturbation, such as a change in the extent or thickness of ice cover, has caused degradation of their foraging and wintering habitat in Baffin Bay and Davis Strait. However, no data exists to establish a causative relationship.	W	M	S	N-ST F	M	L	**Medium**

	Alternatively, depending on the pattern of ice cover loss, it may temporarily increase foraging habitat availability, especially early in the breeding season.							
11.2 Droughts								**N/A**
11.3 Temperature extremes								**N/A**
11.4 Storms and flooding	Potential increases in storms may lead to negative impacts on niche habitat of ivory gulls (Lee pers. comm. 2020).	L	U	S	ST F	M	L	**Low**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Little brown *myotis* (*Myotis lucifugus*)
Populations (if applicable): The NWT population of little brown *myotis* is considered continuous with populations in adjacent provinces.
Percentage of North American population NWT is responsible for: The little brown *myotis* is the most widespread bat in North America and ranges east to west from NL and Labrador to Alaska at its northern limits and from Florida to California at its southern limits. Distribution in Canada includes all provinces and territories except NU. The little brown *myotis* is the most widespread and abundant bat species in the NWT and has been observed in the Boreal Cordillera, Taiga Plains and Taiga Shield. It is not known how far north the species occurs down the Mackenzie Valley. The percent of global range in Canada has been roughly estimated as 50%. No such estimate is available for percentage of population the NWT is responsible for.
NWT General Status Ranks: At Risk
NatureServe Conservation Rank (NWT): S2
***Species at Risk (NWT) Act*:** Special Concern
***Species at Risk Act* (Canada):** Endangered
Reasons for assessment or population trends: Although the range of this species is fairly large and there are at least a few thousand individuals in the NWT, there are currently only two known over-wintering sites. Although white-nose syndrome (WNS) is not currently present in the NWT, it is estimated that at current expansion rates, it could reach our populations from eastern North America in one or two decades. With the recent discovery of WNS in the United States' Pacific Northwest, it is conceivable that this disease could spread to the NWT sooner than predicted. The species is highly susceptible to devastating population declines as a result of WNS. In eastern Canada, populations impacted by WNS have declined by 94%. Human impacts at hibernacula and exclusion and removal of maternity roosts have the potential to affect a large proportion of the species' population at the same time.
Sources used for assessments: SARC (2017c)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[189] = 2		
Dependence on habitats that are sensitive to climate change[190]	Little brown *myotis* is a forest dwelling bat that has seasonally-dependent primary habitat requirements, including summer roost and foraging habitat, autumn mating sites and winter hibernation sites.	2 – Generalist, but some sensitive habitats are important.

[189] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.
[190] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural

	Habitat availability for bats in the NWT has not been quantified; however, both the boreal forest and karst formations are important habitat for this species. The boreal forest covers approximately 614,000 km^2 of the NWT. It is unknown how much of the boreal forest is inhabited by bats, but it may be considered 'potential habitat' for the wider-ranging species such as little brown *myotis* that appear to have fewer geographical restrictions. Across ecoregions, habitat suitability for bats may reach a northern limit below the treeline due to climate (temperature and summer length) and/or availability of summer roosts (e.g. suitable trees). Karst formations are found throughout the NWT. Few have been investigated in winter to determine whether they are used by bats. In addition, there are numerous abandoned mines around the NWT that may act as potential roosts and/or hibernacula. In general, known hibernacula are considered to be a small subset of the hibernacula that must exist on the landscape. Maternity roosts are used repeatedly over many years. Roost choice varies among species, but roosts can often be found in tree cavities and behind flaking bark, in rock crevices and in buildings. *Myotis* species tend to prefer large standing dead or dying trees located in open areas in old growth forest for tree roosts. Bats typically forage in forest gaps and edges, along trails and over still water and rivers. With respect to habitat associations, age of a forest appears to be more important than type, with many bats, including little brown *myotis*, preferring old growth forests. Summer roosts for males and non-reproductive females typically consist of rock cliffs, trees and buildings.	

disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

Sensitivity to climate-relevant abiotic factors[191]	Little brown *myotis* uses daily torpor and seasonal hibernation to conserve energy during periods of low prey abundance (e.g. winter) and/or increased energetic expense (e.g. cooler temperatures). This behaviour allows them to survive extreme and/or unfavourable conditions. During winter, access to hibernation sites with adequate temperature (2°C -12°C) and humidity levels (>80%) is required. If hibernacula temperatures drop below 0°C during hibernation, bats may increase their energetic use, drawing on fat stores to increase their metabolism to arouse and look for a new hibernation site, or to account for cooler temperatures. Alternatively, bats may remain inactive and succumb to freezing. Both responses result in decreased fitness of individuals. Conversely, warming of the hibernacula is a significant threat because northern hibernating bats are adapted to cold microclimates (low metabolic rates), because they enter hibernation with high body mass and because current, relatively cold, northern hibernacula conditions do not represent ideal growth environments for WNS. An increase of hibernacula temperatures could disrupt the energetic balance of northern bats, including little brown *myotis* and increase the growth rate of WNS should it arrive (Lausen pers. comm. 2020). It is possible that warming temperatures may facilitate shorter hibernation periods and a longer breeding season and therefore higher reproductive success. Summer temperature tolerance varies by species. Night time activity appears to be strongly positively correlated with temperature. Short night foraging, combined with shorter summers overall and cool night time temperatures, may limit foraging opportunities and therefore resources available for growth, reproduction and accumulation of winter fat reserves, perhaps creating an effective northern limit to the distribution of bats. However, these matters are complex. Where bats will move farther north with climate change or remain restricted by other factors such as roost availability	2 – Somewhat sensitive or possibly very sensitive.

[191] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

	has yet to be determined.	
Sensitivity to climate-relevant biotic factors[192]	Bats are very sensitive to WNS, which is considered the most serious threat to *Myotis* species. It is unclear how climate change may impact the spread of WNS (although see notes above about hibernacula temperatures). Contact among individuals at maternity colonies and hibernacula, as well as autumn swarming behaviour, may facilitate the transmission of disease among bats. In this context, bat species that exhibit clustering behaviour in hibernacula to conserve body heat (e.g. little brown *myotis*), may be at higher risk for bat-to-bat disease transmission than species that roost alone. Little brown bat is insectivorous and relies on adequate insect presence and abundance to support summer reproduction and winter survival. Using both aerial hawking and gleaning increases their ability to diversify their diet and capitalize on available prey items throughout the season. The little brown *myotis* feeds on a wide variety of insect types, typically four to nine mm in size. Species with a diverse foraging strategy and diet, like little brown *myotis*, may be able to respond to environmental and anthropogenic changes better than those with less diverse foraging capabilities. Climate plays an important role in determining prey availability, which in turn influences reproductive success. Warming temperatures may yield a longer active period with greater reproductive success.	2 - Somewhat sensitive or possibly very sensitive
Non-climate stressors = 2		
Sensitivity to potentially interacting non-climate pressures	WNS poses a potentially serious threat, one that is expected to arrive in the NWT in one to two decades, or sooner. Population dynamic models predict a 99% extinction of little brown *myotis* in eastern Canadian provinces and the eastern United States by 2026. Little brown *myotis* are sensitive to human impacts at hibernacula, exclusion and removal of maternity roosts (non-lethal exclusion or lethal extermination by building owners or incidental removal as a result of development activities), timber harvest, predation by common house cats and mercury contamination.	2 – Moderate pressures or possibly major pressures.

[192] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

Adaptive capacity[193] = 1.5		
Reproductive capacity[194]	Females become sexually mature their first or second year; males may not become sexually mature until their second autumn swarming. Females store sperm over winter and fertilize a single egg during spring ovulation when they leave hibernation. Twinning can occur, but it is rare. The average duration of gestation for Vespertilionidae family of bats is 69.4 days (SE=34). Females may reproduce up to once per year; however, reproductive success is heavily influenced by regional weather patterns and females may forego reproduction in a year of poor resource abundance. In general, reproduction in little brown *myotis* has been shown to decline with increasing latitude. The maximum lifespan for little brown *myotis* is approximately 34 years and the mean life expectancy for little brown *myotis* is six to seven years. Generation time is five to 16 years.	2 – Early reproduction/few offspring
Dispersal capacity[195]	High dispersal capacity. Little brown *myotis* undergo annual dispersal events using flight. Individuals migrate between winter hibernacula and summer roosts. Little brown *myotis* have been observed travelling up to 650 km between summer and winter roosts (range: 10-650 km). During summer, individuals moving between day roosts and evening sites may travel more than five km. There are no geographic features that would prohibit movement into the NWT from provinces farther south (rescue effect).	1 - >10km
Genetic diversity	The high dispersal capacity and promiscuous mating strategy of bats promotes genetic mixing and reduces genetic isolation. Maternity congregations facilitate information transfer, gene flow and social interaction. Genetic studies specific to the NWT are limited to a	N/A

[193] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[194] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.
[195] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

	small sample of little brown *myotis* from the Fort Smith area that were included in a continental analysis. Studies found that little brown *myotis* in the Fort Smith area and Wood Buffalo National Park directly south, were genetically similar to eastern populations including southern AB and SK, suggesting no evidence of isolation of bats in the South Slave region and north. Additional genetic analysis is needed to determine the potential isolation of bats in the Nahanni area given its mountainous terrain and the genetic uniqueness of bats directly west in the YT.	
Phenotypic plasticity	Phenotypic plasticity is likely high (GNWT pers. comm. 2020).	N/A

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas	Little brown *myotis* congregate in maternity colonies in building attics, cabins, private residences and other similar urban buildings. These groups of bats living in buildings have been reported in the Dehcho and South Slave regions. Exclusion and removal of maternity roosts from houses and other urban buildings is addressed under 5.1.							**Neg.**
1.2 Commercial and industrial areas	*Myotis* species may use commercial buildings or abandoned mines for roosting or hibernation. However, there have been no reports of bats roosting in commercial buildings or abandoned mines in the NWT.							**Neg.**
1.3 Tourism and recreation areas	Passive disturbance (entering the cave for research or recreational purposes) during hibernation can cause bats to arouse out of torpor and use up stored fat reserves, resulting in reduced fitness and potential starvation if repeatedly disturbed throughout the season. WNS can also be transferred between substrates in numerous ways, including from bat to bat, from cave substrate to bat and from bat to cave substrate, as well as by humans between sites. In the NWT, the precise locations of winter hibernation sites are considered classified and in an effort to reduce human traffic, are not readily shared with the public. Motion-sensor cameras were deployed at SSR-1 in 2013 to monitor human visitors and detected no human disturbance at the site.							**Neg.**
2. Agriculture and aquaculture								
2.1 Annual and								**N/A**

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	**Overall level of concern**
perennial non-timber crops								
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling								**N/A**
3.2 Mining and quarrying	Human activities that change hibernacula conditions (including accessibility, temperature, humidity, airflow and hydrology) can have a negative impact on bats. This can include decommissioning or reactivating mines and quarrying. Use of abandoned mines for roosting covered in1.2.	L	M	S	ST F	L	L	**Low**
3.3 Renewable energy	Outside of the NWT, wind turbines are considered a threat to various bat species. Local, non-migratory species including *Myotis* are killed at lower rates than long-distance migrant species (e.g. 0-13% of fatalities). As of 2013, about 47,400 bats were killed each year by wind turbines in Canada, of which about 13% were little brown *myotis*. However, there are currently no large-scale wind energy developments in the NWT.	L	L	S	LT F	L	L	**Low**
4. Transportation and service corridors								
4.1 Roads and railroads								**N/A**

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	**Overall level of concern**
4.2 Utility and service lines	Seismic lines are the largest anthropogenic landscape disturbance in the NWT. They are often considered an agent for habitat fragmentation and can have negative impacts on local forest-dwelling animals. Many bat species however, forage along linear features such as trails and roads and radio telemetry studies in the Fort Smith area have observed little brown *myotis* travelling and foraging along power lines.							**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	Bats are not harvested in the NWT; however, it is common across North America for many home/cabin owners to dislike bats roosting in their buildings and desire to remove them. This may result in the non-lethal exclusion of bats from their roosts and/or the lethal extermination of breeding colonies. While the prevalence of this behaviour in the NWT is currently undocumented, extermination of individual bats is known to occur. Public education efforts are working to reduce the number of these incidences. The effects of removing a maternity roost, or excluding bats from a roost (e.g. by sealing entrances), depend on factors such as timing, species and availability of other suitable habitat. Little brown *myotis* may move to new roosts, but this can affect the fitness of displaced bats, including reducing their reproductive success. If adult females are excluded (i.e., roost access is prevented) during the breeding season before their pups have fledged, juveniles will be left without food or hydration. This will most likely result in the	L	M	S	N	H	H	**High**

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
	death of all individuals inside the roost site, which could have a significant impact on local populations. A maternity colony may contain most of the breeding females and offspring for a large area, so colony eradication can be significant to local populations.							
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting	Timber harvest has varying degrees of impact depending on the species. The use of heavy machinery (e.g. timber harvesting equipment) near weak areas of a hibernaculum could cause collapse. Human activities that change hibernacula conditions (including accessibility, temperature, humidity, airflow and hydrology) can have a negative impact on bats. This can include forestry activities that take place around hibernacula. Removal of maternity roost trees may occur through timber harvesting, residential development, or any other development activity that requires clearing forested land. Bats' tolerance to roost loss may depend on local forest conditions, including the availability of alternate roost trees. Removal of occupied maternity roost trees during the breeding season would likely cause mortality, although data on this are lacking. Under section 5.7.2(V) of the commercial timber harvest planning and operations standard operating procedures, timber harvesting operations in the NWT are not currently permitted to occur during the migratory bird nesting season, which overlaps with the breeding season for bats.	L	L	S	ST F	M	L	**Low**

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	**Overall level of concern**
	It has been suggested that forest fragmentation (independent of forest amount) can benefit little brown *myotis* by allowing access to foraging sites from roosting sites. Forestry practices that lead to a decline in the amount of older age forests could have a negative impact, as many bat species are more abundant in the oldest forest stands. This is likely primarily related to the availability of snags and large live trees for roosting; these negative impacts can be reduced through selective harvest practices. Timber harvest also affects foraging habitat. *Myotis* bats generally avoid large areas of cleared land such as clear cuts; however, some bats use the edges of forest patches, regeneration areas and early successional forest as new foraging habitat. The most recent NWT biomass energy strategy states that one of the objectives is to 'increase the use of biomass fuels, such as cord wood, wood chips and pellets, in all segments of the NWT space heating market', suggesting that an increase in timber harvesting will continue to be promoted in the NWT. In the NWT, commercial timber harvesting has occurred in numerous places and is typically done by small-scale businesses in localized areas and in small volumes (500-10,000 m^3 per year). The largest annual harvest since 1980 was in 1996 and totaled 144,461 m^2. FMAs have been signed in the Fort Providence and Fort Resolution areas and land use permits have been issued for timber harvesting in both areas. With these now in place, timber harvesting is expected to dramatically increase in these areas. The land use permits cover five years of timber harvesting, although the FMAs themselves are for 25 years. Timber harvesting in each area will impact							

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	**Overall level of concern**
	approximately 1,000-1,200 ha/year throughout the lifetime of the FMA.							
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities	See 1.3.							**Neg.**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities	Banding efforts for little brown *myotis* have been ongoing since 2011 in the South Slave region, mainly focusing on maternity colonies. Visits to SSR-1 and SSR-2 for research and monitoring purposes have been limited to once per winter or less.	L	L	C	N	H	L	**Low**
7. Natural system modifications								
7.1 Fire and fire suppression	At a local scale, forest fires may cause temporary fragmentation, displacement and/or destruction of bat roost and foraging habitat. While bats may use recently burned areas (<10 years) for occasional foraging, a lack of roost sites results in low bat activity until a forest reaches the old growth stage (76 - >125 years). Conversely, other studies (northern *myotis*) have found an increase in roost availability after a burn. In addition, immediately following a burn, an increase in insect abundance may be observed. Forest fires disturb an average of 600,000 ha of NWT forest annually. It is predicted that climate change will result in an increase in the frequency and intensity of fires, due to hotter, drier	W	U	S	ST F	M	L	**Neg.**

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	**Overall level of concern**
	summers that provide a long fire season. However, studies suggest that forest fragmentation (independent of forest amount) can benefit little brown and northern *myotis* by allowing access to foraging sites from roosting sites. Bats typically forage in forest gaps and edges, along trails and over still water and rivers. Larger areas cleared for farm fields, clear cuts, or as the result of large fires are generally avoided by *Myotis* species, perhaps to avoid the windier conditions characteristic of these cleared areas or because of their influence on prey abundance and risk of predation.							
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications	Human activities that change hibernacula conditions (including accessibility, temperature, humidity, airflow and hydrology) can have a negative impact on bats. This can include blocking or gating cave entrances, making modifications for tourists, decommissioning or reactivating mines, quarrying, or forestry activities that take place around hibernacula.	L	M	S	LT F	L	M	**Medium**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases	WNS is considered the most devastating disease for many cave-hibernating bat species in North America and is caused by the fungus *Pseudogymnoascus destructans*. *P. destructans* likely arrived in North America from Europe, where it is known to occur on bats, although without the same devastating mortality. It is estimated to have resulted in the deaths of more than 5.7 million bats throughout North America. Although WNS is not currently present	W	H	C	ST F	H	H	**High (in future, for WNS)**

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	**Overall level of concern**
	in the NWT, it is estimated that at current expansion rates, it could reach our populations from eastern North America in one or two decades. The discovery on March 11, 2016 of WNS in the Pacific northwest substantially extends its North American range. How it reached this far west, 2,100 km away from the next nearest occurrence in Nebraska, has not yet been determined. This new western occurrence has important implications for management, as it has the potential to accelerate the western spread of WNS. As noted by Lorch et al. (2016: 4), "The severity, magnitude, duration and potential ecosystem-level effects of WNS in North America rank it among the most consequential wildlife disease events ever recorded." It creates a cutaneous infection in bats and disrupts their torpor patterns during winter, which depletes fat reserves and potentially causes dehydration, resulting in death. Fatality rates vary by bat species and are typically much greater for smaller bodied *Myotis*. Infection at a hibernaculum usually results in severe population decline or extirpation. Average decline in six northeastern US states after two years' exposure to WNS was 91% for little brown *myotis* (54 hibernacula, 12 of which declined to zero bats). Declines in eastern Canada where WNS has established have been similarly catastrophic. Population dynamic models predict a 99% extinction of little brown *myotis* in northeastern North America by 2026. It is largely unknown how the ecology of the disease may be affected by the amount of east-west bat movements, wintering ecology and hibernacula conditions in these regions. However,							

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	**Overall level of concern**
	there is evidence that conditions in known hibernacula are conducive to growth of the fungus and that hibernacula with lower bat densities are susceptible to WNS and there is no evidence of containment to date. In addition, an increased exposure period due to longer hibernation durations in the NWT may negate any potential benefits of slower fungus growth and could actually result in higher mortality rates, although documented hibernation periods in the NWT do appear to be roughly comparable to those in more southerly locations. Model results suggest that WNS spread and mortality is most likely to occur in habitats that are drier and colder during winter, such as in the NWT. WNS constitutes the most serious plausible threat for this species, with infection at hibernacula usually resulting in severe population declines or extirpation. Numerous cat-related bat fatalities have been reported in the NWT; in some cases, samples have been submitted to ENR in Fort Smith, but these incidences are not tracked formally and cannot be quantified. Predation by cats is expected to impact bats using building roosts in or near communities, because of their proximity to cats. The impact of this threat on bat populations in the NWT is unknown but presumably small.							
8.2 Problematic native species/diseases	Ectoparasites have frequently reported for little brown *myotis* in the NWT (between 2014-2016, parasites were present on 19-77% of sampled little brown *myotis*, although sample size was small); however, these parasites have not been identified to species and the impact these parasites have on the health of individuals has not							**Neg.**

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
	been studied.							
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases	Rabies, caused by a virus (family Rhabdoviridae, genus *Lyssavirus*) and transmitted most often through saliva, has been reported in 30 of the 39 bat species that live in North America, north of Mexico. The impact rabies has on bats is not clear; recorded die-offs may not be entirely attributable to rabies and there is some evidence of immunity in bats (i.e., 2% of little brown *myotis* had antibodies to the virus, but no lesions in the brain). This apparent immunity is difficult to confirm however, given incubation periods of sometimes over one year and the fact that apparently immune bats may simply not yet have been clinically affected. To date no bats have tested positive for rabies in the NWT (eight little brown *myotis* and one northern *myotis* have been tested throughout the NWT).							**Neg.**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater	Contaminants, such as PBDEs, pesticides, pharmaceuticals and personal care products have been found in tissue samples from many bat species in northeastern North America, including big brown bats and little brown and northern *myotis*. Contaminants like pharmaceuticals and personal care products are likely of little concern for bats in the NWT because of the low-density human population. However, contaminants like PBDEs and pesticides, that	L	U	C	LT F	L	L	**Low**

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	**Overall level of concern**
	are long-ranged transported, may pose more of a threat. PBDEs have been detected in NWT resident wildlife.							
9.2 Industrial and military effluents								**N/A**
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants	Mercury contamination is a potential threat to bats in the NWT but its prevalence and impact in the territory are unknown. Bats appear to be particularly susceptible to mercury accumulation and recent studies have raised concerns about the impact of mercury on bats.	L	U	C	LT F	L	L	**Low**
9.6 Excess energy (noise/light pollution)	Industrial activities in or near hibernacula that cause noise, light or vibrations can also disturb hibernating bats and cause them to arouse from torpor.	L	L	S	LT F	L	L	**Low**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and	Changes to the boreal forest associated with climate change could affect roosting and foraging habitat, prey availability and	W	L	C	ST F	L	L	**Low**

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	**Overall level of concern**
alteration	reproductive success. There may be both positive and negative effects and the ultimate impacts on bats are unknown. Changes in growing season have been observed throughout the NWT. In the Taiga Cordillera, Taiga Plains and western Taiga Shield, spring is arriving earlier and the growing season has lengthened by between nine to 28 days. Warming of the hibernacula is a significant threat because northern hibernating bats are adapted to cold microclimates (low metabolic rates), because they enter hibernation with high body mass and because current, relatively cold, northern hibernacula conditions do not represent ideal growth environments for WNS. An increase of hibernacula temperatures could disrupt the energetic balance of northern bats, including little brown *myotis* and increase the growth rate of WNS should it arrive (Lausen pers. comm. 2020). Conversely, it is possible that warming temperatures may facilitate shorter hibernation periods and a longer breeding season and therefore higher reproductive success.							
11.2 Droughts								**N/A**
11.3 Temperature extremes	Daily torpor and seasonal hibernation are used by bats to conserve energy during times of less than ideal temperatures. These states of lowered activity allow them to survive extreme temperatures. Temperature plays an important role in bat habitat in hibernacula where adequate temperature (-4°C to 13°C) and humidity levels (73-100% relative humidity) are required. Changes in the climate also have the potential to alter the timing and duration of hibernation. Bats may emerge from hibernacula if							**Neg.**

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	**Overall level of concern**
	roost temperatures increase to 5-6°C. Hence, in a warming environment, bats may have shorter hibernation periods, emerge sooner and have longer breeding seasons. In the last 15 years, the NWT has generally been experiencing a warmer climate compared to records from 1961-1990. This is particularly pronounced in the winter (December-February) in the Taiga Plains ecoregion. The Mackenzie District as a whole (encompassing all forested areas of the NWT) has seen the largest winter temperature increase in Canada; increasing by 4.5°C between 1948-2011.							
11.4 Storms and flooding								**N/A**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Mackenzie hairgrass (*Deschamsia mackenzieana*)
Populations (if applicable):
Percentage of North American population NWT is responsible for: Occurs in SK and the NWT. Canadian endemic. Very restricted distribution in the Athabasca sand dunes of northern SK and a single record from Great Slave Lake, NWT (1927). There has been no recent confirmation of the species existing in this locality.
NWT General Status Ranks: May be at Risk
NatureServe Conservation Rank (NWT):
***Species at Risk (NWT) Act*:** Not assessed
***Species at Risk Act* (Canada):** Special Concern
Reasons for assessment or population trends: One of a group of endemic plants restricted to dune habitats in northwestern SK. Although dune habitats are naturally dynamic, the rate of forest encroachment at Athabasca dunes now surpasses the rate of dune formation, likely as a result of climate change impacts on this species. Invasive species are a potential threat, but none are currently known in the dune habitat.
Sources used for assessments: COSEWIC (2018a)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[196] = 3		
Dependence on habitats that are sensitive to climate change[197]	Mackenzie hairgrass grows in all habitats within the Athabasca sand dune complex, with the highest abundance in open, bare sand habitats. Germinates in areas of open sand. The NWT record indicates that a wider distribution is possible; however, as the grass has not been collected since 1927 in the NWT, it is considered an historical collection. Climate change poses an unknown risk to dune formation processes through changing wind patterns that may drive increased forest encroachment. All vegetation in the Athabasca sand dune region, whether stabilized or not, relies on physical disturbance that is virtually continual but variable in space and time. Availability of suitable active sand dune habitat is the primary limiting factor.	4 – Depends on sensitive habitats that are rare.

[196] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.
[197] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

Sensitivity to climate-relevant abiotic factors[198]	To survive harsh sand dune conditions, Mackenzie hairgrass has physiological adaptations including tolerance to intense heat and sand blasting. Changes in rainfall or altered hydrology (i.e., changes in water table) that prevent seed germination or establishment in dune slacks, could limit the mature individual population size.	2 – Somewhat sensitive or possibly very sensitive.
Sensitivity to climate-relevant biotic factors[199]		Unknown.
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	No known non-climate stressors in the NWT.	1 – No pressures.
Adaptive capacity[200] = 1 plus 0.5 for low genetic diversity = 1.5		
Reproductive capacity[201]	Perennial. Little information is available on this species' biology, although various aspects may be inferred from the *Deschampsia cespitosa* complex. All taxa of the *D. cespitosa* complex consist of sexually reproducing, self-incompatible, outcrossing plants. Mackenzie hairgrass is wind pollinated. Age of first reproduction two years. Plant can be long-lived with a maximum lifespan as high as 15 years, but this is likely often reduced in the dynamic dune environment. With the exception of tillers and secondary tillers ramifying to form large clumps, there appears to be no true vegetative propagation in Mackenzie hairgrass. Viviparity has not been noted in Mackenzie hairgrass.	1 – Early reproduction/many offspring
Dispersal capacity[202]	Mature florets disarticulate from the panicles and are dispersed by wind, although this may be habitat-limited.	1 - >10km
Genetic diversity	Lower genetic diversity than its widespread progenitor *Deschampsia cespitosa*. Mackenzie hairgrass	0.5

[198] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.
[199] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).
[200] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[201] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.
[202] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

	(tetraploid) most probably evolved *in situ* via autopolyploidy from the diploid species *D. cespitosa*. It was postulated that a genetic bottleneck in the founding population, coupled with minimal or no gene flow from the genetically more diverse *D. cespitosa*, was likely responsible for the small gene pool observed in Mackenzie hairgrass.	
Phenotypic plasticity		N/A

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	**Overall level of concern**
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling								**N/A**
3.2 Mining and quarrying	There has been active uranium and gold exploration in the Athabasca sand dunes region, including geophysical surveys for uranium ore bodies in 1997-1998. If and when mining becomes							**N/A**

	economically viable, it could take place in close proximity to the park boundaries. This is not likely to directly impact the subpopulations, but the associated access roads and increased human presence would probably alter the fire regime and greatly increase access to and recreational use of the dunes, particularly ATV use.							
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads	If mining in the region becomes economically viable, the construction of roads increasing access to the dunes poses a risk to the endemic plants. A proposed extension of the Cluff Lake road (Hwy 955) to the Lake Athabasca south shore was shelved in the early 1980s because of the decline in uranium mining near Uranium City on the north shore of Lake Athabasca. The route on the west side of the park is used as a winter snowmobile route to provide access from Cluff Lake and it is possible some of this snowmobile traffic makes its way onto the dunes.							**N/A**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals								**N/A**
5.2 Gathering terrestrial plants	Collecting seed for reclamation or collecting voucher specimens are minor potential threats. The taxa are locally abundant and occasional seed collection is unlikely to harm the populations directly. The Athabasca endemics are adapted to survive on sandy, disturbed environments; these are desirable traits for reclamation species on oil and mine sites in northern AB and SK. Firms from AB and SK have reportedly obtained permits and collected seeds from							**N/A**

	the park. Given the remoteness of the site, seed or plant collection is probably a negligible direct threat to the Athabasca endemics.							
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities	Visitors walking over the dunes could cause damage, particularly in gravel pavement habitats. Provincial park officials lack the resources to monitor visitor activities in such a large area. The potential impact of foot visitors on active dune surfaces is low and the impact on gravel pavements can likely be mitigated through education, particularly outreach targeted to tourist guiding operations. ATV traffic could cause damage to dune habitats. ATVs may also be a vector for the introduction of invasive species. ATV traffic on the dunes is likely an insignificantly threat at the present time; such traffic is banned from the park and rogue ATV use is rare. Human activity is currently limited by the remoteness of the site. The dunes are an expensive and not easily accessible destination, moderating the threat of human disturbance. The Athabasca sand dunes are currently only accessible by float plane or boat. Recreational boats can make their way to the dunes from Fort McMurray, travelling via the Athabasca river. Camping is permitted within certain zones of the park and there are a few fishing lodges and outfitters that offer hiking and canoeing traps within the park. The primary risk is that if more roads are built and industrial activity increases in the region, the dunes will become more readily accessible to recreational ATV use.							**N/A**
6.2 War, civil								**N/A**

unrest and military exercises								
6.3 Work and other activities	Subsistence hunting occurs in the Athabasca sand dunes region, but disturbance to the endemic plants is likely negligible.							**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression	Wildfires in SK are managed based on risk including proximity to humans, communities and infrastructure. At the present time, forest fires occurring near or within the Athabasca sand dunes are generally left to burn, given the remoteness of the area from important infrastructure. If new mines open in the Athabasca sand dunes region, fire suppression would likely be implemented to protect mine workers and infrastructure. Fire suppression poses a risk to the dunes, by promoting dune stabilization. Without this natural disturbance, trees and other vegetation can stabilize the sand dunes.							**N/A**
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications	Forest ingress on less active dunes leads to dune stabilization, decreasing dune area and dune habitat for the endemic taxa. Recent assessment of dune dynamics demonstrates that the longitudinal sand movement (parallel to dune axis) in a southeast direction was the key driver creating new sand dune surfaces at a rate of 0.14 km^2 per year. In the Athabasca sand dunes, forest succession on west dune boundaries is estimated to be occurring at a rate of approximately 2 km^2 per year. This likely reflects the reduced sand dune activity on the west edge as the predominant sand dune movement is towards the east. Overall, there was a sequence of increasing net loss of sand dune surface between 1985 and 2014. The net loss was 53.76 km^2, nearly 20% of the total open sand dune extent in 1985. Continuing stabilization of the western Athabasca sand dunes reduces available high-quality open dune habitat. In the area of stabilization, most taxa can persist, including Mackenzie							**N/A**

	hairgrass.							
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases	Vascular plant inventories of the north shore of Lake Athabasca have documented the occurrence of several potential invasive species, including Kentucky bluegrass, lamb's quarters, smooth brome, common dandelion, red-seeded dandelion, white sweet clover, alsike clover and white clover. More recent surveys identified annual hawksbeard as well. The presence of exotic species such as smooth brome and white sweet clover in the Athabasca region is worrying because they are likely to be well adapted to the sand dunes environment. Strongly rhizomatous species like smooth brome are of particular concern due to potential accelerated dune stabilization. Smooth brome is closely related and ecologically similar to northern brome; a rhizomatous native species frequently found growing on the dunes and the south shore of Lake Athabasca. White sweet clover could also rapidly establish and spread on active dune surfaces.							**N/A**
8.2 Problematic native species/diseases								**N/A**
8.3 Introduced genetic material	Hybridization between recognized taxa within the *D. cespitosa* complex is reportedly high. A purported hybrid specimen was noted between Mackenzie hairgrass and sympatric *D. cespitosa*, from Thomson Bay.							**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								

9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents								**N/A**
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants	The Athabasca endemics may be susceptible to acid deposition (primarily nitrogen oxides) arising from regional industrial activity. Species that germinate on open sand or gravel (like Mackenzie hairgrass) could be more at risk to acid deposition because germinating seedlings must rapidly establish root systems to avoid desiccation as the sand dries following precipitation events. Dune sand has a low buffering capacity, high cation leaching potential and increased aluminum solubility. Acid pollution, in the form of sulfur oxides SO_x and nitrogen oxides NO_x is projected to increase in the Athabasca sand dunes region as a result of oil and gas developments in northern AB. Acid deposition in the dune region is estimated to be less than 150 $molc \cdot ha^{-1} \cdot yr^{-1}$, well below the 210 to 250 $molc \cdot ha^{-1} \cdot yr^{-1}$ critical value for forest soils. Exceedance in nitrogen and sulphur deposition has been observed in AB, within 100 km of the Athabasca sand dunes. Direct tests of the effect of simulated acid deposition found limited short-term impacts on the root morphology on species including Mackenzie hairgrass. Nutrient leaching and acidification in dune soils can take decades to become apparent, therefore, the long-term effects on these species are unknown.							**N/A**

	Increased nitrogen deposition can lower species diversity and shift species composition toward fast growing shrubs, graminoids and forbs. This may favour Mackenzie hairgrass and other fast-growing plants dominant on the dunes. One study found a positive relationship between nitrogen deposition and forest expansion in six national parks including Wood Buffalo National Park, located approximately 100 km west of Athabasca Sand Dunes Provincial Park, suggesting a potential link between nitrogen deposition and dune stabilization.							
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Climate change poses an unknown risk to dune formation processes through changing wind patterns that may drive increased forest encroachment. Changes in prevailing wind patterns will influence sand sources for the dunes and potentially dune movement and stabilization patterns. If wind patterns change, the sand source from Lake Athabasca could be greatly diminished. It is currently unknown how likely a change in wind patterns is, or to what degree a change in patterns would lead to changes in sand sources, however, recent data from Uranium City has shown changes in wind patterns. The Athabasca sand dune region of SK and adjacent areas in AB is projected to become warmer and drier with an increase in fire frequency. More frequent stand replacing fires should benefit the							**N/A**

	Athabasca endemics by creating disturbance around the dunes and slowing dune stabilization. Climate change is thus the ultimate driver of the proximate threat of dune stabilization by forest encroachment.							
11.2 Droughts	Drought is an additional long-term threat that may impact the Athabasca sand dune's region, as some climate models predict considerable drying in the region. It is not clear what impact drought may have as the dunes are an arid environment and the dune endemics are likely more drought tolerant than forest species. The impact is potentially greatest on the water table, thus moisture conditions in dune slacks.							**N/A**
11.3 Temperature extremes								**N/A**
11.4 Storms and flooding								**N/A**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Nahanni aster (*Symphyotrichum nahanniense*)
Populations (if applicable):
Percentage of North American population NWT is responsible for: 100%. The global population of this species is restricted to thermal springs in Nahanni National Park Reserve in the NWT.
NWT General Status Ranks: Sensitive
NatureServe Conservation Rank (NWT): S3
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Special Concern
Reasons for assessment or population trends: The global population of this species is restricted to hot springs in Nahanni National Park Reserve. A very small range and population size make this endemic species susceptible to losses through natural alterations due to geothermal processes or to landslide events that may become more frequent as climate warms and permafrost melts.
Sources used for assessments: COSEWIC (2014a)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[203] = 2		
Dependence on habitats that are sensitive to climate change[204]	The global population of this species is restricted to seven known sites in the thermal springs in Nahanni National Park Reserve, within about 150 km of each other. This suggests it tolerates a narrow range of habitat conditions. Given the scarcity of springs with tufa, the species is unlikely to be much more widespread or abundant than currently known. Changes in groundwater discharge at thermal springs due to climate change and seismic activity are potential threats. Species is clearly a habitat specialist, which suggests a score of 4 as most appropriate (depends on sensitive habitats that are rare); however, when viewed through the lens of habitat vulnerability to climate change, this is less clear. A score of 2 seems most appropriate.	2 – Generalist, but some sensitive habitats are important.

[203] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.
[204] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

Sensitivity to climate-relevant abiotic factors[205]	Found at hot and warm spring habitats with tufa (calcium carbonate deposits). The areas immediately surrounding thermal springs presumably offer year-round moderate temperatures and a relatively steady water and nutrient supply. Nutrient availability may also be greater than other surface water habitats, although data are lacking. Water temperatures at the different springs range from 10°C -29°C but are expected to be relatively stable year-round. Water chemistry and temperature data suggest that springs with Nahanni aster are basic or only slightly acidic, with only low concentrations of trace elements and generally warm temperatures; however, there is some variation in abiotic habitat. The water temperature at Old Pots Spring is much cooler than other springs where Nahanni aster occurs and it is thought that it was a hot spring at one time but is now cool. There is little or no apparent ongoing deposition of calcium carbonate over much of the site. Currently, a cold stream begins above the pots, flows into a beaver pond and then through the tufa deposits. Nahanni aster has apparently been able to persist since changes in spring water (or has colonized this spring after the change). In either case, the persistence of Nahanni aster suggests that the species is tolerant of cooler spring temperatures and non-tufa accumulating environments where tufa has been previously deposited. Sibbeston Hotspring is also different in that the spring consists of a seepy hillside with cobbles encrusted with calcium carbonate but lacks tufa terraces. Similarly, the newest confirmed population at Persistent Spring has minor calcium carbonate deposits in the soil and lacks tufa formations. It is also roughly 300 m higher in elevation than the other known sites (Arnold pers. comm. 2020). Unlike the other hot springs with carbonate precipitates, Hotspring 86-030 has extensive red mounds of iron oxides. Seeds of some members of the genus *Symphyotrichum* can germinate without cold stratification, but germination rate increases after refrigeration in a moist atmosphere.	2 – Somewhat sensitive or possibly very sensitive.

[205] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

Sensitivity to climate-relevant biotic factors[206]	Nahanni aster is most commonly rooted in 'brown mosses' (especially *Tomenthypnum nitens* and *Cratoneuron filicinum*), but also occurs in broken old tufa and dense turf with various rushes and sedges. It has also been reported as rooting in sphagnum and that some plants grow 'hydroponically' with exposed roots in open warm water. Microsites with Nahanni asters are typically unshaded by trees or shrubs. Asters are typically pollinated by insects. Flowering occurs in August to September, peaking in mid-late August.	2–Somewhat sensitive or possibly very sensitive.
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	Habitat is protected from industrial development and roads by its isolated location and protected status in the Nahanni National Park Reserve. Potential low-level threats from landslides, invasive species and damage from human access. Climate change is the most likely threat.	1 – No pressures.
Adaptive capacity[207] = 1 plus 0.5 for low genetic diversity = 1.5		
Reproductive capacity[208]	Perennial. It reproduces both by seed and asexually using short rhizomes. Generation time is unknown. Seed production has not been measured, but flowering stems have 1-15 or more flower heads, each with 20-60 disk florets, suggesting that each individual can produce several hundred seeds annually. Asexual production of seed is apparently uncommon. Details on seed maturation, germination timing and seed dormancy for Nahanni aster have not been documented. *Symphyotrichum* seeds are often short-lived and persist only a few years in the seed bank. Individuals of the lance-leaved aster can produce seed in their first year after germination. Longevity of Nahanni aster is unknown, but other species in this genus have been recorded to live for over ten years.	1 – Early reproduction/many offspring
Dispersal capacity[209]	Dispersal presumably occurs by wind-borne seeds, as is the case with other aster species. Dispersal between	1 - >10km

[206] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).
[207] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[208] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.

	springs is probably limited by the scarcity of suitable habitat. Dispersal between known sites has not been demonstrated. Dispersal between the four relatively closely clustered sites (Old Pots, Wildmint, Thirteen Steps and 86-030; within ~10 km radius) is more likely than dispersal between Rabbitkettle, Sibbeston and Persistent, which are more isolated. Despite the distribution of subpopulations in small and dispersed habitat patches, Nahanni aster is not considered to have a 'severely fragmented' distribution because seeds are assumed to be produced in large numbers and widely dispersed by the wind or water.	
Genetic diversity	Genetic diversity is likely low given its small range and small population size (Harris pers. comm. 2020).	0.5
Phenotypic plasticity	Interpopulation analysis of the Nahanni asters revealed that they differ morphologically depending on their spring site; however, sample sizes were quite small. This may suggest that these populations are at least somewhat isolated from each other, but the differences may be related to growing conditions (e.g. nutrients, temperatures, etc.) rather than genetic variability. In-field observations during a 2019 survey noted visual differences in plant morphology (e.g. colour, branching), size, flowering and abundance at sub-plots within sites (Arnold pers. comm. 2020).	N/A

[209] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling								**N/A**
3.2 Mining and quarrying	Wildmint Hotspring is marked on some topographic maps with a mini symbol (pickaxe graphic).							**Neg.**

3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads								**N/A**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals								**N/A**
5.2 Gathering terrestrial plants	Under the *Canada National Parks Act*, picking of any plants (removal or destruction of a natural object) is prohibited. The impact of any unauthorized plant removal is likely dependent on the populations, which vary greatly in abundance.							**Neg.**
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities	Public access to the Rabbitkettle Hotsprings area, prior to park establishment and during the early years of park management, caused some localized damage to the tufa mounds at the site. The area was given protection as a Special Preservation Area (zone 1) under the first park management plan and this status remains in place today, limiting public access to staff-guided interpretive hikes. Even with previous use, there has been no perceptible impact to the area in which Nahanni aster grows at the site.							**Neg.**

	Similar zoning protection (no unaccompanied public access) is afforded to both Wildmint and Old Pots springs under the management plan. Due to the very low frequency of visitor use on the Flat River, the risk from human traffic and trampling is not considered a significant threat at these sites or at Thirteen Steps and 86-030 springs. Sibbeston and Persistent springs are well away from any common visitor travel routes. In addition, aircraft access outside designated landing sites is strictly regulated.							
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities	Under the *Canada National Parks Act*, scientific collection of any kind requires a Parks Canada Research and Collection Permit.							**Neg.**
7. Natural system modifications								
7.1 Fire and fire suppression	Fire patterns in Nahanni National Park Reserve are unpredictable and threats are unknown. Fire would not be suppressed in any of the known locations (Arnold pers. comm. 2020).							**N/A**
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications								**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases	Invasive plants are a potential future threat, but are currently confined primarily to disturbed sites such as the Kraus homestead (downstream of all known Nahanni aster locations). The park reserve surrounds an advanced exploration site and mine under development at Prairie Creek with a road proposed to access the mine. Another mine access road passes through the northwest portion of the park expansion area. An increase in access roads related to resource development is providing a vector for additional species; evidence of this was seen in 2012. None of these	L	U	S	LT F	L	L	**Low**

	road proposals are in close proximity to aster sites, however, with the nearest being Sibbeston Hotspring ~20 km west of the Prairie Creek access road.							
8.2 Problematic native species/diseases	Alteration of thermal spring travertine habitats from trampling by ungulates (moose, woodland caribou, etc.) is more likely than physical impacts from humans; evidence of this is apparent at Wildmint Hotsprings, but it does not appear to be negatively impacting the Nahanni aster population at the site.							**Neg.**
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents								**N/A**
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light								**N/A**

pollution)								
10. Geological events								
10.1 Volcanoes								N/A
10.2 Earthquakes/ tsunamis	Changes in groundwater discharge at thermal springs due to climate change and seismic activity (e.g. fault movements and earthquakes) are potential threats. The extremely limited range of Nahanni aster (seven occurrences covering less than 10 ha in total) make it vulnerable to random environmental events. A seismic fault shift could reduce or stop groundwater flows at a spring. The Nahanni area is one of the most active seismic regions in Canada. Strain transfer from the collision of the Yakutat Terrane in coastal Alaska reaches the surface along the eastern edge of the Mackenzie and Richardson mountains, resulting in seismic activity and very high temperatures beneath the eastern cordillera. In 1985, two major earthquakes occurred in the Sombre Mountains near the North Nahanni River on October 5 (magnitude 6.6) and December 23 (magnitude 6.9). Although neither quake ruptured the surface, the first earthquake produced a huge rock avalanche at the surface. Earthquakes continued for several years, including a magnitude 6 event in 1988. The seismic activity was not traceable to any mapped faults, but instead to a 'blind' fault that doesn't reach the surface. Five seismic events were recorded in the area northeast of Virginia Falls between August 1996 and March 1997. A large landslide in the winter of 1996-1997 at Clearwater Creek was probably triggered by these events. Nahanni aster populations are vulnerable to changes in spring discharge caused by seismic events. Thermal spring flow elsewhere in western Canada has been altered and even stopped by earthquake activity, even when the seismic activity occurs hundreds of km away. However, Nahanni aster may be able to persist after spring discharge has been altered as has apparently	L	U	C	LTF	M	M	**Low**

	been the case at Old Pots.							
10.3 Avalanches/ landslides	Increases in soil and rock slumping have been noted by Nahanni National Park Reserve staff in recent years and are probably due in part to permafrost melt, but seismic activity may also be involved. An assessment of landslide hazards in Nahanni National Park Reserve was undertaken as part of the feasibility studies for park expansion and concluded that the Tlogotsho Range and Ram Plateau were the most active areas. Although Nahanni aster populations may be vulnerable to devastation by slumping, none of the identified populations are in the higher risk slide zones. Observations from Nahanni National Park Reserve staff and other researchers have nevertheless noted the disappearance of some springs in the park and landslides within 1-2km of known Nahanni aster populations (Arnold pers. comm. 2020).	L	M	C	N	M	M	**Medium**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	The climate in Nahanni National Park Reserve is warming and rainfall patterns are changing. Changes in groundwater discharge at thermal springs due to climate change and seismic activity are potential threats. The climate in Nahanni National Park Reserve and vicinity in recent decades is significantly warmer than the 1950-1979 period, based on Environment and Climate Change Canada weather station records from Fort Simpson as a proxy. This has resulted in a longer and warmer growing season and increased August rains. Snowfall has increased, but the warmer winters have resulted in decreased snowpack and earlier spring. The potential threats to Nahanni aster are speculative; changes in precipitation or runoff could alter groundwater discharge, although the observed pattern of increased precipitation could also increase groundwater discharge and available habitat.	W	U	C	N	H	L	**Low**
11.2 Droughts								**N/A**
11.3 Temperature								**N/A**

extremes								
11.4 Storms and flooding								**N/A**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Northern leopard frog (*Lithobates pipiens*)
Populations (if applicable): Western boreal population
Percentage of North American population NWT is responsible for: Occurs throughout most of central and northeastern North America. NWT northern leopard frogs belong to the western boreal population, which extends from western Manitoba through SK and AB.
NWT General Status Ranks: At Risk
NatureServe Conservation Rank (NWT): S1
***Species at Risk (NWT) Act*:** Threatened
***Species at Risk Act* (Canada):** Special Concern
Reasons for assessment or population trends: In the NWT, the northern leopard frog is at the northern-most limit of its range in the world. Unlike some species of frogs, they are not freeze-tolerant and do not hibernate. To overwinter, they go dormant under water. These sites must be well-oxygenated and not freeze. Northern leopard frogs are therefore limited to only the very southern NWT where suitable overwintering sites exist. There is some evidence of population and range reductions. Rescue of the species in the NWT is not plausible because nearby northern leopard frog populations in northern AB and SK have disappeared or are at risk. In the NWT, emerging diseases (chytrid fungus and ranavirus), proposed hydroelectric developments, climate change (from negative effects like drought) and potential air and waterborne pollution likely pose the greatest threats to northern leopard frogs.
Sources used for assessments: SARC (2013a)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[210] = 2		
Dependence on habitats that are sensitive to climate change[211]	In the NWT, the northern leopard frog is at the northern-most limit of its range in the world. The northern leopard frog has three primary habitat requirements: aquatic habitat for breeding, egg laying and tadpole development; foraging habitat; and overwintering habitat. These habitats, often in close proximity, must be connected by travel corridors that are suitable for migration and dispersal.	2 – Generalist, but some sensitive habitats are important.

[210] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.
[211] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	Breeding takes place in a wide variety of permanent and semi-permanent wetlands that contain a combination of open water and emergent vegetation. Suitable sites include beaver ponds, springs, oxbows, quiet backwaters of streams, lake edges, flooded meadows, swamps and marshes and man-made habitats such as roadside ditches and borrow pits. Northern leopard frogs show a strong fidelity to breeding sites, returning to the same sites year after year. Summer feeding areas are frequently found along the margins of water bodies, including breeding ponds and stream banks. Preferred areas are open and semi-open with short vegetation. Heavily forested areas and areas with dense aquatic vegetation, tall grass, or shrubs are avoided. Northern leopard frogs usually overwinter on the sand or mud bottoms of water bodies. Streams, creeks, rivers, lakes, deep ponds and springs may all provide appropriate overwintering conditions. Springs that do not freeze may be important if deep water is not available. Terrestrial overwintering may occur in small mammal burrows, caves or under rocks, woody debris or leaf litter. Northern leopard frogs may exhibit site fidelity to overwintering sites. Habitat requirements during dispersal are not well known. Habitat limitations that likely determine the species' distribution in the NWT include the availability of suitable breeding or overwintering sites. Wetland isolation (separation of wetlands by large distances) may also limit distribution. Habitats of pond-breeding amphibians in general, including those of northern leopard frogs, tend to be naturally fragmented.	
Sensitivity to climate-relevant abiotic factors[212]	Unlike some species of frog, northern leopard frogs are not freeze-tolerant and do not hibernate. To overwinter, they go dormant under water. These sites must be well-oxygenated and not freeze. Terrestrial overwintering sites must have moisture present to	2 – Somewhat sensitive or possibly very sensitive.

[212] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

	prevent desiccation and burrows must be below the frost line. Northern leopard frogs have smooth, moist skin, making them vulnerable to desiccation. Metamorphs and smaller juveniles have a higher surface area to volume ratio and are more vulnerable to desiccation than adults. They can survive the loss of up to 50% of total body water (~40% of body mass) at 5°C. They have behavioural adaptations to prevent desiccation, such as burrowing in the sand and choosing moist micro-sites and habitats. Water in breeding habitats is usually shallow (less than 1.5 m), pH neutral and fishless. A pH of 7.8 was recorded in Leland Lake in July 2005, while the Calgary Zoo has recorded pH values that include and range between 7.0 to over 10.0. Warm water is required for rapid embryo and tadpole development. Time of egg hatching is dependent on water temperature and usually occurs in five to nine days, but may be extended to more than two weeks in cool weather. Metamorphosis of tadpoles takes two to three months and is temperature dependent. Early drying of semi-permanent sites leads to increased tadpole density, accelerated development and metamorphosis at a reduced size. Adults may move some distance from water if sufficient moisture and cover are available. Northern leopard frogs are ectotherms. They thermoregulate behaviourally. Lethal minimum and maximum temperatures for northern leopard frogs are - 1.6°C and 35°C, respectively. The ability of northern leopard frogs to maintain high levels of activity (such as migration to breeding sites, breeding and foraging) increases with temperature and peaks at 20°C -29°C. Northern leopard frogs emerge from overwintering habitats early in the spring as the ice begins to melt and air and water temperatures warm. Migration from overwintering sites has been observed at water temperatures of 9°C -12°C and 7-10°C. Another study observed that frogs did not leave overwintering sites until the air temperature exceeded 13°C.	

	Random events such as freezing temperatures or drought can have major impacts on cohorts or even an entire population, resulting in extirpation. A decrease in summer precipitation might increase the frequency and duration of droughts, negatively affecting the persistence of smaller wetlands used for breeding and decreasing connectivity across the landscape. Summer droughts and late spring freezing during the northern leopard frog's breeding season could lead to catastrophic reproductive failures.	
Sensitivity to climate-relevant biotic factors[213]	Climate change may favour earlier breeding due to advanced ice melt. Breeding takes place between mid-April and late June depending on weather conditions and water temperature. While there are benefits to synchronous, communal breeding, the risk is that large numbers of eggs or tadpoles could be adversely affected by environmental conditions such as freezing or drought. Tadpoles are primarily herbivorous, but will also feed on dead plants and animal carcasses. Adults and juveniles are primarily ambush predators, feeding largely upon arthropods.	2 – Somewhat sensitive or possibly very sensitive.
Non-climate stressors = 2		
Sensitivity to potentially interacting non-climate pressures	The most significant non-climate stressors faced by northern leopard frogs in the NWT include hydroelectric development, diseases, UV-B radiation and pollution.	2 – Moderate pressures or possibly major pressures.
Adaptive capacity[214] = 1.5		
Reproductive capacity[215]	Generation time is three years. Each egg mass laid contains 600-7,000 eggs. Clutch size is correlated with female body size, which is related to age. Hatching success is highly variable, ranging from 50-99%and depends on several factors affecting embryo mortality (e.g. physical breakup of egg masses, parasitism and disease). The eggs are fertilized externally as they are being laid. Breeding is usually communal and explosive (occurring over just a few warm, calm days), but the period may be extended if air and water temperatures	1 – Early reproduction/many offspring

[213] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).
[214] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[215] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.

	are less suitable. Survivorship from egg to metamorphosis was reported as 1-6% in Minnesota. Young-of-the-year can comprise 95-98% of the fall population, but they may suffer 93% mortality during the first winter. Adult mortality rates may reach 60% annually. Sexual maturity is dependent on size more than age, but is attained over one to three years. Northern leopard frogs rarely live longer than four to five years in the wild, though they can live up to nine years in captivity. Generation time is an average of three years of age.	
Dispersal capacity[216]	Key habitats must be connected by travel corridors that are suitable for migration and dispersal. Summer feeding areas may be up to 2 km from breeding sites. High vagility (ability to move) within home ranges. Limited dispersal abilities. Maximum recorded dispersal movements of up to 10 km.	2 – 1-10km.
Genetic diversity	The prairie/western boreal designatable unit (of which the western boreal population is a part) is supported by the high degree of genetic uniformity of southern and northern Alberta and NWT populations. Recent observations of northern leopard frogs in the western boreal population of the north have been confined to an area in extreme northeastern AB and northwestern SK north of Lake Athabasca and the adjacent South Slave region of the NWT. Connectivity of northern and southern populations is considered unlikely at this time. There may be a connection along the Canadian Shield in SK and major rivers/drainages in the north.	N/A
Phenotypic plasticity		N/A

[216] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling								**N/A**
3.2 Mining and quarrying								**N/A**
3.3 Renewable								**N/A**

energy								
4. Transportation and service corridors								
4.1 Roads and railroads	Roads remove woodland habitat and fragment habitat, but more importantly they represent barriers to dispersal and migration and result in road kill events which may lead to population declines. Adults and metamorphs are especially vulnerable near breeding, foraging and overwintering sites, where mass movements may occur. Naturally fragmented habitat may be further fragmented if road corridors and transmission lines in the South Slave region are changing habitat characteristics (e.g. making terrain too dry) or blocking migration and dispersal. The actual impact of these features on northern leopard frog habitat is likely negligible since most dispersal occurs along riparian corridors and wetlands. However, road mortality of migrating and dispersing frogs may be an undocumented issue in the NWT, especially if breeding ponds are located adjacent to roads. Road mortalities and barriers to movement are a potential limiting factor for northern leopard frogs at the western edge of their range in the NWT along Highway 5 into Fort Smith and similarly south of Fort Smith to Fort Fitzgerald/Hay Camp in AB.							**Neg.**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	The collection and harvest of northern leopard frogs in the NWT is suspected to occur at a low level and with a low impact. Nonetheless, this activity has the potential to impact local populations. Northern leopard frogs can be harvested without a permit for any use such as bait, pets, or food. Frogs (species not specified) have reportedly been used as bait by fishing guides in the							**Neg.**

	NWT.							
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression								**N/A**
7.2 Dams and water management/use	Water management activities related to hydroelectric developments that increase water levels might create excessive currents that disrupt breeding activities and overwintering habitat and dislodge egg masses. Decreased water levels might result in the loss of breeding ponds or in ponds drying up before metamorphosis. There has been hydroelectric power generation on the Taltson River since 1965. Existing structures include a dam and power generation facility at Twin Gorges dam, a rockfill dam and overflow spillway at Nonacho Lake and an overflow spillway through Trudel Creek known as the South Valley spillway. The proposed expansion project would add to the existing infrastructure and may have significant impacts on northern leopard frog habitats and	W	U	C	N	H	L	**Low**

	populations in the NWT, if the project goes ahead. The project infrastructure includes winter roads, a new transmission line and a new hydroelectric plant. The winter road and transmission line require water body crossings (between Fort Smith, Twin Gorges Damand Nonacho Dam), but with no instream works and minimal riparian brushing. The greatest impacts would result from changes to the existing hydrology regime in the Taltson River, where summer flows would be reduced and winter flows would be increased. Flows would be reduced in the Trudel Creek spillway. Artificial ponds may be colonized by northern leopard frogs but these ponds may only be population sinks that have a negative effect on population persistence, especially if they are semi-permanent or provide poor overwintering or foraging habitat. With limited knowledge of current northern leopard frog breeding and overwintering sites, impacts of this project on habitats cannot be adequately assessed. The expansion project is currently on hold while the proponent determines if there is a viable market. The flow regime of the Slave River has been affected by the upstream Bennett Dam since 1968. Significant changes in flow in the Slave River over the past 40-50 years have been noted by scientists and by Fort Smith and Fort Resolution residents. These changes include reduced overall flow, earlier peak flow, decreased summer flow, increased winter flow and less variable annual flow. Flow regulation as well as climatic change have been identified as drivers of these changes. Participants at a community workshop in Fort Smith indicated that the decline in water levels in the Slave River and Delta ecosystem has led to drying of wetlands, fens, channels and lakes and cited this drying of frog habitat as one possible reason for the decline in frogs they had observed. Dampened flows from mid-May through the summer months may have had an impact on the available breeding and rearing habitats for northern leopard frogs along formerly flooded shorelines.							

7.3 Other ecosystem modifications								**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases	Introduced plant species such as white and yellow sweet clover might degrade northern leopard frog shoreline habitat. However, this is thought to pose very little threat at the present time.							**Neg.**
8.2 Problematic native species/diseases								**N/A**
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin	Diseases caused by chytrid fungus and ranaviruses are an immediate threat; magnitude of the impact is likely small at this time. Considered the most serious plausible threat. These diseases have not be found in NWT populations of northern leopard frogs as of 2012, but have been detected in other frogs elsewhere in the NWT. If and when these diseases occur, their mode of transmission suggests that they could affect all NWT northern leopard frog populations almost simultaneously. Anglers, float planes and boats could be a vector for pathogen spread, depending on their cleanliness and origins. Release of bait frogs may also be a vector for disease transmission. Chytridiomycosis, caused by the chytrid fungus *Batrachochytrium dendrobatidis* (Bd), is widespread in amphibians across North America, including northern leopard frogs. The Bd population in North America is a hyper virulent lineage that resulted from the anthropogenic mixing of two other lineages and subsequent anthropogenic spread (probably through the global trade in amphibians). It may require other co-stressors such as increased UV-B radiation for the disease to become pathogenic. It has been found on northern leopard frogs in AB and BC and on wood frogs,	W	U	C	LTF	L	L	**Low**

	western roads and boreal chorus frogs near Fort Liard. A survey in AB showed that the disease is widespread and common in a variety of amphibians. Curiously, the disease was not found in the population on the Canadian Shield. Bd is suspected of suppressing northern leopard frog populations in BC. There is evidence that some amphibian species are able to survive Bd epidemics, either through increased immunity, which allows them to live with low-level fungal infections, the evolution of less pathogenic strains of Bd, favourable environmental conditions, low infection intensities, or through adaptation and the evolution of better defenses (such as anti-microbial peptides on their skin). While there is evidence that Bd is a spreading pathogen that can have negative consequences for amphibian populations, there is also evidence that Bd is widespread in areas where there is little evidence of harm, or where Bd has become endemic in apparently stabilized populations. Infections and mortalities due to ranavirus have been reported for northern leopard frogs in captive and wild populations. A positive test result for ranavirus occurred in a northern leopard frog at Bocquene Lake, in the Shield population of AB, in 2009. Northern leopard frog die-offs have been linked to or associated with ranaviruses in southern ON and near Estevan, SK. In the NWT, ranaviruses were recently found to be widespread in wood frogs across the Sahtú and Dehcho regions. Ranaviruses can be transmitted between host species and host populations may differ in their response to infection. Bd and ranavirus testing is ongoing for samples obtained from northern leopard frogs, wood frogs, boreal chorus frogs and Canadian toads from the South Slave region.							

	'Red leg', caused by infection by the bacterium *Aeromonas hydrophila*, is most often fatal. It was the cause of high mortality in northern leopard frogs in AB in 1976; however, there were no population extirpations. There have been no reports of this disease from the NWT, where its prevalence is unknown.							
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents	Environmental contamination has not been identified as a current threat to northern leopard frogs in the NWT, but contaminants in the water were noted as a potential reason for frog declines observed by community workshop participants. There is a high level of community concern about contaminants in the Slave River water and their effects on fish, birds and other wildlife. Airborne pollution is also of concern to people living in the area. It is not conclusively known whether contamination from the AB oil sands is having downstream and downwind effects on northern leopard frogs in the NWT, but there is a high level of community concern about water contamination and airborne pollutants in general. Oil sand process-affected substrates and water were shown to have negative effects on wood frog egg and tadpole survival, growth and development. Environment and Climate Change Canada is evaluating the health of wild amphibians and amphibian populations close to and at varying distances from oil sands operations. There are study sites in the NWT near Fort Smith and Fort Resolution. The wood frog is the primary indicator species in these studies; however, it is noted that northern leopard frog is also a good indicator species, as it is a more aquatic species than	W	U	C	LTF	M	L	**Low**

	the wood frog and part of its natural history life cycle involves overwintering in aquatic environments. Because northern leopard frogs spend more time in and exposed to water, they could be more susceptible to water-borne contaminants. Compared to wood frog, northern leopard frog may be more sensitive to pollution. However, other amphibian species will be sampled if encountered. Amphibians will be screened for diseases, malformations, organic chemicals and heavy metals. Effects on populations, such as survival, are not being monitored. Spills of fuel oil, various chemicals such as antifreeze and glycol-based products for vehicles, lube oil and other hydrocarbons have increased in recent years. Although the spills to date are mostly linked to mining developments outside of the range of the northern leopard frog in the NWT, any spills along the proposed winter road for the Taltson Basin Hydroelectric Expansion Project could affect some northern leopard frogs in the future. Contaminants such as mercury, PCBs, DDT (dichlorodiphenyltrichloroethane), PBDEs and organohalogens are being monitored in predatory fish in the NWT, including some lakes near the range of the northern leopard frog (Nonacho and Stark lakes). Like predatory fish, northern leopard frogs are bioaccumulators. Levels of these contaminants in fish are increasing, especially in smaller lakes, but the impact on frogs cannot be projected from these data, which are collected to assess human health risks from fish consumption. Heavy metals including zinc, cadmium and copper can have negative effects on amphibian growth, development and survival. Chlorinated hydrocarbons, polycyclic aromatic hydrocarbons, nutrients and heavy metals such as aluminum, cadmium, chromium and copper at study site in ON exceeded provincial guidelines for							

	the protection of aquatic life, caused reduced tadpole survivorship, higher tadpole deformity frequency and reduced time to metamorphosis. Road salts affect tadpoles by reducing their activity and weight and inducing physical abnormalities and large concentrations of salt are toxic to amphibians. They prefer a neutral pH and are sensitive to acidic conditions, particularly after emerging from overwintering. The use and prevalence of environmental contaminants in the water and sediments in the range of northern leopard frog in the NWT are unknown.							
9.3 Agricultural and forestry effluents (including erosion)	Northern leopard frogs are vulnerable to environmental contaminants such as pesticides, herbicides, fertilizers and heavy metals that pollute their aquatic habitats (see 9.2). The pesticide malathion kills the plankton that tadpoles feed on. Several compounds such as atrazine, DDT, dieldrin and acids cause immunosuppression in amphibians in low concentrations. Atrazine can be acutely toxic to northern leopard frogs and it can disrupt sexual development. In wetlands with water and sediment containing elevated levels of metals and nutrients early-stage tadpole survivorship was lower, deformity frequency was higher and time to metamorphosis was reduced.							**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants	Levels of polycyclic aromatic compounds (PAC) in the Athabasca River basin are likely toxic to fish embryos. The PACs were deposited to the snowpack as airborne particulates, originating from oil sands mining and processing. Airborne emissions also deposited 13 elements considered priority pollutants. Concentrations of seven pollutants in Lake Athabasca (cadmium, copper, lead, mercury, nickel, silver and zinc) exceeded guidelines for the protection of aquatic life. These findings suggest that	W	U	C	LT F	M	L	**Low**

	upstream and upwind oil sands developments in AB may cause future impacts to northern leopard frogs in the NWT. Environment and Climate Change Canada is evaluating the health of wild amphibians and amphibian populations close to and at varying distances from oil sands operations.							
9.6 Excess energy (noise/light pollution)	UV-B radiation is a threat of low magnitude, but it may be higher in combination with other stressors. A thinner ozone layer is allowing more biologically damaging UV radiation (UV-B) to reach the earth's surface. UV-B radiation is lower at higher latitudes. Chemical contamination of amphibian habitats and UV-B radiation may cause deformities (deformities can also frequently be caused by physical traumas). Out of 225 frogs examined, one adult wood frog with a deformed hind foot was found in the Dehcho and Sahtú regions in 2007 and 2008. Eleven frogs (out of 258), including three of 11 northern leopard frogs examined in the South Slave region had gross physical abnormalities including missing eyes, curved spines and deformed hind limbs. The cause of the amphibian deformities observed in the South Slave region was not determined and the implications of the abnormalities on the population of northern leopard frogs there is unknown. Increasing UV-B radiation has been proposed as a potential cause of amphibian declines through effects on hatching success. This could be especially problematic in species like the northern leopard frog, which lay eggs near the water surface.	W	U	S	N	H	L	**Low**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat	Global climate change may have both negative and positive impacts	W	U	C	N	H	L	**Low**

shifting and alteration	on northern leopard frog habitat. The potential impacts over the next decade are unknown or ambiguous at best. Climate models predict increases in temperature and precipitation in Canada, with the most warming projected for northern Canada. Long-term trends have not been predicted for the South Slave region of the NWT but recent summers have been wetter than previously recorded, which have led to very low forest fire seasons. The Mackenzie District (which includes all forested parts of the NWT) is experiencing warming and more variable weather in all seasons. Precipitation is likely to increase in winter and spring, but decrease in summer. Snow season length is predicted to decrease, but increased snowfall amounts will more than make up for the shorter snow season, resulting in increased snow accumulation. Data collected in the Mackenzie District indicated winter snowfall may in fact be declining. Effects of climate change are already being observed locally. Residents have noticed a number of warmer winters with less snow and also colder winters with lots of snow. There is less rain, less snow and the snow is melting faster (due to more wind and higher temperatures) and evaporating instead of entering the groundwater system. Drying and shrinking of ponds, lakes, creeks, rivers, fens and wetlands in the Slave River and delta ecosystem has been noticed by residents of the area. Thawing of permafrost will change patches of boreal forest habitat, especially in areas of discontinuous permafrost. Changes in permafrost underlying peat plateau are causing mortality of overlaying vegetation and a change from forest to bog-fen habitat. Rates of permafrost reduction have been measured at 0.5% (area cover) per year. These changes in permafrost have been studied on a small scale in the Dehcho region but how these changes apply to the range of northern leopard frogs in the NWT needs further							

	investigation. Positive impacts from climate change in the north may include earlier breeding due to advanced ice melt and range expansion by amphibians that are presently excluded from beyond their northern limit by the brief ice-free period.							
11.2 Droughts	Random events such as freezing temperatures or drought can have major impacts on cohorts or even an entire population, resulting in extirpation. A decrease in summer precipitation might increase the frequency and duration of droughts, negatively affecting the persistence of smaller wetlands used for breeding and decreasing connectivity across the landscape. Summer droughts and late spring freezing during the northern leopard frog's breeding season could lead to catastrophic reproductive failures. Drought in southern AB in the 1970s and 1980s was linked to some population extirpations, but not to the widespread declines.	L	U	S	ST F	M	L	**Low**
11.3 Temperature extremes	See 11.2.	L	U	S	ST F	M	L	**Low**
11.4 Storms and flooding	Projected increases in storms and flooding may alter the pH balance of other biochemical factors in water habitats (Lee pers. comm. 2020).	L	U	S	LT F	M	L	**Low**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Woodland caribou (northern mountain population) (*Rangifer tarandus caribou*)
Populations (if applicable): Northern mountain population
Percentage of North American population NWT is responsible for: Northern mountain caribou are almost exclusively found in western Canada in BC, the NWT and YT, with a small portion of the range overlapping eastern Alaska. Low elevation winter ranges of the Redstone, South Nahanni, Coal River and La Biche subpopulations are found exclusively in the NWT. The NWT contains 40-44% of the estimated 50,000-55,000 northern mountain caribou in Canada and North America, including the two largest subpopulations: Redstone and Bonnet Plume.
NWT General Status Ranks: Sensitive
NatureServe Conservation Rank (NWT): N4N5
Species at Risk (NWT) Act**:** Special Concern (assessed, listing under consideration)
Species at Risk Act **(Canada):** Special Concern
Reasons for assessment or population trends: The range of this species is remote and relatively undisturbed outside of localized areas. However, northern mountain caribou in the NWT are subject to a number of important threats. Northern mountain caribou are vulnerable to the effects of climate change, particularly the already noticeable decline in ice patches in the Mackenzie and Selwyn mountains. These areas, used to escape insects and cool down in the summer, are considered critical habitat components. Other threats include harvesting, recreation activities, resource development and disrespectful harvesting behaviour. Although most of these threats are localized at the scale of the whole range of northern mountain caribou, they are expected to result in measurable negative impacts in some significant portions of the range, including within the calving and summering range of the Redstone herd, the largest herd in the NWT. There is strong local interest and support for management interventions in the range of northern mountain caribou. However, there exists strong concern that this is not being translated into meaningful management actions. Northern mountain caribou have a number of limiting biological characteristics that make them particularly vulnerable to the effects of climate change in particular (e.g. cold-adapted, reliance on ice patch habitat) and can limit population recovery in the event of a decline (e.g. low reproductive capacity, high levels of calf mortality). Northern mountain caribou have the potential to become Threatened if the effects of climate change continue within their habitat and localized threats are not managed effectively. Additionally, population declines or displacement have been reported by Indigenous knowledge holders in the Sahtú and Gwich'in regions. This has been particularly noticeable over the last ten to 12 years for the Redstone herd. However, much of the scientific population data are outdated. Although rescue from neighbouring populations is possible, the NWT contains the two largest subpopulations of northern mountain caribou in Canada and would more likely act as a source population.

Sources used for assessments: SARC (2020b)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[217] = 3		
Dependence on habitats that are sensitive to climate change[218]	Plasticity in winter range/habitat use could help caribou respond to variable environmental conditions. Although individual caribou often return to the same general wintering areas each year, fidelity to specific area within those wintering areas is variable. Some northern mountain caribou in the NWT may switch both winter ranges and wintering strategies between years. Northern mountain caribou rely on ice patches to minimize harassment from insects and for cooling themselves during hot weather. These summer critical habitat components are observably declining in the Mackenzie and Selwyn mountains. Caribou may rely heavily on boreal lichens during the winter. Access to lichens, particularly in winter, is essential to caribou. The slow rate of lichen growth underlines the significance of habitat stability and snow conditions (to maintain access to lichens) to caribou. With warmer, drier summers, an increase in wildfire frequency and severity is expected resulting in abrupt changes in vegetation composition. Most of the northern mountain caribou range in the NWT overlaps the continuous permafrost zone, with lower elevation areas along the eastern portion of the range overlapping the extensive discontinuous permafrost zone. Climate change could result in permafrost degradation, which could lead to changes in vegetation species composition.	3 – Depends on sensitive habitats that are not rare.
Sensitivity to climate-relevant abiotic factors[219]	Caribou are highly adapted to their environment and cold winter conditions (large feet, prominent dew claws, thick hollow guard hairs, thin woolen underfur).	3 – Likely very sensitive.

[217] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.
[218] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.
[219] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

	Environmental changes that result in changes in snow conditions (depth and hardness) that impact cratering and movements may have a significant impact on body condition and therefore productivity. Hot weather can result in heat stress. Habitat use is influenced by weather – most caribou are found in high terrain when it's hot, but there will also be individuals in breezy rocky habitat or on gravel bars to keep bugs away. It may be that one of the greatest threats of climate change is the unpredictable nature of these environmental changes and an increasing frequency of unfavourable conditions, such as snow depth, snow crusting, delays in snow melt, etc.	
Sensitivity to climate-relevant biotic factors[220]	Increased rain/freeze events can limit availability of terrestrial lichens by creating conditions that make it difficult for caribou to detect and forage for terrestrial lichens. Icing could also be advantageous for wolves, if snow conditions allow wolves to run on top of the crust but not caribou. There are complex predator/prey interactions associated with climate change that may result in some species expanding their range northward into northern mountain caribou habitat, or endemic species shifting their distribution. Some elders are worried that earlier spring weather might bring bears out of hibernation earlier, creating greater predation pressure during the calving period. White-tailed deer and elk appear to be becoming more abundant in the Mackenzie Mountain area. Apparent competition in the NWT is less likely to occur however (compared to southern portions of the range), unless alternate prey densities increase substantially. Climate change could alter the parasites and diseases that affect caribou. For some parasites, life cycles could potentially be shortened and/or ranges could extend northward. Insect harassment could potentially increase at the same time that snow patches become less available for caribou to use to avoid them, which can lead to increased energy expenditure by caribou	3 – Likely very sensitive.

[220] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

	during the insect season. Although no information is available on prevalence of the winter tick on northern mountain caribou in the NWT, increasing prevalence of winter tick on boreal caribou in northeastern BC and the NWT has been observed. Vegetation composition is expected to change as warmer conditions result in increased productivity, which could support vegetation favoured by other prey species. Increased shrub growth has already been observed in alpine and Arctic tundra ecosystems. Increased shrub abundance could out compete lichens and support higher densities of other ungulates. The timing of seasonal movements may be disrupted, leading to a chain of events that influence distribution. For example, if the snow arrives early, females will start to move into their wintering grounds early.	
Non-climate stressors = 2		
Sensitivity to potentially interacting non-climate pressures	Currently, subpopulation ranges in the NWT are large and primarily undisturbed. Climate change is one of the most important threats. Non-climate threats include industrial development, linear developments, unsustainable harvesting practices, disturbances from flights and recreational activities, fire, predation increases and contaminants. Habitat alteration due to fire and anthropogenic disturbances can further exacerbate climate change-related threats like permafrost degradation.	2 – Moderate pressures or possibly major pressures.
Adaptive capacity[221] = 2.5		
Reproductive capacity[222]	Adult females usually do not breed until they are at least two years of age (28 months) with some not breeding until they are three years old (40 months). Females typically give birth to one calf and twinning is rare. Pregnancy rates for caribou are generally high (72-93% in reported studies). With an older age of first breeding and calf production limited to only one calf, caribou have a low reproductive rate compared to other deer species, such as moose, which can start breeding as yearlings and which frequently have twins. A low reproductive rate,	4 – Late reproduction/few offspring

221 Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.

222 Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.

	coupled with high levels of calf mortality, could result in a slow rate of population recovery following a decline. Generation length based on IUCN calculations is nine years. Ages of northern mountain caribou in the NWT based on caribou harvested by Indigenous harvesters suggests that the adult females can live up to at least 15 years of age and adult males can live up to at least 13 years of age. Average annual survival rate of radio-collared adult female caribou in the South Nahanni subpopulation (the only available estimates) are 89%.	
Dispersal capacity[223]	Mountain caribou can easily move through any type of terrain in their range. Most northern mountain caribou in the NWT undergo long distance migrations and can travel up to 250 km between winter and summer ranges, while some individuals remain close to their winter ranges all year round.	1 - >10km
Genetic diversity	Indigenous and community knowledge research results indicate that there may be more extensive overlap and known mixing between barren-ground and mountain caribou populations (historically and currently) than is generally supported by science. The Finlayson and Hart River subpopulations in YT are genetically indistinguishable from the Bonnet Plume, Redstone, South Nahanni and Tay River subpopulations, suggesting that they have not experienced isolation from each other.	N/A
Phenotypic plasticity		N/A

[223] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas	The Tungsten, NWT town site was shut down in 1986. During subsequent periods of mine operation, the bunkhouses in the town were used for accommodation.							**Neg.**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling	Activities associated with mineral and hydrocarbon exploration and development, including fracking associated with hydrocarbon development, can result in mechanical disturbance to habitat. Currently, there is no fracking taking place in the NWT.							**N/A**

3.2 Mining and quarrying	Most northern mountain caribou range in the NWT is relatively undisturbed. Mineral exploration and mining activities are located primarily in the area around the NWT/YT border, especially in areas accessed by the South Nahanni Range Road and the North Canol Road, which is an area consistently used by caribou during calving. There are indications that industrial exploration and development will increase in the near future; this is already underway in the YT portion of the range. Of particular concern is the advanced mineral exploration in the Macmillan Pass area (Fireweed Zinc) and the potential development of the Mactung property nearby. When the Mactung and Cantung properties/deposits sell, increased activity is expected in the areas. Currently, several mining companies have interests in the Macmillan Pass area (North American Tungsten, Colorado, Crest, Gayna River, Bear-Twit, Coates Lake/Redstone, Jay, Lened, Hudson Bay, Eagle Plains, Overland Resources, Silver Range, Three Aces, Selwyn mine and other lead/zinc/precious metal interests). There is limited information about the effects of industrial activities on northern mountain caribou in the NWT. Potential effects include habitat alteration and displacement. Activities that result in displacement of calving caribou could result in increased mortality risk at a time when caribou calves are already highly vulnerable to mortality. In alpine range, caribou may be displaced from preferred habitat by resource exploration and development. Terrestrial lichens are also sensitive to mechanical disturbance and can take 30-80 years to recover following disturbance. Disturbance to high elevation habitat, regardless of the presence of lichens, could also require long recovery times due to harsh growing conditions. Disturbed soils in some habitat types could also lead to	L	L	S-C	N	L-M	L	**Low-Medium (localized impact over whole range but substantial threat in calving and summering range of Redstone herd)**

	increased productivity of shrubs and other vegetation favoured by other prey species such as moose. Although industrial activities occur in NWT northern mountain caribou ranges, most of the industrial activities (mineral exploration and development, seismic lines) have occurred or are occurring along the periphery of the ranges, leaving large areas within the ranges that are not accessible by road. To augment that, Nahanni National Park Reserve and Náátsʼįhchʼoh National Park Reserve together protect 34,850 km^2 in and adjacent to South Nahanni, Coal River, La Biche and Redstone caribou ranges, securing for the future those portions of the ranges.							
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads	Much of mountain caribou habitat isn't accessible by road. Roads in NWT northern mountain caribou range include the Canol Road, the Nahanni Range Road, Howard's Pass Access Road and the Prairie Creek Road. A new 35 km access road has been proposed originating from the North Canol Road in Yukon to the Mactung property. When the Cantung and Mactung properties sell, increased activity is expected along those access roads. There is particular concern about the Howard's Pass Access Road as it parallels the Little Nahanni River for a portion of its length and that valley includes a portion of the South Nahanni herd's calving, summer and rut ranges. This is an important area for the South Nahanni herd and caribou migrate across the road at specific times during the year. Currently, a restricted activity permit is required for anyone using the Howard's Pass Access Road within Náátsʼįhchʼoh or Nahanni National Park Reserves, but the Howard's Pass Access Road is likely to contribute to recreational use of the Macmillan Pass area; staff of Náátsʼįhchʼoh National Park Reserve	L	L	S-C	N	L-M	L	**Low-Medium (localized impact over whole range but substantial threat in calving and summering range of Redstone herd)**

	are already hearing of overland travel to Mile 222 facilitated by the road. The Canol Road/Trail bisects the Redstone caribou range. Large areas within the ranges are not accessible by road. Nahanni National Park Reserve and Náátsʼįhchʼoh National Park Reserve together protect 34,850 km² in and adjacent to South Nahanni, Coal River, La Biche and Redstone caribou ranges, securing for the future those portions of the ranges. The Howard's Pass Access Road and the approved all season Prairie Creek Road traverse portions of the national park reserves. Roads in winter range are a main concern because animals tend to be more sedentary, limited by snow, attracted to road salt and then vulnerable to being hit by traffic or potentially hunted. Potential effects of roads and linear corridors include habitat alteration; direct and indirect mortality associated with access roads and increased predation. Northern mountain caribou tend to avoid roads, despite the presence of preferred habitat close to the road.							
4.2 Utility and service lines	Seismic lines are located in the low elevation portions of the range along the eastern, northeastern and northern boundaries of the range.	L	L	C	N	H	L	**Low**
4.3 Shipping lanes								**N/A**
4.4 Flight paths	Air traffic (helicopter support, fixed-wing transport) associated with mineral exploration activities and with servicing mineral exploration camps and developed mines and commercial use of drones, could affect northern mountain caribou. There are a number of airstrips within northern mountain caribou ranges including in the Macmillan Pass area, Tungsten and at the Prairie Creek property. Increasing recreational use of drones, including for hunting	L	L	S	N	H	L	**Low**

	purposes, could result in disturbance/displacement of caribou and higher mortality rates due to hunting. Helicopters flying hunters into remote areas may be making habitat destruction more widespread. Overflights and helicopter activity can disturb and spook caribou. This is tied to population declines and vacated preferred habitats over the last several decades. The impact of habitat loss and displacement due to human activity is thought to expose caribou to greater health risks as a result of stress, nutrition and higher levels of predation.							
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	Indigenous and local residents of the NWT and YT hunt mountain caribou for subsistence. In addition, non-resident sport hunting occurs in the Mackenzie Mountains annually, mostly during the months of August and September. Resident harvest is almost exclusively of males. Non-resident hunters can only hunt mountain caribou with registered guides within outfitting concessions in the NWT. Non-resident and resident harvest is limited to one northern mountain caribou/year. There are eight outfitters operating in the NWT portion of mountain caribou range. There are no formally established limits on the total number of northern mountain caribou that each guide-outfitter can take each year. Although resident and non-resident harvest is relatively low, it has increased in recent years. There is little information available on Indigenous harvest. Traditional knowledge holders have noted that there are many disrespectful practices taking place, like wasting caribou and wounding animals. There are also concerns about harvesting by boat in some parts of the Sahtú and reports in the Gwich'in region of skidooers chasing mountain caribou. Poor harvesting practices are tied to a lack of awareness and respect for Dene/Métis laws.	L	U	C	N	H	L	**Low-Medium – Localized in the whole range of the species, but substantial in portions of the Redstone range, the largest subpopulation in the NWT**

	This threat is already occurring and is causing serious impacts to subpopulations that can be accessed by roads. Increases in hunting pressure are tied to observed population declines and avoidance in some areas. Concentrated harvest associated with access roads could impact caribou in these localized areas. The most recent adult sex ratios for the Coal River subpopulation (2008-2011) averaged 33 bulls:100 cows, which is lower than that observed in moderately hunted herds. The most recent adult sex ratio for the South Nahanni subpopulation (2014) had also dropped down to just over 30 bulls:100 cows. Adult sex ratios for the Bonnet Plume and Redstone subpopulations based on non-resident hunter observations averaged 81 and 30 bulls:100 cows, respectively, from 1991-2010. There was no overall trend for the Redstone subpopulation and an increasing overall trend for the Bonnet Plume subpopulation, although there was a declining trend from 1991-1999 for both subpopulations.							
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting	Increasing logging in a winter range could increase moose forage and increase the number of wolves in the area. Unlike the southern portions of the range in BC, moose densities are much lower in the NWT and there is no forest harvesting on northern mountain caribou ranges. There is perhaps some forestry potential in the Fort Liard and Nahanni areas.							**N/A**
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities	Recreational activities are generally more concentrated in areas with ground access. In northern mountain caribou range in the NWT, recreational activities beyond existing roads and trails is likely low. However, increasingly widespread habitat destruction	L	U	C	N	H	L	**Low-Medium – In some localized**

	occurring in areas frequented by hunters on ATVs has been noted. Habitat destruction may be getting increasingly widespread as hunters take ATVs off-road. Off-road vehicle use can also compact soil and damage underlying permafrost, resulting in damaged, muddy areas. Side trails then develop as users attempt to avoid the mud, resulting in further habitat damage. Recreational activities may introduce and spread invasive plant species.							**areas there could be a major impact.**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities	Negative impacts of collaring for research purposes. No population-level impacts noted.							**Neg.**
7. Natural system modifications								
7.1 Fire and fire suppression	The primary natural disturbance in northern mountain caribou ranges is fire. Caribou use of burned areas is generally low, but caribou have been known to travel through extensive burns. Like other habitat alteration, fire can eliminate lichens from a site and can create conditions that support vegetation that is favoured by other ungulates. Lichens, the primary winter food source, are slow growing and *Cladina* spp., the preferred caribou terrestrial forage lichens, often do not become abundant following fire disturbance until 30-80 years post-disturbance. Inferences from fire disturbance data suggests that most of the fire disturbance in northern mountain caribou ranges occurred in the 1990s. Since then, the amount of area burned has decreased, but this could partially be due to less area being available for burning following the fires in the 1990s. Climate change may dramatically alter fire regimes, which could impact winter ranges.	L	L	S	LT F	L	L	**Low**
7.2 Dams and water								**N/A**

management/use								
7.3 Other ecosystem modifications								**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases	Invasive plant species could result in increased competition with lichens, which could lead to declines in lichen abundance. Although there is no information on invasive species in NWT northern mountain caribou ranges, they will likely have the greatest effects along access routes including roads and trails.	L	L	C	LTF	M	L	**Low**
8.2 Problematic native species/diseases	Predation is the leading cause of calf and adult mortality. Wolves are the main predator of mountain caribou, with bear, wolverine and cougar predation significant in some ranges. There are some indications of increasing grizzly bear populations. Grizzly bear abundance has always been high in some areas, but in the north Mackenzie Mountains, the current densities are the highest some outfitters have ever seen and may be changing caribou distribution patterns. Some concerns have been expressed regarding increasing densities of other ungulate species (i.e., moose, white-tailed deer and elk). However, the density of moose and other prey around northern mountain caribou ranges in the NWT is currently thought to be relatively low and unlikely to lead to altered predator/prey interactions.	W	U-L	C	N	M	L	**Low**
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**

8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents	There are numerous oil spills and contaminated wastes from past mining and military operations along the Canol route. Federal programs continue to target the clean-up of these materials. This results in local degradation of habitat and has the potential to impact the health of northern mountain caribou.	L	L	C	N	H	L	**Low (re: impact to the population)**
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste	The Canol pipeline was abandoned in April 1945 and some of the equipment (e.g. engines) and an unknown amount of pipe was salvaged; however, much of the equipment, including abandoned vehicles, structures and caches of oil and fuel barrels remained. Salvage operations continued until at least 1953. Entanglement of wildlife in downed telephone wire has been a hazard. From 2015-2017, telephone wire was removed from 322 km along the Canol Trail and a three-year remediation project was initiated in 2018 to reduce major environmental and human health risks associated with the abandoned pipeline and related infrastructure.							**Neg.**
9.5 Airborne pollutants	Levels of cadmium were found to be lower for caribou than for moose sampled in the Mackenzie Mountains. Cesium-134 was not detected in any caribou sampled in 2011 but was detected in one of the caribou sampled in 2012 and 2013. Cesium-134 levels are the result of the Fukushima reactor accident in March 2011. Cesium-137 was detected in 27 of 28 caribou sampled and is primarily a remnant of the nuclear weapons tests in the 1960s. The levels of Cesium-134 and Cesium-137 were low and risks to caribou were							**Neg.**

	considered negligible. Although kidneys from caribou showed minor histological changes, kidney function was not expected to be affected.							
9.6 Excess energy (noise/light pollution)	Traditional knowledge holders in BC note that habitat fragmentation resulting from roads, railways and industrial development has negative effects on caribou and habitat through elevated noise, dust, pollution and contaminants; these effects can result in population decline or abandonment of range. Yukon-based knowledge holders report that there has been a shift from more traditional hunting methods to the use of disruptive technology like ATVs, helicopters and planes. As a result, there is a lot of noise, a lot of habitat disturbance and many disrespectful practices taking place.							**Neg.**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Climate change has already affected areas in and around northern mountain caribou ranges in the NWT. In Norman Wells, since the late 1950s, mean annual, winter, spring, summer and fall temperature has increased by 2.0°C, 2.9°C, 3.0°C, 1.1°Cand 1.9°C, respectively. With respect to precipitation, Norman Wells has experienced an increase in fall and winter precipitation and a decrease in spring and summer precipitation. Climate change may result in changes in frequency and severity of natural disturbances, changes in vegetation composition, changes in distribution of other ungulates, increased incidence of icing and increased incidence of disease and parasites. Other potential effects of climate change include: reduced size, number and persistence of	W	M	C	N	H	M	**Medium**

	snow patches, degradation of permafrost (including possible slumping) and heat stress for caribou in summer. With warmer, drier summers, an increase in wildfire frequency and severity is expected resulting in abrupt changes in vegetation composition. Even without natural disturbance events, vegetation composition is expected to change as warmer conditions result in increased productivity, which could support vegetation favoured by other prey species. Increased shrub growth has already been observed in alpine and Arctic tundra ecosystems. Increased shrub abundance could out compete lichens and support higher densities of other ungulates. Increased rain/freeze events can further limit availability of terrestrial lichens by creating conditions that make it difficult for caribou to detect and forage for terrestrial lichens. Icing could also be advantageous for wolves, if snow conditions allow wolves to run on top of the crust but not caribou. Climate change could also alter the parasites and diseases that affect caribou. For some parasites, life cycles could potentially be shortened and/or ranges could extend northward. Insect harassment could potentially increase at the same time that snow patches become less available for caribou to use to avoid them, which can lead to increased energy expenditure by caribou during the insect season. Most of the northern mountain caribou range in the NWT overlaps the continuous permafrost zone, with lower elevation areas along the eastern portion of the range overlapping the extensive discontinuous permafrost zone. Climate change could result in permafrost degradation, which could lead to changes in vegetation species composition. Habitat alteration due to fire and anthropogenic disturbances can further exacerbate permafrost degradation. Many of these changes are already occurring (e.g. wildfire frequency/intensity, increased warble fly disturbance, increasing							

	moose/predator populations, disappearance of ice patches) and are believed to be causing serious impacts to some populations. Environmental changes that limit the distribution and abundance of lichens (e.g. shrubification, fires), or result in changes in snow conditions (depth and hardness) that impact cratering and movements, may have a significant impact on body condition and therefore productivity. Mountain caribou rely on ice patches to minimize harassment from insects and for cooling themselves during hot weather. These are considered critical habitat components in summer habitat. Warble flies can cause a caribou to abandon feeding, run for miles and lose weight. Because success in reproduction has to do with body condition and various stressors, fly harassment can be an important stressor and influence reproductive success. Hot weather can result in heat stress.							
11.2 Droughts								**N/A**
11.3 Temperature extremes								**N/A**
11.4 Storms and flooding								**N/A**
11.5 Other								**N/A**
12. Other threats								
The sacred relationship that Indigenous communities have with caribou is being changed by non-Indigenous policy, climate change and other factors. This changing relationship is a threat to caribou, as upkeep of the human side of the relationship (including travel to and through the area, harvest and seeking/passing along information) is an important factor in monitoring and protecting caribou. Traditional management practices (based on respect and traditional knowledge and yielding immediate actions), have been replaced by science-based management systems that are influenced by politics. In this current management system, knowledge takes time to acquire and actions typically come too late, or not at all.		W	L	C	N	H	M	**Low**

Species: Northern *myotis* (*Myotis septentrionalis*)
Populations (if applicable):
Percentage of North American population NWT is responsible for: Northern *myotis* is present across Canada and the central and eastern United States. Distribution in Canada includes all provinces and territories with the exception of NU. The percent of global range in Canada has been roughly estimated as 50%. No such estimate is available for percentage of population the NWT is responsible for.
NWT General Status Ranks: At Risk
NatureServe Conservation Rank (NWT): S2
***Species at Risk (NWT) Act*:** Special Concern
***Species at Risk Act* (Canada):** Endangered
Reasons for assessment or population trends: Although WNS is not currently present in the NWT, it is estimated that at current expansion rates, it could reach our populations from eastern North America in one or two decades. With the recent discovery of WNS in the United States' Pacific Northwest, it is conceivable that this disease could spread to the NWT sooner than predicted. This species is highly susceptible to devastating population declines as a result of WNS. In eastern Canada, populations impacted by WNS have declined by 94%. Human impacts at hibernacula and exclusion and removal of maternity roosts have the potential to affect a large proportion of the species' population at the same time.
Sources used for assessments: SARC (2017c)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[224] = 2		
Dependence on habitats that are sensitive to climate change[225]	Northern *myotis* is a forest dwelling bat that has seasonally-dependent primary habitat requirements, including summer roost and foraging habitat, autumn mating sites and winter hibernation sites. Habitat availability for bats in the NWT has not been quantified; however, both the boreal forest and karst formations are important habitat for this species. The boreal forest covers approximately 614,000 km^2 of the NWT. It is unknown how much of the boreal forest is inhabited by bats, but it may be considered 'potential	2 – Generalist, but some sensitive habitats are important.

[224] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.
[225] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	habitat' for the wider-ranging species such as northern *myotis* that appear to have fewer geographical restrictions. Across ecoregions, habitat suitability for bats may reach a northern limit below the treeline due to climate (temperature and summer length) and/or availability of summer roosts (e.g. suitable trees). Karst formations are found throughout the NWT. Few have been investigated in winter to determine whether they are used by bats. In addition, there are numerous abandoned mines around the NWT that may act as potential roosts and/or hibernacula. In general, known hibernacula are considered to be a small subset of the hibernacula that must exist on the landscape. Maternity roosts are used repeatedly over many years. Roost choice varies among species, but roosts can often be found in tree cavities and behind flaking bark, in rock crevices and in buildings. *Myotis* species tend to prefer large standing dead or dying trees located in open areas in old growth forest for tree roosts. Bats typically forage in forest gaps and edges, along trails and over still water and rivers. With respect to habitat associations, age of a forest appears to be more important than type, with many bats preferring old growth forests. Undisturbed forest is important for both roosts and foraging, with individuals typically foraging under closed canopy.	
Sensitivity to climate-relevant abiotic factors[226]	Northern *myotis* uses daily torpor and seasonal hibernation to conserve energy during periods of low prey abundance (e.g. winter) and/or increased energetic expense (e.g. cooler temperatures). This behaviour allows them to survive extreme and/or unfavourable conditions. Maternity colonies reduce individual energetic expense due to increased collective body heat. During winter, access to hibernation sites with adequate temperature (2°C-12°C) and humidity levels (>80%) is required. If hibernacula temperatures drop below 0°C during hibernation, bats may increase their energetic use, drawing on fat stores to increase their metabolism to arouse and look for a new hibernation site, or to account for cooler temperatures. Alternatively, bats may remain inactive and succumb	2 – Somewhat sensitive or possibly very sensitive.

[226] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

	to freezing. Both responses result in decreased fitness of individuals. Conversely, warming of the hibernacula is a significant threat because northern hibernating bats are adapted to cold microclimates (low metabolic rates), because they enter hibernation with high body mass and because current, relatively cold, northern hibernacula conditions do not represent ideal growth environments for WNS. An increase in hibernacula temperatures could disrupt the energetic balance of northern bats, including northern *myotis* and increase the growth rate of WNS should it arrive (Lausen pers. comm. 2020). It is possible that warming temperatures may facilitate shorter hibernation periods and a longer breeding season and therefore higher reproductive success. Summer temperature tolerance varies by species. Night time activity appears to be strongly positively correlated with temperature. Short night foraging, combined with shorter summers overall and cool night time temperatures, may limit foraging opportunities and therefore resources available for growth, reproduction and accumulation of winter fat reserves, perhaps creating an effective northern limit to the distribution of bats. There has been speculation about warming temperatures increasing habitat availability for bats at the northern limit of their range; however, changing climate patterns are complex. Whether bats will move farther north with climate change or remain restricted by other factors such as roost availability has yet to be determined.	
Sensitivity to climate-relevant biotic factors[227]	Bats are very sensitive to WNS, which is considered the most serious threat to *Myotis* species. It is unclear how climate change may impact the spread of WNS (although see notes above about hibernacula temperatures). Contact among individuals at maternity colonies and hibernacula, as well as autumn swarming behaviour, may facilitate the transmission of disease among bats. In this context, bat species that exhibit clustering behaviour in hibernacula to conserve body heat may be at higher risk for bat-to-bat disease	2 - Somewhat sensitive or possibly very sensitive

[227] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

	transmission than species that roost alone. Northern *myotis* is insectivorous and relies on adequate insect presence and abundance to support summer reproduction and winter survival. Using both aerial hawking and gleaning increases their ability to diversify their diet and capitalize on available prey items throughout the season, although northern *myotis* is more specialized than little brown *myotis* for gleaning. The northern *myotis* feeds primarily on moths, beetles, caddis flies, true flies and non-flying prey items such as spiders and moth larvae. Climate plays an important role in determining prey availability, which in turn influences reproductive success. Warming temperatures may yield a longer active period with greater reproductive success.	
Non-climate stressors = 2		
Sensitivity to potentially interacting non-climate pressures	WNS poses a potentially serious threat, one that is expected to arrive in the NWT in one to two decades, or sooner. Population dynamic models predict a 99% extinction of little brown *myotis* in eastern Canadian provinces and the eastern United States by 2026, with equally devastating extinction rates for northern *myotis*. Northern *myotis* are sensitive to human impacts at hibernacula, exclusion and removal of maternity roosts (non-lethal exclusion or lethal extermination by building owners or incidental removal as a result of development activities), timber harvest, predation by common house cats and mercury contamination.	2 – Moderate pressures or possibly major pressures.
Adaptive capacity[228] = 1.5		
Reproductive capacity[229]	Females become sexually mature their first or second year; males may not become sexually mature until their second autumn swarming. Females store sperm over winter and fertilize a single egg during spring ovulation when they leave hibernation. The average duration of gestation for Vespertilionidae family of bats is 69.4 days (SE = 34). Females may reproduce up to once per year; however, reproductive success is heavily influenced by regional weather patterns and females may forego reproduction in a year of poor	2 – Early reproduction/few offspring

[228] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[229] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.

	resource abundance. The maximum lifespan for northern *myotis* is approximately 19 years. Mean life expectancy is not reported in the literature for northern *myotis*. Generation time is 6.8-8.5 years.	
Dispersal capacity[230]	High dispersal capacity. Northern *myotis* undergo annual dispersal events using flight. Individuals migrate between winter hibernacula and summer roosts. Northern *myotis* have been observed travelling up to 89 km between summer and winter roosts. During summer, individuals moving between day roosts and evening sites may travel approximately 2.2 km. There are no geographic features that would prohibit movement into the NWT from provinces farther south (rescue effect).	1 - >10km
Genetic diversity	The high dispersal capacity and promiscuous mating strategy of bats promotes genetic mixing and reduces genetic isolation. Maternity congregations facilitate information transfer, gene flow and social interaction.	N/A
Phenotypic plasticity	Likely high (GNWT pers. comm. 2020).	N/A

[230] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas	Passive disturbance (entering the cave for research or recreational purposes) during hibernation can cause bats to arouse out of torpor and use up stored fat reserves, resulting in reduced fitness and potential starvation if repeatedly disturbed throughout the season. WNS can also be transferred between substrates in numerous ways, including from bat to bat, from cave substrates to bat and from bat to cave substrate, as well as by humans between sites. In the NWT, the precise locations of winter hibernation sites are considered classified and in an effort to reduce human traffic, are not readily shared with the public. Motion-sensor cameras were deployed at SSR-1 in 2013 to monitor human visitors and detected no human disturbance at the site.							**Neg.**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**

2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling								**N/A**
3.2 Mining and quarrying	Human activities that change hibernacula conditions (including accessibility, temperature, humidity, airflow and hydrology) can have a negative impact on bats. This can include decommissioning or reactivating mines and quarrying.	L	M	S	ST F	L	L	**Low**
3.3 Renewable energy	Outside of the NWT, wind turbines are considered a threat to various bat species. Local, non-migratory species including *Myotis* are killed at lower rates than long-distance migrant species (e.g. 0-13% of fatalities). Studies found that as of 2013 about 47,400 bats were killed each year by wind turbines in Canada. However, there are currently no large-scale wind energy developments in the NWT.	L	L	S	LT F	L	L	**Low**
4. Transportation and service corridors								
4.1 Roads and railroads								**N/A**
4.2 Utility and service lines	Seismic lines are the largest anthropogenic landscape disturbance in the NWT. They are often considered an agent for habitat fragmentation and can have negative impacts on local forest-dwelling animals. Many bat species however, forage along linear features such as trails and roads and radio telemetry studies in the Fort Smith area have observed little brown *myotis* travelling and foraging along power lines.							**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and								**N/A**

collecting terrestrial animals								
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting	Timber harvest has varying degrees of impact depending on the species. The use of heavy machinery (e.g. timber harvesting equipment) near weak areas of a hibernaculum could cause collapse. Human activities that change hibernacula conditions (including accessibility, temperature, humidity, airflow and hydrology) can have a negative impact on bats. This can include forestry activities that take place around hibernacula. Removal of maternity roost trees may occur through timber harvesting, residential development, or any other development activity that requires clearing forested land. Bats' tolerance to roost loss may depend on local forest conditions, including the availability of alternate roost trees. Removal of occupied maternity roost trees during the breeding season would likely cause mortality, although data on this are lacking. Under section 5.7.2(V) of the commercial timber harvest planning and operations standard operating procedures, timber harvesting operations in the NWT are not currently permitted to occur during the migratory bird nesting season, which overlaps with the breeding season for bats. Forestry practices that lead to a decline in the amount of older age forests could have a negative impact, as many bat species are more abundant in the oldest forest stands. This is likely primarily related to the availability of snags and large live trees for roosting; these negative impacts can be reduced through selective harvest practices. Timber harvest also affects foraging habitat. *Myotis* bats generally avoid large areas of cleared land such as clear cuts;	L	L	S	ST F	M	L	**Low**

	however, some bats use the edges of forest patches, regeneration areas and early successional forest as new foraging habitat. The most recent NWT Biomass Energy Strategy states that one of the objectives is to 'Increase the use of biomass fuels, such as cord wood, wood chips and pellets, in all segments of the NWT space heating market', suggesting that an increase in timber harvesting will continue to be promoted in the NWT. In the NWT, commercial timber harvesting has occurred in numerous places and is typically done by small-scale businesses in localized areas and in small volumes (500-10,000 m^3 per year). The largest annual harvest since 1980 was in 1996 and totaled 144,461 m^2. FMAs have been signed in the Fort Providence and Fort Resolution areas and land use permits have been issued for timber harvesting in both areas. With these now in place, timber harvesting is expected to dramatically increase in these areas. The land use permits cover five years of timber harvesting, although the FMAs themselves are for 25 years. Timber harvesting in each area will impact approximately 1,000-1,200 ha/year throughout the lifetime of the FMA.							
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities	See 1.3.							**Neg.**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities	Banding efforts have been ongoing since 2011 in the South Slave region, mainly focusing on maternity colonies. Visits to SSR-1 and SSR-2 for research and monitoring purposes have been limited to once per winter or less.	L	L	S	N	H	L	**Low**

7. Natural system modifications								
7.1 Fire and fire suppression	At a local scale, forest fires may cause temporary fragmentation, displacement and/or destruction of bat roost and foraging habitat. While bats may use recently burned areas (<10 years) for occasional foraging, a lack of roost sites results in low bat activity until a forest reaches the old growth stage (76 - >125 years). Conversely, other studies (northern *myotis*) have found an increase in roost availability after a burn. In addition, immediately following a burn, an increase in insect abundance may be observed. Forest fires disturb an average of 600,000 ha of NWT forest annually. A weak trend indicates a slight reduction in both total area burnt and the number of fires larger than 200 ha between 1988 and 2008. It is predicted that climate change will result in an increase in the frequency and intensity of fires, due to hotter, drier summers that provide a long fire season. However, studies suggest that forest fragmentation (independent of forest amount) can benefit little brown and northern *myotis* by allowing access to foraging sites from roosting sites. Larger areas cleared for farm fields, clear cuts, or as the result of large fires are generally avoided by *Myotis* species, perhaps to avoid the windier conditions characteristic of these cleared areas or because of their influence on prey abundance and risk of predation.	W	L	S	ST F	M	M	**Low**
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications	Human activities that change hibernacula conditions (including accessibility, temperature, humidity, airflow and hydrology) can have a negative impact on bats. This can include blocking or gating cave entrances, making modifications for tourists, decommissioning or reactivating mines, quarrying, or forestry activities that take place around hibernacula.	L	M	S	ST F	L	M	**Medium**

8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases	WNS is considered the most devastating disease for many cave-hibernating bat species in North America and is caused by the fungus *Pseudogymnoascus destructans*. *P. destructans* likely arrived in North America from Europe, where it is known to occur on bats, although without the same devastating mortality. It is estimated to have resulted in the deaths of more than 5.7 million bats throughout North America. Although WNS is not currently present in the NWT, it is estimated that at current expansion rates, it could reach our populations from eastern North America in one or two decades. The discovery on March 11, 2016 of WNS in the Pacific northwest substantially extends its North American range. How it reached this far west, 2,100 km away from the next nearest occurrence in Nebraska, has not yet been determined. This new western occurrence has important implications for management, as it has the potential to accelerate the western spread of WNS. As noted by Lorch et al. (2016: 4), "The severity, magnitude, duration and potential ecosystem-level effects of WNS in North America rank it among the most consequential wildlife disease events ever recorded." It creates a cutaneous infection in bats and disrupts their torpor patterns during winter, which depletes fat reserves and potentially causes dehydration, resulting in death. Fatality rates vary by bat species and are typically much greater for smaller bodied *Myotis*. Infection at a hibernaculum usually results in severe population decline or extirpation. Average decline in six northeastern US states after two years' exposure to WNS was 98% for northern *myotis* (30 hibernacula, 23 of which declined to zero bats). Declines in eastern Canada where WNS has established have been similarly catastrophic. Population dynamic models predict a 99% extinction of little brown *myotis* in northeastern North America by 2026, with equally devastating extinction rates for northern *myotis*.	W	H	C	ST F	H	H	**High (in future, for WNS)**

	It is largely unknown how the ecology of the disease may be affected by the amount of east-west bat movements, wintering ecology and hibernacula conditions in these regions. However, there is evidence that conditions in known hibernacula are conducive to growth of the fungus and that hibernacula with lower bat densities are susceptible to WNS and there is no evidence of containment to date. In addition, an increased exposure period due to longer hibernation durations in the NWT may negate any potential benefits of slower fungus growth and could actually result in higher mortality rates, although documented hibernation periods in the NWT do appear to be roughly comparable to those in more southerly locations. Model results suggest that WNS spread and mortality is most likely to occur in habitats that are drier and colder during winter, such as in the NWT. WNS constitutes the most serious plausible threat for this species, with infection at hibernacula usually resulting in severe population declines or extirpation. Common house cats prey on bats that roost in buildings. Numerous cat-related bat fatalities have been reported in the NWT, but these incidences are not tracked formally and cannot be quantified. Predation by cats is expected to impact bats using building roosts in or near communities, because of their proximity to cats. The impact of this threat on bat populations in the NWT is unknown but presumably small.							
8.2 Problematic native species/diseases								**N/A**
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases								**N/A**

of unknown origin								
8.5 Viral/prion-induced diseases	Rabies, caused by a virus (family Rhabdoviridae, genus *Lyssavirus*) and transmitted most often through saliva, has been reported in 30 of the 39 bat species that live in North America, north of Mexico. The impact rabies has on bats is not clear; recorded die-offs may not be entirely attributable to rabies and there is some evidence of immunity in bats (i.e., 2% of little brown *myotis* had antibodies to the virus, but no lesions in the brain). To date no bats have tested positive for rabies in the NWT (eight little brown *myotis* and one northern *myotis* have been tested throughout the NWT).							**Neg.**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater	Contaminants, such as PBDEs, pesticides, pharmaceuticals and personal care products have been found in tissue samples from many bat species in northeastern North America, including big brown bats and little brown and northern *myotis*. Contaminants like pharmaceuticals and personal care products are likely of little concern for bats in the NWT because of the low-density human population. However, contaminants like PBDEs and pesticides, that are long-range transported, may pose more of a threat. PBDEs have been detected in NWT resident wildlife.	L	U	C	LT F	L	L	**Low**
9.2 Industrial and military effluents								**N/A**
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants	Mercury contamination is a potential threat to bats in the NWT but its prevalence and impact in the territory are unknown. Bats	L	U	C	LT F	L	L	**Low**

	appear to be particularly susceptible to mercury accumulation and recent studies have raised concerns about the impact of mercury on bats.							
9.6 Excess energy (noise/light pollution)	Industrial activities in or near hibernacula that cause noise, light or vibrations can also disturb hibernating bats and cause them to arouse from torpor.	L	L	S	LT F	L	L	**Low**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Changes to the boreal forest associated with climate change could affect roosting and foraging habitat, prey availability and reproductive success. There may be both positive and negative effects and the ultimate impacts on bats are unknown. Changes in growing season have been observed throughout the NWT. In the Taiga Cordillera, Taiga Plains and western Taiga Shield, spring is arriving earlier and the growing season has lengthened by between nine to 28 days. Warming of the hibernacula is a significant threat because northern hibernating bats are adapted to cold microclimates (low metabolic rates), because they enter hibernation with high body mass and because current, relatively cold, northern hibernacula conditions do not represent ideal growth environments for WNS. An increase of hibernacula temperatures could disrupt the energetic balance of northern bats, including northern *myotis* and increase the growth rate of WNS should it arrive (Lausen pers. comm. 2020). Conversely, it is possible that warming temperatures may facilitate shorter hibernation periods and a longer breeding season and therefore higher reproductive success.	W	L	C	ST F	L	L	**Low**

11.2 Droughts								**N/A**
11.3 Temperature extremes	Daily torpor and seasonal hibernation are used by bats to conserve energy during times of less than ideal temperatures. These states of lowered activity allow them to survive extreme temperatures. Temperature plays an important role in bat habitat in hibernacula where adequate temperature (-4°C to 13°C) and humidity levels (73-100% relative humidity) are required. However, these microclimates tend to have stable environments independent of outside climate-relevant abiotic factors. Changes in the climate also have the potential to alter the timing and duration of hibernation. Bats may emerge from hibernacula if roost temperatures increase to 5°C-6°C. Hence, in a warming environment, bats may have shorter hibernation periods, emerge sooner and have longer breeding seasons. In the last 15 years, the NWT has generally been experiencing a warmer climate compared to records from 1961-1990. This is particularly pronounced in the winter (December-February) in the Taiga Plains ecoregion. The Mackenzie District as a whole (encompassing all forested areas of the NWT) has seen the largest winter temperature increase in Canada; increasing by 4.5°C between 1948-2011.							**Neg.**
11.4 Storms and flooding								**N/A**
11.5 Other								**N/A**
12. Other threats								

Species: Northern wolffish (*Anarhichas denticulatus*)
Populations (if applicable):
Percentage of North American population NWT is responsible for: Inhabits boreal and subarctic waters on both sides of the North Atlantic and in the Arctic. In Canadian waters, it extends from the Canadian portion of the Gulf of Maine north to the Bay of Fundy, the Scotian Shelf, the Grand Banks, Gulf of St. Lawrence, Northeastern NL Shelf and Labrador Sea as far as the waters west of Greenland. There are also a few records from the western Arctic. This suggests the possibility that the range could extend right across the Arctic, though more surveys are needed to verify this.
NWT General Status Ranks: At Risk
NatureServe Conservation Rank (NWT): G?
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Threatened
Reasons for assessment or population trends: This species underwent strong declines in both abundance and in range size during the 1980s. For the next decade there was little change, but since about 2002 there have been small increases in both range size and abundance. These have been in parallel with recovery measures, including mandatory release of individuals taken as bycatch. While these recent increases are encouraging, the species is still at very low levels compared with the beginning of research surveys in the 1970s. Although there has been a general decrease in the level of fish over its range, its recovery may still be limited by bycatch in fisheries in the deep waters in which it occurs.
Sources used for assessments: COSEWIC (2001, 2012c), Fisheries and Oceans Canada (2020)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[231] = 1.7		
Dependence on habitats that are sensitive to climate change[232]	Found in cold and cool continental shelf waters across the North Atlantic from Norway to southern Newfoundland. Its southern range is limited. Found at a broad range of depths, but most often at depths greater than 100 m (151-900 m) in offshore waters over soft bottoms and in proximity to boulders. This species is the deepest living and also the most pelagic	2 – Generalist, but some sensitive habitats are important.

[231] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.
[232] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	of all Atlantic wolffishes. Changes to marine ecosystems could affect distribution and abundance of northern wolffish.	
Sensitivity to climate-relevant abiotic factors[233]	Water temperature appears to be a major factor determining habitat selection in this species, which is most common at temperatures between 2°C and 5°C. Temperature is believed to limit their distribution and habitats. A period of exceptionally cold water temperatures (late- and early-1990s) may have coincided with the rapid contraction in the range of wolffish species, although most declines began prior to this. Shallower waters may have been abandoned by these species, possibly in favour of deeper, warmer waters. However, this possibility remains hypothetical. The long-term trend in water temperatures is uncertain, although a temperature increase in northern waters is expected. An increase in water temperatures in the northwest Atlantic may lead to a northward shift of many marine cold-water fish species such as this one, as has been documented in the northeastern Atlantic.	2 – Somewhat sensitive or possibly very sensitive.
Sensitivity to climate-relevant biotic factors[234]	Benthopelagic predatory fish. Somewhat territorial. The size of the territory is quite restricted. Non-schooling.	1 – Not sensitive.
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	There are no direct studies of factors responsible for the declines observed in wolffish abundance. Overfishing is the largest global threat; however, there is no indication what, if any, role the NWT plays in this.	1 – No pressures.
Adaptive capacity[235] = 2.5		
Reproductive capacity[236]	Large, slow-growing, long-lived, solitary. Average fecundity may be ~23,000 eggs/female, more than any other wolffish species, although low for a fish this size. They make nests and generally guard their eggs. Maturity reached at five years of age or more. Can live to at least 14 years. Generation time estimated at 10.5	3 – Late reproduction/many offspring

[233] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.
[234] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).
[235] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[236] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.

	years.	
Dispersal capacity[237]	Dispersal is limited. Non-migratory. Relatively sedentary and local in their range. This limited migration makes the northern wolffish vulnerable to the impact of intensive local fishing and habitat destruction.	2 – 1-10km.
Genetic diversity	Genetic differences among the three species of wolffish of the northwestern Atlantic Ocean were evaluated on the basis of their mitochondrial DNA genomes and nuclear genetic markers. These studies showed that the three wolffish species in the Atlantic are distinct from each other, with the northern wolffish less related to the other two. Genetic differentiation was significant between Atlantic Canada and the Barents Sea, but not between northern and southern regions of Atlantic Canada.	N/A
Phenotypic plasticity		N/A

[237] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling								**N/A**
3.2 Mining and quarrying	Dredging and aggregate extraction harm bottom habitats on the Canadian continental shelf by destabilizing the seabed, increasing erosion and polluting previously healthy areas.							**N/A**

3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads								**N/A**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals								**N/A**
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources	Not commercially fished, but are taken as by-catch. When caught, it is discarded. Wolffish (all species) landings in the western Atlantic peaked in 1979 at around 22,000 tonnes but have fallen steadily to around 2,000 tonnes by 1997. Removals as by-catch have a negative impact on northern wolffish populations and bottom trawling that destroys and disrupts spawning habitat is probably detrimental as well. However, trawl fisheries are now subject to widespread moratoriums. Because the northern wolffish is not the target of a directed fishery in the North Atlantic it is unmanaged and there are no specific mechanisms, such as total allowable catch limits, in place that afford it protection. However, it is now mandatory to release bycatch. While it is of little interest to forest fishers, there is unreported bycatch mortality. Apart from direct mortality of catch, there are also indirect detrimental effects. The groundfish trawls in which wolffish are							**N/A**

	caught result in incidental mortality and damage to fish which come in contact with the gear but are not caught. Perhaps even more importantly, the steel doors of the net, along with heavy bottom lines and rollers, scour the seabed. This can cause significant habitat damage by removing or re-distributing the rocks and boulders under and around which these fish shelter, spawn and build nests. Impacts can vary quite a bit depending on local conditions, but the greatest and most lasting impacts occur on hard substrates in deep water, just those habitats where the wolffish are found. Bottom trawling for fish and dredging for scallops and clams, in addition to digging up and disrupting bottom habitats, also resuspend bottom sediments which can smother spawning areas and damage gills. Given declines in fish populations, bans on fishing have been in effect in most regions for various periods of time and these continue in the Newfoundland region. Fishing predation is thus much relaxed.							
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression								**N/A**
7.2 Dams and water								**N/A**

management/use								
7.3 Other ecosystem modifications								**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases								**N/A**
8.2 Problematic native species/diseases								**N/A**
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents								**N/A**
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne								**N/A**

pollutants								
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Climate change may also affect the distribution and abundance of the northern wolffish. However, details are uncertain (Fisheries and Oceans Canada 2020).							**N/A**
11.2 Droughts								**N/A**
11.3 Temperature extremes	Water temperature appears to be a major factor determining habitat selection in this species, which is most common at temperatures between 2°C and 5°C. Temperature is believed to limit their distribution and habitats. A period of exceptionally cold water temperatures (late- and early-1990s) may have coincided with the rapid contraction in the range of wolffish species, although most declines began prior to this. Shallower waters may have been abandoned by these species, possibly in favour of deeper, warmer waters. However, this possibility remains hypothetical. The long-term trend in water temperatures is uncertain. An increase in water temperatures in the northwest Atlantic may lead to a northward shift of many marine cold-water fish species such as this one, as has been documented in the northeastern Atlantic.	W	U	C	LTF	M	L	**Low**
11.4 Storms and flooding								**N/A**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Olive-sided Flycatcher (*Contopus cooperi*)
Populations (if applicable): No known subspecies or varieties.
Percentage of North American population NWT is responsible for: 53% of its breeding range across most of forested Canada and the remainder in the western and northeastern United States. Estimates suggest that Quebec and BC together support about half the current Canadian breeding population. In the NWT, it is found north to the Gwich'in Settlement Area, as well as east and west of Great Slave Lake and Great Bear Lake and has been documented at many sites across the southern edge of the territory.
NWT General Status Ranks: At Risk
NatureServe Conservation Rank (NWT): SUB
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Threatened (2008; re-assessed Special Concern in 2018)
Reasons for assessment or population trends: The Canadian population of this widespread forest songbird has experienced a substantial long-term decline, although the rate of decrease has slowed over the past decade. Loss of wintering habitat in northern South America is likely the greatest threat facing this aerial insectivore, but the species may also be affected by changes on the breeding grounds such as the effects of altered fire regimes and changing climates on nesting habitat quality and reductions in the abundance and availability of aerial insect prey. Concerns for the species remain, as most of these threats are continuing and those related to climate change may increase.
Sources used for assessments: COSEWIC (2018c)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[238] = 2		
Dependence on habitats that are sensitive to climate change[239]	Olive-sided flycatcher is most often associated with edges of coniferous or mixed forests with tall trees or snags for perching, alongside open areas, or in burned forest with standing trees and snags. In natural conditions, these habitats may include open to semi-open mature forest stands, as well as mature stands with edges near wet areas (such as rivers, muskeg, bogs, or swamps), burned forest, openings created by insect outbreaks, barrens, or other gaps. The species also uses forest stands adjacent to	2 – Generalist, but some sensitive habitats may be important.

[238] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.
[239] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	human-created openings (such as clearcuts, thinned stands and prescribed burns). Range retraction/declines are likely in the south, but northward expansion may be possible.	
Sensitivity to climate-relevant abiotic factors[240]	It is unknown what physiological tolerance limits related to climate exists for this species, or if habitat moves northward, how readily olive-sided flycatchers will be able to shift into new regions.	Unknown
Sensitivity to climate-relevant biotic factors[241]	Aerial insectivore. In YT, the most commonly observed prey types were Odonata (dragonflies and damselflies) and large Hymenoptera, followed by Diptera (flies). They are socially monogamous, with large territories of 10-20 ha and nesting pairs generally well-spaced. Nests are typically built in coniferous trees. Of ten nests observed in the NWT, eight were placed in live black spruce and two in snags, at an average nest height of 4.8 m and average nest tree height of 7.6 m. Both breeding site and wintering ground fidelity. Olive-sided flycatcher abundance may be positively associated with insect outbreaks that create forest openings with dead snags, such as spruce budworm in the eastern boreal forest and mountain pine beetle in the western Montane areas.	2 – Somewhat sensitive or possibly very sensitive.
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	Insectivorous birds as a group have been experiencing declines, likely associated with widespread insect declines, pesticide use (particularly neonicotinoids) and changes in prey availability during the breeding season as a possible result of climate change. Habitat loss or degradation is likely affecting this species on both the breeding and wintering grounds. In the NWT, threats are few, although declines in prey species could be potentially important.	1 – No pressures.
Adaptive capacity[242] = 2		

[240] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.
[241] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

Reproductive capacity[243]	Average clutch size is three eggs and a single brood is raised. Nest success ranges from 30-65%, differing by region and habitat type. Re-nesting is common if the first clutch fails. Olive-sided flycatchers have been known to live for at least seven years. Generation time is unknown, but likely ~3 years, similar to most other small passerines. New World flycatchers (Tyrannidae) breeding in North America have the lowest reproductive rates of all passerines and are not known to produce more than one brood per season. Similar to other flycatchers, growth rates of young are slow, leading to a lengthy nesting period that may result in greater likelihood of nest predation. Its life history traits may limit its potential for population growth and recovery, given that it has a lengthy nesting period, one of the shortest breeding ground periods among passerines and possibly the longest migration of any North American flycatcher species. Olive-sided flycatchers apparently breed on their first return to the breeding grounds (i.e., in their second year). Very few data exist on lifespan and survivorship of adults.	2 – Early reproduction/few offspring
Dispersal capacity[244]	Widespread migratory species. They travel as much as 8,000 km between their wintering and breeding grounds, with migration and wintering periods accounting for most of the annual cycle. It has the longest migration of any North American flycatcher species, possibly increasing its exposure to adverse weather events and other risks associated with migration (e.g. loss or degradation of stopover habitat). Breeding territories generally well-spaced, ranging	2 = 1-10km

[242] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[243] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.
[244] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

	in size from 10.5-26.4 ha in Alaska. Territories can be larger though. Olive-sided flycatchers may have strong breeding site fidelity, although data are scarce. From banding recapture data, there is also evidence to indicate wintering ground site fidelity.	
Genetic diversity		N/A
Phenotypic plasticity		N/A

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas	Collision with houses and other buildings in the United States kills many birds in North America annually, but less than 0.5% of the breeding bird population in Canada. While there are few data on collisions specific to olive-sided flycatcher, the species largely avoids urban areas and the impact of this threat is likely negligible.							**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops	Forest loss on the wintering grounds in Central and South America may be the most significant factor driving population declines. One study stated that as of 1985, 85% of Andean Montane forests had been significantly altered. Another study predicted that, if habitat loss continued at 1991 rates, olive-sided flycatcher would lose 39% of its wintering habitat between 1980-2000 though this hypothesis was not subsequently evaluated. Significant forest alteration continues at high rates in areas thought to be important non-breeding areas for olive-sided flycatcher, such as Colombia and western Brazil. Estimates in some regions of Colombia are as high as 3.7% of forest cover loss per year. Recent geolocator and GPS data from birds migrating from breeding sites in boreal Alaska confirm that wintering grounds overlap with areas of high forest loss.							**N/A**

2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling	See 4.1.							**N/A**
3.2 Mining and quarrying	See 4.1.							**N/A**
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads	Although olive-sided flycatchers use disturbed landscapes, species distribution models predict lower densities in association with linear features and anthropogenic disturbances. Detection rates of olive-sided flycatcher in the boreal forest are lower near roads. Predicted densities are also higher in protected areas than in managed areas, suggesting sensitivity to anthropogenic disturbance and habitat fragmentation. In Canada's boreal forest ecozone, recent increases in oil and gas development, mines and their associated transportation and service corridors have resulted in the loss of nests of many bird species. These activities are likely to affect a small proportion of the population over the next ten years.							**Neg.**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and								**N/A**

collecting terrestrial animals								
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting	The boreal forest is estimated to support 57% of the population and approximately 20% of the boreal forest has been affected by anthropogenic disturbance. Fire, forest harvesting and other disturbances are also impacting habitat availability and quality across the breeding range, though impacts have not been well qualified. Given that olive-sided flycatchers use anthropogenically created forest gaps, one author suggested that the amount of suitable habitat may have actually increased in eastern Canada since European settlement. However, the continued decline of this species across its breeding range suggests that either breeding habitat supply is not the only concern for this species or that early successional forests created by timber harvest are unsuitable and may act as ecological traps. On the breeding grounds, the impacts of logging depend on the method used and the region in which it is employed. To date, the specific effects of forest harvesting on olive-sided flycatcher abundance and nest success are unclear and likely depend on type, timing and location of harvesting. Although forest harvesting is practiced across a large proportion of the species' range, its severity and impacts are unknown.							**Neg.**
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational								**N/A**

activities								
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression	Olive-sided flycatcher was more abundant in burned areas than either unburned or burned and salvage-logged forests in SK, though time since burn is likely important. Changes in the fire regime may have mixed effects. Increasing forest fire frequency and severity due to climate change, particularly in the western part of the range, may eliminate breeding habitat and also reduce insect availability over the short-term, though edges of burns can be attractive to olive-sided flycatcher. Conversely, fire suppression has reduced burned areas and lengthened fire cycles in parts of the boreal region. Fire suppression is typically conducted close to areas of human settlement, thus, population trends based on breeding bird survey data may over-represent the impacts of fire suppression.	W	U	S	N	H	L	**Neg.**
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications	Occupancy and abundance seem to be influenced by the type of forest management techniques used (including clearcutting, thinning, block retention and other treatments). Not applicable in the NWT. Reductions in prey populations are a threat over the entire life cycle. These may result from various factors, including use of pesticides/herbicides, changing moisture regimes, habitat change from forestry or fire, or habitat loss due to land conversion. Globally, declines and range retractions of insects have been widely documented. Declines of pollinator insects such as Hymenoptera,	W	U	S	LT F	M	L	**Low**

	an important diet item on breeding and wintering grounds, are widespread in North America and habitat loss or degradation is estimated to have threatened or impacted over 90% of insect groups worldwide. Scored to the right. Increasing use of neonicotinoid pesticides has been associated with declines in insectivorous birds in Europe, at least in part through reducing availability of insect prey and are speculated as a factor in Olive-sided Flycatcher declines, although specific effects on this species have not been demonstrated. Health Canada has recently proposed to ban imidacloprid, the most commonly used neonicotinoid pesticideand to phase out all agricultural and most common uses within three to five years. Whether this likely ban impacts concentration of neonicotinoids in the environment will depend upon its enforcement and what other agricultural chemicals become commonly used in the place of imidacloprid. Negative impacts during migration may also be possible; suggesting that exposure outside of Canadian borders may have impacts. Not applicable in the NWT.							
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases	Although there is some documentation of predation by red squirrels, gray jays and other natural predators, predation rates are poorly quantified. It is unknown whether there are threats to olive-sided flycatcher related to predation and/or parasitism by invasive species.							**N/A**
8.2 Problematic native species/diseases								**N/A**
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**

8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents	Mercury contamination has been documented as a threat for the rusty blackbird, which also preys on insects. Although olive-sided flycatchers have not been specifically tested for mercury contamination, they predominantly feed on insects with aquatic larval stages and thus may be at risk for mercury bioaccumulation, particularly on the eastern part of the range. However, mercury levels from blood of breeding olive-sided flycatchers in Alaska were found to be relatively low compared to other songbirds.							**N/A**
9.3 Agricultural and forestry effluents (including erosion)	It is unknown whether neonicotinoids or other pesticides or herbicides have direct lethal or sub-lethal physiological effects on olive-sided flycatcher. Extent and timing of exposure is not known.							**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**

11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Large avian distributional shifts may eventually occur in response to climate change. For olive-sided flycatcher, population change based on climate is predicted to be -3.1% (CI -9.1-6.1%) between 2011 and 2040, with more severe declines in 2041-2070 (means of -10.3%, CI -26.6-3.7%). However, due to limits for forest growth and succession, there may be lags between climate change and vegetation change. A 30-year vegetation lag would be expected to reduce core Olive-sided Flycatcher habitat by only 1%, compared to 23% for a 60-year lag. Changes in timing of insect emergence due to climate change may affect synchronization between olive-sided flycatcher hatching and peak food abundance. The prey-breeding temporal mismatch has been proposed to explain severe declines in pied flycatcher, as well as other migrant birds. Effects may be more severe for long-distance migrants such as olive-sided flycatcher. The mismatch hypothesis has also been proposed to explain declines in rusty blackbird, an insectivore with a breeding range overlapping that of olive-sided flycatcher.	W	U	C	N	M	L	**Low**
11.2 Droughts	The NWT is projected to see an increase in the number of droughts, which may disturb olive-sided flycatcher habitat (Lee pers. comm. 2020).	L	U	S	LT F	L	L	**Low**
11.3 Temperature extremes	It is unknown what physiological tolerance limits related to climate exists for this species, or if habitat move northward, how readily Olive-sided Flycatchers will be able to shift into new regions.							**N/A**
11.4 Storms and flooding	Short breeding season, single brood raised and very long migration may increase vulnerability of this species to adverse weather events. Storms and extreme weather events have been documented as causing mortality in olive-sided flycatcher nestlings. Large storm events (e.g. hurricanes) during migration have caused mass fatalities in other long-distance migrants, such as chimney swift. An increasing frequency in storms and extreme weather is projected.	L	M	S	LT F	L	L	**Low**

11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Peary caribou (*Rangifer tarandus pearyi*)
Populations (if applicable): Western Queen Elizabeth Islands (Melville, Prince Patrick, Eglinton, Borden, Mackenzie King, Brock), Banks Island, northwest Victoria Island (Minto Inlet).
Percentage of North American population NWT is responsible for: Peary caribou are restricted to the high Arctic (Queen Elizabeth Islands) and the mid-Arctic islands of Canada, as well as the very north extension of the mainland (Boothia Peninsula). The NWT holds about 30-60% of the global population of Peary caribou.
NWT General Status Ranks: At Risk
NatureServe Conservation Rank (NWT): S1
***Species at Risk (NWT) Act*:** Threatened
***Species at Risk Act* (Canada):** Endangered
Reasons for assessment or population trends: All three Peary caribou subpopulations in the NWT display similar trends. High abundance was recorded in either the 1970s or 1980s (Banks and northwest Victoria islands) or the early 1960s (western Queen Elizabeth Islands), followed by steep declines (averaging >90%), with little evidence for recovery to historic higher numbers over a 20-year period. The only evidence of some recovery has been seen in the Queen Elizabeth Islands. The sustained low numbers (estimated 7,250 individuals) and high population variability between survey years suggest high vulnerability to further declines. A key influence that likely halted the decline of Peary caribou in the 1990s was the restriction of hunting, especially female caribou. There does not seem to be an imminent threat (i.e., they are not facing imminent extinction), but they are very vulnerable to random catastrophic events. Peary caribou only exist in the NWT and NU. NWT and NU cannot count on a rescue effect from each other, because Peary caribou numbers are low across their entire range.
Sources used for assessments: SARC (2012c)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[245] = 2		
Dependence on habitats that are sensitive to climate change[246]	Peary caribou are the most northerly group of caribou in North America. They are sometimes seen out on sea ice. Peary caribou use a relatively wide variety of habitats (terrain and vegetation types).	2 – Generalist, but some important habitats may be sensitive.

[245] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.
[246] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

Sensitivity to climate-relevant abiotic factors[247]	Although Peary caribou are adapted to extreme cold, their tolerance of heat is unknown. Annual variability in winter conditions is characteristic of Peary caribou habitat. It is uncertain whether Peary caribou show regular fluctuations depending on a relationship between amounts of forage and caribou abundance, or whether Peary caribou could be considered in a 'non-equilibrium grazing system' where sporadic, unpredictable abiotic variable affect vital rates and population trends.	2 – Somewhat sensitive or possibly very sensitive.
Sensitivity to climate-relevant biotic factors[248]	Peary caribou depend on a wide variety of forage plants and the stage of growth (flower bud, leaf bud) is likely as important as the particular species. Unlike for BGC, lichens are not a key part of winter diet for Peary caribou because they are scarce on the Arctic islands.	2 – Somewhat sensitive or possibly very sensitive.
Non-climate stressors = 2		
Sensitivity to potentially interacting non-climate pressures	The primary threat to Peary caribou is climate change; however, shipping lanes, competition/predation and extreme weather also considered threats.	2 – Moderate pressures or possibly major pressures.
Adaptive capacity[249] = 2.5		
Reproductive capacity[250]	Peary caribou in good condition can calve every year after sexual maturity is reached between two to four years of age. Peary caribou are relatively long-lived, with females living as long as 12-16 years and males for a few years less.	4 – Late reproduction/few offspring
Dispersal capacity[251]	Peary caribou are described as being highly mobile animals; however, almost nothing is known about dispersal in Peary caribou.	1 - >10km.
Genetic diversity	The Peary caribou on the NWT western Queen Elizabeth Islands are relatively isolated from Banks and northwest Victoria Islands with DNA analyses	N/A

[247] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.
[248] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).
[249] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[250] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.
[251] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

	indicating a lack of recent gene flow. Peary caribou from Banks and northwest Victoria Islands were not significantly different from each other. The Peary caribou from Melville and Eglinton Islands were distinct from Banks Island and northwest Victoria Island. Peary caribou from Melville Island were less genetically diverse and showed stronger evidence for past bottlenecks (small population size).	
Phenotypical plasticity		N/A

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas	The possibility of increased tourism represents a threat to some habitats such as calving areas. However, the levels of access on these islands are generally very low. For example, tourist, staff and youth camp participants (total visits) to Aulavik National Park on northern Banks Island averaged <50 individuals per year over the past decade, with spikes in numbers often the result of a single day-visit by a cruise ship or single season visit by private, often European, groups. Similar trends of low numbers were observed in Tuktut Nogait National Park on the adjacent mainland.							**Neg.**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater								**N/A**

aquaculture								
3. Energy production and mining								
3.1 Oil and gas drilling	On Banks, Melville and Prince Patrick islands, although seismic activity was widespread during the early 1970s, currently there is no seismic exploration. However, there is potential for more seismic activity in the future. In NU, fluctuations in Peary caribou and muskoxen distributions were attributed by local hunters in part to petroleum development. In particular, more numerous ground vehicles, aircraft and dust from seismic activities (especially on Bathurst Island) was reported to have detrimentally affected wildlife and concerns are evident regarding the potential effects of noise, dust and pollution from further exploration.	L	M	C	LTF	M	M	**Low**
3.2 Mining and quarrying	Increased interest in coal exploration driven by demand from Asian markets is a concern. As of February 2012, there were several active prospecting licenses and coal exploration licenses on Banks Island in particular, predominantly clustered on the southeast and northwest portions of the island and inland from Jesse Bay. The licensed areas to the northwest and those close to Jesse Bay notably overlap with areas identified as caribou calving grounds. Mineral exploration has occurred in the Shaler Mountains of northwest Victoria Island in the 1990s. So far, the exploration has not led to development. Human activity on the Canadian Arctic islands has not yet reached a scale at which habitat loss through displacement can be identified. However, the low densities of caribou mean that the displacement would have to have a large effect to be measurable.	L	M	C	LTF	M	M	**Low**
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads	Activities that can potentially fragment habitat such as ice roads were more frequent in the early 1970s on Banks Island and the NWT western Queen Elizabeth Islands during exploration for oil	L	U	S	LTF	M	L	**Low**

	and gas. Based on experience elsewhere, disturbances such vehicles can increase caribou energetic costs if those human activities interrupt caribou foraging or cause caribou to move away in response.							
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes	Several sources note that open water shipping channels related to industrial development would impede travel of wildlife between Banks and northwest Victoria Islands. Shipping increased by 75% from 1990-2011 inclusive, reaching a record of 19 transits in 2010. A few large vessels, all icebreakers, are taking the northern route between Melville and Banks Island. It is unclear what influence increased shipping will have on Peary caribou in the NWT, but any transits that result in open leads may impede movements of caribou between islands.	L	U	S	STF	H	H	**Low**
4.4 Flight paths	Currently, specific concerns from communities include stress on caribou from low-flying helicopters performing geological surveys. Based on experience elsewhere, disturbances such as low-level aircraft flights can increase caribou energetic costs if those human activities interrupt caribou foraging or cause caribou to move away in response.							**Neg.**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	Potential for overharvesting. While overharvesting was important in the past, it is not seen as a current threat. An NWT-wide harvest quota was introduced in 1990and a zero-harvest policy initiated by the OHTC in 1993 for northwest Victoria Island. A male-only hunting quota has been implemented on Banks Island since 1990 and harvests have been less than this number since 1994. On Banks Island, the quota is annually reviewed. Given general estimates of 700 to 1,100 adult caribou on Banks Island during this period, the harvest rate has generally been <2-3%and as low as 1% since the mid-2000s.	L	L	C	N	H	H	**Low**

	Although the Inuvialuit have the right to hunt caribou on the western Queen Elizabeth Islands, hunting rarely occurs on these northern-most islands as there are no communities and hunters can rarely reach them. In summary, for all subpopulations, hunting is currently controlled and likely has low impact on Peary caribou, but any reduced survival of adult female Peary caribou may impede the population from increasing.							
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression								**N/A**
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications								**N/A**

8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases								**N/A**
8.2 Problematic native species/diseases	MUSKOXEN: Potential competition for food and space with muskoxen. Populations of muskoxen increased greatly since the 1960s. This increase is tied to a 1950s wolf poisoning program. Indications that interactions with muskoxen are detrimental to Peary caribou are more numerous for Banks Island than northwest Victoria Island. The limited size of the Arctic islands may be one factor that leads to competition between muskoxen and Peary caribou, although this isn't a universally held belief. However, the 2001-2009 decline in muskoxen numbers on Banks Island has not yet contributed to caribou recovery. It is uncertain what is driving the muskoxen decline and what it will mean for Peary caribou foraging, predation rates, or parasites. WOLVES: Predation on Peary caribou by wolves is a threat due to small population size of Peary caribou. Wolf numbers began to recover in the mid-1970s (from the poisoning program) on northwest Victoria Island and were reportedly also increasing in the 1990s. Although wolf sightings have increased during aerial surveys since the 1990s for Banks Island, coinciding with an increase in muskox abundance, there are insufficient data to measure predation as a threat relative to the continued low abundance of Peary caribou. However, even small declines in the survival rate of adult female Peary caribou are likely to prevent the population from increasing, so even incidental predation could be a factor in maintaining low abundance. The decline in muskox since the early 2000s raises questions about the presence and timing of the wolf population's numerical response and incidental predation on Peary caribou. Therefore, wolf predation is an unknown but likely threat to Peary caribou populations especially	W	L	C	N	H	H	**Low**

	when Peary caribou abundance is low. GRIZZLIES: Grizzly bears are being seen with increasing frequency on the NWT Arctic islands and given their known use of caribou as a dietary source; it is possible that grizzly bears are a predator of Peary caribou. Although grizzly bear predation is likely, the extremely low numbers of grizzly bears observed so far in Peary caribou range suggest that population effects on Peary caribou are negligible.							
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents	The evidence based on sampling in the 1990s suggests that contaminants do not appear to be current threats to caribou health. Despite these findings, contaminants were included among potential threats because over time the types of contaminants change as new chemicals come into common use.							**Neg.**
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste								**N/A**

9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)	Based on experience elsewhere, disturbances such as low-level aircraft flights, people on foot and vehicles can increase caribou energetic costs if those human activities interrupt caribou foraging or cause caribou to move away in response.	L	L	S	N	H	H	**Low**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Because Peary caribou are already responsive to the effects of weather on forage, climate change will likely cause a cascade of interacting positive and negative effects. However, in general, the effects of weather may be difficult to gauge because of compounding factors like natural population cycles, inter-species interactions, harvesting and predation. Extreme climatic variability is also characteristic of the region. OBSERVED CHANGES: In general, there appears to be a clear increase in both temperature and fall-time snowfall at all stations (Sachs Harbour, Mould Bay and Ulukhaktok). Residents report less sea ice (annual and multi-year), fewer ice floes, less landfast ice and more open water in winter and spring. Residents link these conditions to warmer weather in winter and to changes in wind direction, strength and frequency. In the western continental Arctic, there are measured trends for increasing plant productivity based on satellite imagery and changes in vegetation such as an increase in shrub growth. Changes in the timing of snow melt for eastern Banks and western Victoria Islands have been noted. The mean date of snow melt on Banks Island was 7.5 days earlier for	W	M	C	N-STF	H	H	**Medium**

	1987-2004 compared to 1967-1986, although melt has actually occurred later in the 2000s than in the 1990s. Changes also include a longer mosquito season and warmer summers. FORAGE: Aspects of climate change alter availability of forage. Deep, hard snow cover can inhibit access to forage and force caribou to feed in more raised wind-blown areas where there is less snow cover. Rain and associated icing on the ground can lead to caribou starvation in the spring and fall. The effects of freezing rain on the availability of habitat for Peary caribou may be more severe on Banks Island because of its small size. Also, while some seem to infer that an earlier green-up of vegetation on Banks Island is potentially beneficial to the forage available for caribou, it has also been suggested that an earlier onset of green-up can lead to a reduction in important nutrients for calves and a decrease in their rate of survival. Freezing weather could have a positive effect on the availability of some types of vegetation (freezing can preserve fresh green forage for later consumption). Warmer summers and more rain mean more vegetation, which is good for animals. Summer weather likely affects the timing and amount of plant growth and in turn the amount of forage influences pregnancy rates as well as caribou winter survival. FREEZING RAIN: Erratic weather is linked to the prevalence of freezing rain and indications are that erratic weather events are becoming more common on Banks Island due to climate change. A caribou die-off was recorded in the winter of 1977-1978 after a freezing rain event in 1977. Andy Carpenter noted that die-offs occurred about every three years through the 1970s and 1980s. Changing weather patterns are unpredictable but a warming climate will likely increase fall temperatures, which would increase the frequency of freeze-thaw cycles.							

	SNOW: The effect of the warmer temperatures in the fall and winter that can cause either rain or melting within the snowpack is moderated by snow depths. In shallow snow, the warmer temperatures will improve forage availability as the snow disappears, but in deeper snow the melting causes ground fast ice, reducing forage availability. However, not all winters with deeper snow are detrimental to forage availability as temperatures and wind strength affect the snow pack characteristics. The snow and ice conditions can make foraging energetically costly or make it impossible. The degree of the effect and its geographical extent influences how severely caribou are affected, whether they can find alternate foraging and the proportion of the population affected. MOVEMENTS: Aspects of climate change alter ability to move between islands. Many sources have documented hunters' observations that sea ice is becoming less reliable. Changes in the climate may be leading to caribou spending more time in the south of Banks Island around Fish Lakes (migrating north in the spring slightly later) and returning south slightly earlier. RAINFALL: An aspect of summer weather that should be considered is the influence of low rainfall. Typically, Peary caribou forage in the drier plant communities (polar desert communities). Elsewhere in the arctic, summer moisture can limit plant growth for the upland plant communities, which caribou tend to use in winter. Crude protein levels in sedge may also vary between wet and dry years. SURVIVAL/HEALTH: Warmer winters are better for caribou and muskoxen (presumably because they require less energy and fat reserves to survive). Another effect of climate change is reported to be more wind, which is said to make it easier for caribou to cope							

	with mosquitoes in the summer. The trend toward warmer summers will modify conditions for parasites and diseases, although the effects will be complex and are currently unknown.							
11.2 Droughts	Projected increases in drought (using Climate Moisture Index (CMI)). It is unknown how this would impact plant growth on plants that the Peary caribou rely on (Lee pers. comm. 2020)							**N/A**
11.3 Temperature extremes	Overall, extreme cold temperature events are projected to decrease, while extreme heat temperatures are projected to increase. However, extreme heat events will likely continue to be rare in the high Arctic, where Peary caribou reside. The heat tolerance of the Peary caribou is unknown (Lee pers. comm. 2020).							**N/A**
11.4 Storms and flooding	Peary caribou are vulnerable to catastrophic events. An increase in storms and flooding is projected for the NWT. This may impact Peary caribou, though there is much uncertainty concerning the impacts (Lee pers. comm. 2020).							**N/A**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Peregrine Falcon (*Falco peregrinus anatum/tundrius*)
Populations (if applicable):
Percentage of North American population NWT is responsible for: Widely distributed across Canada, breeding in every jurisdiction except Prince Edward Island and the island of NL. Arctic-nesting peregrine falcons breed from the Beaufort Sea coast of the YT east to Labrador and north to Baffin Island. Over 60% of the North American range occurs in Canada. Disjunct distribution between southern and northern Canada.
NWT General Status Ranks: Sensitive
NatureServe Conservation Rank (NWT): S3B
***Species at Risk (NWT) Act*:** Not assessed/listed
***Species at Risk Act* (Canada):** Special Concern (2017 re-assessment, Not at Risk)
Reasons for assessment or population trends: Following dramatic declines in the mid-20th century, this species has rebounded significantly over the past few decades, with continued moderate to strong increases in many parts of Canada since the last status report in 2007. The initial recovery was a result of reintroductions across much of southern Canada following the ban of organochlorine pesticides (e.g. DDT). Increasingly, the ongoing population growth is a function of healthy productivity and, in the case of urban-nesting pairs, exploitation of previously unoccupied habitat. While pollutants continue to be used on the wintering grounds of some individuals and can be found in tissue samples, they appear to be at levels that are not affecting reproductive success at the population level. The extent to which populations have recovered relative to historical levels is generally unknown, but the consistent strong growth of the overall population suggests that there are currently no significant threats to the species.
Sources used for assessments: COSEWIC (2017a)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[252] = 1.3		
Dependence on habitats that are sensitive to climate change[253]	The peregrine falcon is an extremely versatile and plastic species, adapting to a wide range of habitats and ecological conditions around the globe. The peregrine falcon breeds in a wide variety of habitats, including tundra, coastal islands, desert canyons and major metropolitan centers. Higher densities are often	1 – Broad generalist.

[252] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.
[253] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	found in Arctic and coastal habitats. Those that nest in northern Canada nest primarily on cliffs along large river systems. Observed increase in the number of nesting territories over a 20-year period averages +13.5% in northern Canada (range -5% to +100%). In the NWT, some nest loss has occurred due to slumping and erosion of riverbanks, as well as the loss of stick nests from forest fires. Large tracts of dense, closed forests appear to be one of the few habitat types where Peregrine Falcons do not occur, as they require open or partially open conditions to hunt for prey. Roosting sites are an important component of breeding habitat. These are often used repeatedly over time and are often located on small rock ledges or projects on rock faces, often under overhangs. Migratory habitat is widespread across Canada. Wintering habitat in the neotropics is largely coastal or inland wetlands.	
Sensitivity to climate-relevant abiotic factors[254]	As noted in the threats assessment, it is likely vulnerable to temperature extremes and storms/precipitation events, especially in the Arctic.	2 – Somewhat sensitive or possibly very sensitive.
Sensitivity to climate-relevant biotic factors[255]	Although its diet is flexible, it breeds only where there is access to sufficient food supplies. Because of their aerial hunting strategy, peregrine falcons require an ample supply of prey species of suitable size, in areas that facilitate aerial hunting. In the tundra, some specialize on insectivorous birds (songbirds and shorebirds). Resident birds such as ptarmigan and early migrants such as snow buntings can be especially important, representing the only available avian prey species when migrating peregrine falcons return to the breeding territory in the spring. However, individual falcons can show considerable flexibility and adaptability in response to novel food sources. Peregrine falcons often cache surplus prey, especially during breeding season.	1 – Not sensitive.

[254] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

[255] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

	Peregrine falcons are solitary breeders and are highly territorial towards other peregrine falcons, although relatively high densities may occur in areas of high prey abundance. Black flies are a potential emerging threat, related to shifts in range as a result of climate change.	
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	There are few threats to peregrine falcons in the NWT. The most significant threats likely relate to climate change (temperature extremes and storms).	1 – No pressures.
Adaptive capacity[256] = 2.5		
Reproductive capacity[257]	Generation time estimated at six years. Only one brood is raised annually. Re-nesting may occur if the nest fails in the laying or incubation periods. This occurs rarely in the Arctic due to the more restricted nesting season, although some instances have been observed. Clutch size is typically three to four eggs, with smaller clutches (x = 2.9) in Arctic regions. Age of first breeding is typically two to three years old. Maximum known longevity is 20 years.	4 – Late reproduction/few offspring
Dispersal capacity[258]	The peregrine falcon is considered a long-distance migrant and a trans-equatorial migrant capable of long water crossings. Migration behaviour of peregrine falcons is directly related to their prey. Northern-nesting peregrine falcons generally migrate the farthest, to Central and South America. Some Arctic-nesting birds in North America may migrate up to 25,000 km annually. Proximity to water appears to be important. Urban nesting sites are often within one to 20 km of water. Estimates of average home range size vary from 100-500 km^2, although home ranges up to 1,500 km^2 have been reported. During the breeding season foraging flights have been reported as ranging from eight to 79 km of the nest site.	1 = >10km

[256] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[257] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.
[258] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

	Adult peregrine falcons typically show territorial fidelity, returning annually after migration to the same breeding territory or nesting area.	
Genetic diversity	There are weak genetic differences between parts of the range traditionally associated with *anatum* and *tundrius*, but these appear to be due mainly to changes in genetic diversity within the *anatum* range related to the reintroduction of birds (in adjacent US states) from a variety of genetic backgrounds. Results suggest there is considerable gene flow between areas traditionally associated with *tundrius* and *anatum* peregrine falcon populations across Canada, Alaska and Greenland.	N/A
Phenotypic plasticity		N/A

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas	Hazards leading to mortality include collisions with transmission lines, towers and high-rise buildings, particularly for recently fledged birds. The fast speed of the peregrine falcon puts it at risk of colliding with transmission lines. Conversely, buildings provide safe and productive nesting locations for many peregrine falcons, allowing for population growth in areas otherwise not suitable for the species. Therefore, while collisions clearly kill some peregrine falcons annually, the continued growth of urban peregrine falcon subpopulations suggests that residential and commercial development has an overall neutral or positive effect for *anatum/tundrius*. Foraging habitat has been degraded in some highly developed anthropogenic landscapes such as southern BC, ON and Quebec.							**Neg.**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops	Foraging areas can be impacted by agricultural land uses. Loss of such wetland habitat has been particularly important in ON and BC. The expansion in corn and soybeans may contribute to a decline in foraging habitat quality.							**N/A**
2.2 Wood and pulp								**N/A**

plantations								
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling								**N/A**
3.2 Mining and quarrying								**N/A**
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads								**N/A**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	Regulated harvest levels for falconry purposes appear to be sufficiently low to avoid population impacts. Globally, peregrine falcons continue to be a very highly sought-after species for falconry. North America comprises 9% of the global source of exported peregrine falcons. Concurrent with the recovery of the peregrine falcon across Canada, several Canadian jurisdictions have recently liberalized their falconry regulations. Ten of 13 Canadian jurisdictions now allow falconry, seven allow a limited take of raptors from the wild and five specifically allow a regulated and very limited take of wild peregrine falcons.							**Neg.**

	Persecution was historically a concern, with shooting of individuals and destruction of nests, especially where birds of prey were seen as threats to wildlife and domestic poultry. While shooting is much scarcer in Canada in recent decades, it is still a minor threat for migrating and wintering birds.							
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression								**N/A**
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications	There was an evident dramatic decline in peregrine falcon numbers in the middle of the 20th century because of widespread contamination by DDT, which resulted in impaired reproduction through thinning of eggshells. Although generally increasing, northern-nesting peregrine falcon subpopulations have shown more variability across jurisdictions and years (range -5% to +100%).							**N/A**

	There has been a decline in foraging habitat due to wetland loss in more developed parts of Canada and the conversion and simplification of agricultural landscapes in some parts of southern Canada.							
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases	Peregrine falcons are known to be infected by West Nile virus, although they appear to be less affected by the disease than many raptor species.							**Neg.**
8.2 Problematic native species/diseases	There is evidence to suggest that climate change is allowing for the northward range expansion of ornithophilic black flies, which is posing a risk to peregrine falcons in northern Canada, especially on Arctic islands. Observed outbreaks of ornithophilic black flies may reflect a climate-related range shift in response to increasing summer temperatures and increased frequency of heavy rainfall events, but this link is still considered hypothetical and more research is needed to determine if the severity of this threat is increasing and if it is having a population impact. At this point it still seems to be a rare occurrence.	W	U	S	N	L	L	**Low**
8.3 Introduced genetic material	Genetic introgression is considered to be minor and changes in genetic composition are not considered a significant threat to the population.							**N/A**
8.4 Problematic species/diseases of unknown origin	The parasitic disease trichomoniasis is transmitted to peregrine falcons by ingesting infected prey such as rock pigeons. Trichomoniasis has been found in young peregrine falcons in southern ON and may be a threat to some southern urban populations. However, it is considered a negligible threat to the overall Canadian population.							**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and								**N/A**

urban wastewater								
9.2 Industrial and military effluents	PCBs have been found in high concentrations in peregrine falcons and are a potential concern, although a clear relationship between high levels and reproductive effects has not been established. Recently identified threats include emerging long-lasting chemicals such as brominated flame retardants and PBDEs. High concentrations of PBDEs have been found in the eggs of peregrine falcons in northern Sweden and have been shown to bioaccumulate, raising concerns for potential reproductive impacts. Such impacts have not been confirmed in peregrine falcons, but comparable concentrations have been found to cause reproductive effects in American kestrels. Increasing trends in PBDE concentrations have been noted in peregrine falcons in Greenland (1986-2003), the northeastern United States, the Canadian Great Lakes basin and north-central Vancouver Island and the Lower Mainland. Some limits on the manufacture and use of PBDEs have been in place in Canada since 2009. Heavy metals such as lead continue to pose a level of risk to peregrine falcons and there have been recent cases of lead poisoning. Mercury is a contaminant of concern because of its toxicity, bioavailability and increasing concentrations over time. Aquatic prey are typically more contaminated than terrestrial prey. While mercury occurs naturally in the environment, anthropogenic sources and long-range transport may contribute significantly to the occurrence of mercury in Arctic ecosystems, resulting in increasing mercury concentrations in a variety of Arctic biota.							**Neg.**
9.3 Agricultural and forestry effluents (including erosion)	Peregrine falcons have proven highly susceptible to chemical contamination, as shown by the widespread reproductive failure, particularly in *anatum* peregrine falcons, from uptake of organochlorine pesticides. With the prohibition on DDT use in North America in the 1970s, DDT levels in the environment began							**N/A**

	to decline and reproductive success started to improve. However, DDT is still used in other parts of the world, potentially including parts of the winter range in South and Central America. DDT usage has declined there, being primarily used for spot treatments within homes rather than being used widely in agriculture. However, DDT contamination can occur in soil and water even from this residual or spot spraying. The continued controlled used of DDT for the control of malaria has been recognized as legitimate by the World Health Organization and United Nations Environment Programme, although there are current joint initiatives by both organizations to phase out the use of DDT completely by the early 2020s. Chemical bird control agents such as 4-amino-pyridine (avitrol), strychnine and fenthion can pose hazards to non-target species, through both direct and secondary poisoning. Organophosphorus fenthion, commonly used as an avicide to control European starlings and other pest birds, has been implicated in the deaths of several peregrine falcons in North America. This and other organophosphorus compounds are used widely in North America. In a sample of 19 peregrine falcons in the early 2000s, two had trace amounts of avitrol while quantifiable amounts were found in five additional birds that died of traumatic injuries. While these birds did not contain lethal amounts, researchers speculated that any disorientation could be fatal to raptors flying at high speeds. ON has voluntary pesticide control guidelines in place to limit the use of chemical bird control agents near 34 known urban nesting sites.							
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light								**N/A**

pollution)								
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Climate change may have some positive effects, including access to snow-free nest sites sooner for early-arriving birds, allowing for earlier initiation of breeding and hatching in Arctic-nesting subpopulations. Hatching dates for peregrine falcons along the Mackenzie River advanced by 1.5-3.6 days/decade from 1985-2010, dependent on latitude. The advancement of hatching dates may have reached a limit based on arrival dates and has now apparently stabilized around June 25. Earlier hatching is an advantage for Arctic-nesting birds, giving the young additional rearing time to learn how to successfully catch prey prior to fall migration. Amelioration of weather during the breeding season, including earlier and warmer springs and warmer autumns that have led to a longer breeding window, may have facilitated the recent breeding range expansion of peregrine falcons into the high Arctic in northern Greenland, potentially representing the most northerly breeding sites in the world. In Arctic Canada, one impact may include the collapsing of nest sites on soil cliffs with the melting of the underlying permafrost. Nesting sites on Arctic slopes are susceptible to loss due to bank slumping and mass movement as a result of increased summer temperature and summer precipitation.	W	U	S	N	M	L	**Neg.**
11.2 Droughts	Observations from the northwestern United States in the 1930s revealed that peregrine falcons flourished during periods of wet weather, but declined precipitously during drought years with	L	M	S	LT F	M	M	**Medium**

	limited water availability, coinciding with reduced nesting populations of shorebirds. Increased drying or drought conditions can reduce available wetland habitat, in turn reducing available shorebird populations for foraging peregrine falcons. Drought events or conditions are expected to increase in frequency in the NWT (NRCan N.D.).							
11.3 Temperature extremes	Some climate-related changes are likely to be greatest in northern regions, including warming temperatures over land. As this area has the majority of Canada's *anatum/tundrius* Peregrine Falcons, there are potential population implications. Increasing summer temperatures may have an impact on Arctic cliff-nesting peregrine falcons through dehydration and hyperthermia. Nestlings in nests exposed to direct sunlight can be stressed by thermal- and water-balance issues and heat-induced deaths of peregrine falcon nestlings have been documented. Recent observations of mortality among Arctic-nesting incubating Brunnich's guillemots appeared to result from a combination of high daily maximum temperatures, nest exposure to insolation and high numbers of mosquitoes due to weather-related earlier emergence.	L	U	S	N	M	L	**Low**
11.4 Storms and flooding	Owing to their tendency to nest on open cliffs and similar sites, peregrine falcons appear to be vulnerable to extreme weather events associated with changes in weather patterns. Heavy rainfall events (i.e., >8mm/day), which have increased in recent decades, were responsible for 28% of the deaths of nestlings in an Arctic-nesting peregrine falcon subpopulation. In Rankin Inlet, there was a linear relationship between mean chick survival and the amount of precipitation during rainstorms of three or more days and more frequent summer heavy rain events appear to be having a negative effect on this subpopulation. The frequency of heavy rain events has a much greater influence on nestling survival and overall productivity than the amount of rainfall. Heavy late spring snowfalls can cause the abandonment of nests being incubated, as well as higher chick mortality if the young are not yet able to	L	M	S	ST F	M	M	**Medium**

	thermoregulate. The effect of severe weather in the Arctic regions can be exacerbated because of the much narrower window for successfully breeding. Heavy rain events can also have indirect effects on Arctic-nesting peregrine falcons by reducing prey abundance/availability. Weather-mediated changes in lemming populations may influence avian prey abundance, as Arctic fox prey more upon bird eggs when lemmings decline, subsequently affecting the avian prey base.							
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Polar bear (*Ursus maritimus*)
Populations (if applicable): Northern Beaufort, Southern Beaufort, Viscount-Melville and Arctic Basin
Percentage of North American population NWT is responsible for: 6-10% of the global population.
NWT General Status Ranks: Sensitive
NatureServe Conservation Rank (NWT): S3
***Species at Risk (NWT) Act*:** Special Concern
***Species at Risk Act* (Canada):** Special Concern
Reasons for assessment or population trends: There are approximately 1,500-2,000 polar bears in the NWT (with 930-1,240) mature individuals. This may be considered less than 1,000 mature individuals (the threshold for Threatened status), but there is no estimate of numbers for the Arctic Basin subpopulation that would contribute to the total for the NWT. Survival and reproduction are influenced by ice conditions; ice conditions are changing, which influences their ability to hunt seals. Climate change will affect ice conditions differently in different parts of the Arctic. In the short term, optimal sea ice will be lost in some areas and gained in others. It is predicted that most polar bear subpopulations will be negatively impacted by climate change in the long term. Climate change, a primary threat, cannot easily be reversed nor managed effectively. Polar bears have a unique niche of hunting seals from a sea ice platform. Polar bears are long-lived and have low reproductive rates. They reach maturity late and do not reproduce every year. Polar bears are top predators, at the top of the food chain, making them susceptible to bioaccumulation of pollutants. Threats to polar bears and their habitat include cumulative effects of: climate change on sea ice causing changes to availability of food (access to and abundance of seals); offshore oil and gas exploration and development and marine traffic; pollution and contamination; behavioural changes resulting in more bear-human conflicts; and invasive research techniques.
Sources used for assessments: SARC (2012d, 2020a), Graham et al. (2019), Government of Canada (2019)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[259] = 3.3		
Dependence on habitats that are	Polar bears are dependent on sea ice as a hunting and denning platform and the physical attributes of sea ice	4 – Depends on sensitive habitats

[259] Overall sensitivity score is based on the average of habitat, abioticand biotic factor scores

sensitive to climate change[260]	are the primary determinants of the quality of polar bear habitat. As a species entirely dependent on sea ice as a platform upon which to hunt seals, conditions of sea ice can be viewed as one of the main, indirect limiting factors to polar bears. There has been an observed decline in the number and size of pressure ridges – a key ice feature from which bears hunt seals. This is attributed to thinner ice and increased ice movement. There is no more multi-year ice anywhere in the southern Beaufort Sea along the coast of the YT and NWT, nor in Amundsen Gulf off the coast of Ulukhaktok. Knowledge holders from Tuktoyaktuk observed that multi-year ice had disappeared from the coastal area north of Tuktoyaktuk by about 2000. In the southwest Northern Beaufort Sea unit, bears are likely to have increasingly less access to ice year-round. In contrast, year-round availability of sea ice among NWT islands in the Arctic Archipelago appears to be somewhat less impacted by recent climatic trends. However, even Viscount Melville Sound has begun to experience unusual periods of low sea ice in September. The type of ice present in Viscount Melville Sound (multi-year vs. annual) may also be changing. Polar bears in the low-latitude Beaufort Sea, where divergent sea ice conditions exist, appear to be most at risk from periods of low ice coverage. Where climate warming eliminates annual winter sea ice or substantially increases the open water season from maximum periods associated with areas of current occupancy by polar bears, the species is not expected to persist. Erosion is a potential concern for Southern Beaufort Sea polar bears because many pregnant bears may den on barrier islands and next to coastal banks where the terrain allows drifting snow to accumulate. Some coastal denning habitat may disappear in the future and this may result in a change in denning distribution.	that are rare.

[260] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

Sensitivity to climate-relevant abiotic factors[261]	Polar bear skin is black, which enhances absorption of solar radiation. Polar bears are adapted to an extreme and variable environment. Physiological tolerances otherwise not discussed.	2 – Somewhat sensitive or possibly very sensitive.
Sensitivity to climate-relevant biotic factors[262]	Changes in sea ice and associated snow cover affect light transmission and thermodynamic processes important to lower trophic levels of the Arctic marine ecosystem. These, in turn, influence the distribution of important food species such as ringed and bearded seals. Polar bears are best characterized as an obligate predator of seals using sea ice as a hunting platform. While polar bears in some areas are observed to be diversifying their diet, associated with increasing time spent onshore, a few studies show that terrestrial foods do not appear to provide substantive nutritional resources for polar bears. While polar bears are adept at hunting and scavenging on land, there would likely be a decline in population before sufficient adaptation to new ranges/food species could be make. While ringed seal abundances are not well-known throughout the NWT, it is notable that the species was recently assessed nationally as Special Concern, specifically due to changes in ice conditions in the Arctic. Reductions in habitat availability are resulting in increased competition, which is reflected in declining body condition and reproduction of females in the southern Beaufort Sea.	4 – Known sensitive.
Non-climate stressors = 2		
Sensitivity to potentially interacting non-climate pressures	Climate change is the most significant threat to polar bears in the NWT. Climate change is causing or compounding all major threats to polar bears and their habitat in the NWT, including changes in sea ice habitat, offshore oil and gas exploration and development and increased marine traffic. The combined effects of climate change with rapidly increasing development and activity in the Arctic are cause for high uncertainty and immense concern about cumulative impacts on polar bears and their habitat. Other potential threats include: increased oil and gas development, increased shipping, human-bear conflicts and pollution.	2 – Moderate pressures or possibly major pressures.

[261] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.
[262] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

Adaptive capacity[263] = 2.5 plus 0.5 for low genetic diversity = 3		
Reproductive capacity[264]	Age at first reproduction for females may be as early as four years, with most polar bears throughout the Canadian Arctic Archipelago producing litters at relatively high rates by age six. Pregnancy rates appear to vary markedly among subpopulations. Litter sizes are generally one to two bears, with triplet litters being rare except under very good conditions. The mean time between successful litters (interbirth interval) was estimated to be approximately three to four years. It appears most males do not enter the reproductive segment of the population until they are eight to ten years old. Polar bears do not usually live beyond 25 years. Generation length has been poorly studied, although the IUCN/SSC uses 15 years; COSEWIC uses 12 years.	4 – Late reproduction/few offspring
Dispersal capacity[265]	Polar bears can cover a huge range in search of prey and mates and are known to be capable of swimming long distances in open water. They can travel between continents (Canada and Russia). Polar bears are capable of traveling across varied terrain including very thin ice. Movements by some bears can be very large (e.g. hundreds of kilometers within a single year). Polar bears travel over exceedingly large areas relative to other terrestrial mammals. Annual home ranges of females vary from 940 km^2 to 540,700 km^2.	1 - >10km.
Genetic diversity	Low genetic diversity points to a prolonged decline in polar bear numbers during the last half million years. Studies based on allele frequencies suggest that polar bears from these various subpopulations are genetically similar and that there is no evidence that any of the groups have been evolutionarily separated for significant periods of time. No localized adaptations have led to the genetic isolation of any subpopulation.	0.5
Phenotypic plasticity		N/A

[263] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.

[264] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.

[265] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling	Since the mid-1960s, exploration for energy and mineral reserves has led to an increased amount of industrial activity in the Arctic. The Mackenzie shelf has high potential for oil and gas development and other regions within NWT waters are believed to have high	L	U	C	LT F	H	L	**Low**

	potential for undiscovered hydrocarbons. There are extensive discovered and recoverable oil and gas reserves in Nunavut, including the Sverdrup sedimentary basin, which overlaps the subpopulations of Viscount Melville Sound and Northern Beaufort Sea. Continued development of natural gas petroleum reserves of the Beaufort Sea/Mackenzie Delta in the NWT may put additional pressure on the Southern Beaufort Sea subpopulation of polar bears. There is also potential for negative impacts to seals from seismic research and blasting. In North Star Harbour and Sachs Harbour, a decline in seal health associated with seismic research resulted in a decline in polar bear health. Industrial activity near the shoreline can interrupt bears' denning cycles or cause them to abandon their young cubs. Increased development may result in changes in the migrations of not only the polar bear but all the marine mammals along the Beaufort Sea.							
3.2 Mining and quarrying								**N/A**
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads								**N/A**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes	The opening of the Northwest Passage to marine traffic is seen as having the potential to be one of the most serious threats to polar bear habitat. In all likelihood and within our lifetime, due to changing climate patterns, the Northwest Passage will remain open for increasing periods of time, making it attractive as a major shipping route.	L	U	S	LTF	H	L	**Low**

	Polar bears in the NWT and in the vicinity of this new shipping route may be exposed to traffic and levels of pollution that no subpopulation of polar bears has yet experienced. How they will respond to these cumulative effects is unknown. Marine traffic in the form of ice-breakers, submarines, cargo ships and cruise ships could travel through open leads, preventing the leads from re-freezing properly and by doing so; contribute to the decline in multi-year ice. In the Viscount Melville Sound and M'Clure Strait, concerns have been expressed about ship traffic affecting the fall and spring migration of polar bears between Banks, Victoria and Melville islands. Olokhaktomiut are concerned that marine traffic in the Richardson Collinson Inlet and Glenelg Bay area will have a negative impact on polar bear denning and on a critical community harvesting area. Specifically, the community is concerned that ships will destroy polar bear dens in multi-year ice that the noise will disturb denning bears and that ship tracks will pose dangers to hunters in the area. Paulatukmiut are concerned that shipping, along with exploration and development, will impact polar bear denning in the Parry Peninsula, Franklin Bay, Darnley Bay, Amundsen Gulf offshore and offshore islands. Marine traffic could also increase the release of oil, introduction of invasive species, ship emissions and noise.							
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	In all parts of the NWT, the harvest of polar bears has been below the quota for many years. Harvest rates of polar bears in the NWT are all likely less than 5% of the territorial population. Harvesting and human-caused mortality are not, at this time, considered threats to the NWT polar bear population. However, one likely impact of climate change is an anticipated increase in human-bear conflicts. Increases in polar bear activity in areas most affected by climate warming have been reported in recent years, including for	W	U	C	N	H	L	**Low**

	communities adjacent to the southern Beaufort Sea and western Hudson Bay. For western Hudson Bay, the earlier the breaks up, the more problem bears there are in a year and vice versa. However, in the NWT, defence of life and property kills are counted under a subpopulation's quota. Reductions in food availability may result in increases in nutritionally stressed bears spending longer periods of time onshore. Signs of nutritional stress are already being observed. If bears begin to starve because of changes to their habitat and prey availability, it is likely they will become nuisance bears as they scavenge for food and become less shy of people. This could lead to an increase in nuisance kills and cannibalism.							
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities	Inuit interviewed for Indigenous knowledge studies have real concerns about scientific research methods, whereby bears are immobilized using drugs and helicopters and snowmobiles are used to capture bears, which may cause displacement of bears or result in long-term, adverse physiological effects. Invasive research techniques may hinder hunting efforts, lead to							**Neg.**

	injuries, or cause disturbance, avoidance behaviour, or accidental death, while immobilization drugs and handling affect individual health, behaviour and survivorship. In an examination of the impact of research, long-term effects on polar bears of tagging and radio collaring are considered largely negligible from the perspective of population dynamics.							
7. Natural system modifications								
7.1 Fire and fire suppression								**N/A**
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications								**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases	An increased prevalence of disease has been projected for polar bears and marine mammals, in general, as a consequence of climate change and a northward expansion of pathogens.	W	U	C	LTF	H	L	**Low**
8.2 Problematic native species/diseases	Of potential concern is the greater competitive ability of the grizzly bear, compared to polar bear, when the two species come into contact with one another. There is evidence of grizzly bears expanding their range in northern Canada. However, although there is no evidence that grizzly bears are playing a significant role in displacing polar bears within the species' current range, the more generalist feeding strategy of grizzly bears might potentially provide this species with a competitive foothold on Victoria Island or on other Arctic Islands.							**Neg.**
8.3 Introduced genetic material	More grizzly bears have been observed on Banks and Victoria Islands than in the past. The first recorded polar-grizzly hybrid was in 2006 in southeast Banksland. There is yet no evidence to suggest that hybridization between polar bears and grizzly bears is a threat							**Neg.**

	to the existence of either species, although grizzly bears may be reducing the reproductive chances of polar bear contributing to their population.							
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents	The primary threat to polar bears from industrial development may come from the potential for environmental contamination, especially large-scale oil spills. Oil is extremely toxic and potentially lethal to bears in even small amounts. Recently, oil companies have pointed out practical difficulties of drilling a relief well in the event of an oil well blow-out in Arctic waters. Although some oil-spill simulations suggest that relatively few bears in Canada (southern Beaufort Sea) would encounter oil if a major spill occurred from existing operations, as climate change increases access to the polar basin we might anticipate increased risks to bears with increased development in the Canadian Arctic Archipelago. Concerns remain very high today about the current and potential impact of offshore oil and gas exploration and development on polar bears and their habitat. Polar bears are top predators, at the top of the food chain, making them susceptible to bioaccumulation of pollutants. Polar bears are attracted to and may consume foreign substances (e.g. petroleum products or ethylene glycol [antifreeze]) that can be harmful or cause death. Factors such as pollution and the accumulation of	L	H	S	LT F	M	L	**Med**

	environmental contaminants (mainly organochlorines) in tissues of polar bears are not likely to be a current limiting factor for polar bear populations, but new studies indicate that sub-clinical impacts on the health of individuals may over time have cumulative effects on whole populations through lowered immune systems and reproduction rates. In recent years, significant levels of various contaminants (organochlorines and other persistent organic pollutants) have been documented in polar bear tissues or tissues of their prey, particularly adipose tissue. Effects of various compounds in the tissues of polar bears or of the seals they feed on remains largely unknown and there has been little demonstration of demographic effects from contaminants on polar bears. Greater time spent ashore (associated with climate change) may actually reduce the risks to polar bears of pollutants (e.g. PCBs, organochlorine pesticides, PBDEs), if geographic distribution is altered from a pelagic to a more coastal feeding niche.							
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)	Polar bears are a sensitive species with excellent senses. Disturbances from increased development (sound, smoke, etc.) will scare bears away and impact their migration. Harvesters and elders from numerous communities have discussed how disturbances such as hunting, helicopters, gunfire, or other startling occurrences	L	U	C	LT F	M	L	**Low**

	can 'spook' bears. 'Spooked bears' are jumpy, are ineffective hunters and eventually suffer from starvation. However, it has also been noted that polar bears are curious and are capable of habituation in cases where food rewards still exist. Olokhaktomiut are concerned that shipping noise will disturb denning bears.							
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Intensifying effects of climate change have been observed on the weather, sea state, sea ice and snow since the 1980s. Changes in sea ice and associated snow cover affect light transmission and thermodynamic processes important to lower trophic levels of the Arctic marine ecosystem. These, in turn, combined with depth and kinematic or topographic characteristics of sea ice; influence the distribution of important food species such as ringed and bearded seals. People from all communities have noticed a decline in the number and the size of pressure ridges – a key ice feature from which bears hunt seals. This is attributed to thinner ice and increased ice movement. There is no more multi-year ice anywhere in the southern Beaufort Sea along the coast of the YT and NWT, nor in Amundsen Gulf off the coast of Ulukhaktok. Knowledge holders from Tuktoyaktuk observed that multi-year ice had disappeared from the coastal area north of Tuktoyaktuk by about 2000. In the southwest Northern Beaufort Sea unit, bears are likely to have increasingly less access to ice year-round. In contrast, year-	W	H	C	N	H	L	**High**

	round availability of sea ice among NWT islands in the Arctic Archipelago appears to be somewhat less impacted by recent climatic trends. However, even Viscount Melville Sound has begun to experience unusual periods of low sea ice in September. The type of ice present in Viscount Melville Sound (multi-year vs. annual) may also be changing. Erosion is a potential concern for Southern Beaufort Sea polar bears because many pregnant bears may den on barrier islands and next to coastal banks where the terrain allows drifting snow to accumulate. Some coastal denning habitat may disappear in the future and this may result in a change in denning distribution. Polar bears in the lower latitude Beaufort Sea are currently showing signs of stress and decline, likely in response to climate change-related losses of sea ice habitat. The extended ice-free season in the lower-latitude Beaufort Sea is likely to have resulted in lower juvenile and adult survival, compared to the higher-latitude Beaufort Sea and Viscount Melville Sound areas. In the Southern Beaufort Sea subpopulation, the duration of time spent by bears onshore has also increased by over a month. While polar bears in some areas are observed to be diversifying their diet, associated with increasing time spent onshore, a few studies show that terrestrial foods do not appear to provide substantive nutritional resources for polar bears. While polar bears are adept at hunting and scavenging on land, there would likely be a decline in population before sufficient adaptation to new ranges/food species could be made. While ringed seal abundances are not well known throughout the NWT, it is notable that the species was recently assessed nationally as Special Concern, specifically due to changes in ice conditions in the Arctic. Conversely, some Inuvialuit believe that polar bears will adapt to climate change and changes in sea ice (change their diet, possibly live on the land).							

	Reductions in habitat availability are resulting in increased competition, which is reflected in declining body condition and reproduction of females in the southern Beaufort Sea. There is also evidence from bears in the southern Beaufort Sea that the frequency of long-distance swims may be increasing, leading to concerns about the effects of this behaviour on body condition and survival. The best available evidence suggests that the NWT will most likely have fewer polar bears after three generations than there may exist today. However, there is no quantitative, direct data from western science to inform us about the magnitude of any potential decline. Polar bears in the low-latitude Beaufort Sea, where divergent sea ice conditions exist, appear to be most at risk from periods of low ice coverage. Where climate warming eliminates annual winter sea ice or substantially increases the open water season from maximum periods associated with areas of current occupancy by polar bears, the species is not expected to persist. It is also possible that changing conditions of the higher-latitude Beaufort Sea (and possibly also Viscount Melville Sound) may have benefitted polar bears, which prefer less heavy sea ice than has historically occurred in this region (for feeding on seals). Likewise, if climate change increases prey diversity in some areas, where it is presently low, this could be important. This might apply to polar bears at the extreme northern edge of the species' range, where historically low primary productivity and heavy, multi-year ice limits densities of and access to ringed seals, but these are also small populations that are inherently vulnerable in nature.							
11.2 Droughts								**N/A**
11.3 Temperature extremes	Heat extremes are projected to increase throughout the NWT though will remain relatively rare in the Arctic. Polar bears are adapted to an extreme and variable climate, but physiological	L	U	S	LT F	M	L	**Low**

	tolerances are not defined (Lee pers. comm. 2020).							
11.4 Storms and flooding	Increasing storm frequency and intensity may further decrease sea ice (Graham et al. 2019, Government of Canada 2019).	L	U	S	LT F	M	L	**Low**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Red Knot (*Calidris canutus - rufa* and *islandica* subspecies)
Populations (if applicable):
Percentage of North American population NWT is responsible for: The breeding range of *rufa* is entirely within the central parts of the Canadian Arctic, while about 40% of the breeding population of *islandica* is in the northeastern Canadian Arctic.
NWT General Status Ranks: At Risk
NatureServe Conservation Rank (NWT): S1S2B
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Endangered (*rufa*) and Special Concern (*islandica*)
Reasons for assessment or population trends: *Rufa* – As of its 2007 assessment, the subspecies had shown a 70% decline in abundance over the past three generations (15 years). It is threatened by a depletion of horseshoe crab eggs, a critical food source used during northern migration. There is no potential for rescue from other populations. *Islandica* – This subspecies has declined by 17% over the last three generations (15 years), as of its 2007 assessment. There are (as of 2007) no identified threats to individuals in Canada. Habitat on the Canadian breeding grounds is likely stable, but shellfish harvesting on the wintering grounds in Europe presents an ongoing threat.
Sources used for assessments: COSEWIC (2007b), NRCan (n.d.)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale	
Sensitivity[266] = 3.5 (*rufa*)		Sensitivity = 3 (*islandica*)	
Dependence on habitats that are sensitive to climate change[267]	In the Arctic, red knots nest on relatively barren habitats such as windswept ridges, slopes, or plateaus, often with less than 5% vegetation. Nest sites are usually located in dry, south-facing areas and may be located near wetlands or lake edges, where the young are led after hatching. Foraging habitats can be considerable distances (up to 10 km) from the nest and are usually in damp or barren areas. On migration and wintering areas, red knots use coastal areas with extensive sandflats (sometimes mudflats), where the birds feed on bivalves and other benthic invertebrates. They are also known to	4 – Depends on sensitive habitats that are rare (*rufa*).	3 – Depends on sensitive habitats that are not rare (*islandica*).

[266] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.
[267] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	use peat banks, salt marshes, brackish lagoons, mangrove areas, mussel beds and in South America, *restingas*, which are rocky intertidal platforms with a rich invertebrate fauna. *Rufa* - During spring migration in Delaware Bay, red knots forage on sandy beaches used by nesting horseshoe crabs. They may on occasion also forage on tide wrack on beaches. An important aspect of habitat quality for red knots is the proximity of suitable roosting areas that provide an undisturbed area safe from predators. Major concerns include changes in habitat, especially long-term reductions in high Arctic habitats and uncoupling of phenology of food resources and breeding events. As the southern extent of the high Arctic zone is expected to shift northwards, red knots, as high Arctic breeders, are likely to be among the species most affected. This would particularly be the case for populations breeding towards the southern part of the high Arctic zone, such as *rufa* breeding in the central Canadian Arctic. Potential losses of intertidal habitats owing to sea level rise was projected to range between 20-70% during the next century at five major sites in the United States, including Delaware Bay. While detailed effects are difficult to predict, the scale of the projected losses cast serious doubts on the ability of the sites to continue supporting current numbers of shorebirds, indicating increased potential for future stress on red knot populations. Fidelity to wintering, migration and breeding grounds makes habitat changes related to climate change particularly concerning. It is difficult to predict whether they would adapt readily to new or different areas under changing environmental conditions, even if such areas were available.		
Sensitivity to climate-relevant abiotic factors[268]	None noted.	Unknown.	

[268] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

Sensitivity to climate-relevant biotic factors[269]	Uncoupling of phenology of food resources and breeding events, such as a mismatch between peak invertebrate abundance and chick hatch, is a concern. Failure to accumulate the needed stores and to undergo the series of physiological transformations before migration and before breeding may have severe survival consequences.	3 – Likely very sensitive.
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	The only known threat in the NWT is from climate change.	1 – No pressures.
Adaptive capacity[270] = 1 plus 0.5 for low genetic diversity = 1.5		
Reproductive capacity[271]	Monogamous, with pairs usually laying a single clutch of four eggs. Egg laying occurs after a period of physiological reorganization, with eggs being formed from local food resources rather than from body stores brought from elsewhere during migration. Red knots generally start breeding at age two. Only one clutch is normally laid per year. Breeding success varies considerably from year to year, depending on weather and the abundance of predators. Densities on the breeding grounds are usually low (<1/km^2). The oldest recorded Red Knot was 25 years old (*islandica*). The potential lifespan is therefore considerable, but most live much shorter lives (likely seven to eight years). Generation time, four to five years. Many specializations in life history and physiology, such as low fecundity (≤4 eggs, high nest failure, one brood/year) and delayed maturity – appear to make them vulnerable to rapid environmental change.	1 = Early reproduction/many offspring
Dispersal capacity[272]	*Rufa* – Migrates thousands of kilometers between its Arctic breeding grounds and wintering areas at	1 - >10km.

[269] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).
[270] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[271] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.

	the tip of South America. *Islandica* – Migrates to wintering grounds in Europe. Territories are large, with nests widely separated (0.75-1 km apart). Although territories are defended from other conspecifics, off-duty birds tend to feed away from their territory in communal feeding areas. Knots often return to the same general breeding area from year to year, though little is known concerning site fidelity. The young leave the nest within 24 hours and within a day or two, the brood wanders over large distances (several kilometers or more).	
Genetic diversity	Knots have very low genetic variability and it is not known if this may imply reduced behavioural plasticity and a greater susceptibility to environmental perturbations. However, as there are multiple subspecies, it may be more accurate to note low variability within disparate populations (Woodard pers. comm. 2020).	0.5
Phenotypic plasticity		N/A

[272] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling								**N/A**
3.2 Mining and quarrying	Barging has been proposed in connection with diamond mining developments near Attawapiskat on the west coast of James Bay, which could affect the river mouth habitats.							**N/A**

3.3 Renewable energy	Tidal power development in the Bay of Fundy could have a major impact on important shorebird migration areas.							**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads								**N/A**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	Human hunting of shorebirds, including knots, may occur in some areas, including Caribbean islands and north-central Brazil. Although this practice is thought to have decreased greatly in the latter area over the past decade, harvest in South America is still quite significant for many species (Woodard pers. comm. 2020).							**N/A**
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources	The single largest threat to the *rufa* subspecies is the over exploitation of horseshoe crabs in Delaware Bay, leading to a significant reduction in numbers of horseshoe crab eggs, the single-most important food source utilized by red knots during spring migration. The result is that the birds are unable to attain adequate departure masses before the flight to their Arctic breeding grounds, at least in some years. Failure to attain the required stores before migration can have severe fitness consequences. Although protective measures have been introduced for knots in Delaware Bay, including reductions in the horseshoe crab harvest and protection from disturbance, initial results suggest that there has not been a noticeable recovery in the crab populations and hence egg availability. Given that horseshoe crabs do not attain sexual maturity until eight to nine years of age, it would appear that a							**N/A**

	recovery of the food resource would be unlikely in the near future and could be difficult. Drastic reductions in crab numbers have also been reported in other areas (e.g. Cape Cod). The widespread reductions in horseshoe crabs suggest that alternate suitable spring staging areas are much less available than before. Furthermore, there is some doubt that alternative food resources may be able to replace the loss of horseshoe crab eggs. Although knots generally feed on bivalves and other intertidal invertebrates during migration and winter, invertebrates in many Atlantic coast habitats may not, unlike horseshoe crab eggs, supply the energetic needs of knots on spring migration. Overfishing of shellfish on major wintering areas in the Dutch Wadden Sea has affected *islandica* wintering in Europe. Mechanical dredging has also resulted in declines in food availability.							
6. Human intrusion and disturbance								
6.1 Recreational activities	Numerous studies have shown that repeated disturbance can negatively affect shorebirds, disrupting behaviour patterns and affecting their energy balance. Although disturbance was initially a significant problem for shorebirds in Delaware Bay during spring migration, closure of major sections of the New Jersey shore since 2003 to human use at the peak of migration has successfully reduced disturbance. In other parts of the range, disturbance can be a significant factor. Disturbance of roosting and feeding flocks by humans and dogs has been reported from Florida, Georgia, North Carolina, South Carolina, Virginia and Massachusetts. On the wintering grounds in Tierra del Fuego, roosting flocks at Rio Grande are frequently disturbed by walkers, runners, fishers, dogs, ATVs and motor cycles. In Argentina, disturbance of birds during migration has been reported from Rio Gallegos, Peninsula Valdes, San Antonio Oeste and Bahia Samborombon.							**N/A**

6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression								**N/A**
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications	Extensive wetland losses in the United States have included the disappearance of almost half of the marshes extant in 1900 along the Atlantic and Gulf coasts. Loss rates in the North and mid-Atlantic regions were high up to 1978 though have declined dramatically since protective legislation has been passed. Nevertheless, it is clear that a large portion of the previously available habitat has been altered or destroyed. This suggests that knots faced with a significant reduction of food resources in Delaware Bay now have fewer available alternative habitats, potentially limiting population recover.							**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases								**N/A**
8.2 Problematic native species/diseases	In the migration and wintering areas, the increase of raptor populations over the past several decades has affected the behaviour of small shorebirds and it is possible that knots are also being affected.							**N/A**
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases								**N/A**

of unknown origin								
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents	Extensive oil developments, with onshore and offshore wells, occur near major wintering areas of *rufa* knots in both the Chilean and Argentinean sectors of Tierra del Fuegoand represent a considerable potential for disaster. Two oil spills from shipping have been recorded near the Strait of Magellan First Narrows and small amounts of oil have been noted on knots captured during banding operations in Bahia Lomas. Over the past eight to ten years, oil operations have been decreasing in Chile near Bahia Lomas and increasing on the Atlantic coast of Tierra del Fuego. The important migration stopover area at San Antonio Oeste, Argentina, also faces potential pollution from a soda ash factory (which could release up to 250,000 tons or more of calcium chloride per year, affecting intertidal invertebrate food supplies) and from port activities (e.g. pollution from shipping). In North America, important estuarine areas such as Delaware Bay and the Gulf of St. Lawrence are at risk from pollution and shipping incidents. The Mingan Islands, in the St. Lawrence, are particularly at risk because large ships carrying titanium and iron navigate through the archipelago to the Havre-St-Pierre harbour throughout the year.							**N/A**
9.3 Agricultural and forestry effluents								**N/A**

(including erosion)								
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Long-term changes resulting from climate change in the Canadian Arctic are likely to affect knots, probably in a negative fashion. The Arctic is one of the regions most likely to be affected by climate change. Major concerns include changes in habitat, especially long-term reductions in high Arctic habitats and uncoupling of phenology of food resources and breeding events. As the high Arctic zone is expected to shift northwards, red knots, as high Arctic breeders, are likely to be among the species most affected. This would be particularly the case for populations breeding towards the southern part of the high Arctic zone, such as *rufa* breeding in the central Canadian Arctic. Potential loss of intertidal habitats owing to sea level rise was projected to range between 20-70% during the next century at five major sites in the US, including Delaware Bay. While detailed effects are difficult to predict, the scale of the losses cast serious doubts on the ability of the sites to continue supporting current numbers of	W	M (i), H (r)	S	ST F-LT F	M-H	M	**Medium (*islandica*), High (*rufa*)**

	shorebirds, indicating increased future stress on knot populations.							
11.2 Droughts								**N/A**
11.3 Temperature extremes								**N/A**
11.4 Storms and flooding	There has recently been a significant increase in the number and strength of hurricanes globally, including those occurring in the North Atlantic region at times and in areas used by knots. Whether knots have actually been affected is not known, but the increasing number of severe weather events during their southward migration across the North Atlantic represents an increased risk, which is likely to increase with predictions of global warming and increasing ocean temperatures. Hurricanes have also recently been recorded in the southern Atlantic Ocean. The Climate Moisture Index projected for the Arctic coast appears to be moist and wet for the coast along the northern Atlantic Ocean. This could potentially impact nesting sites that require dry habitats (NRCan n.d.).	L	U	S	LTF	M	L	**Low**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Red-necked Phalarope (*Phalaropus lobatus*)
Populations (if applicable):
Percentage of North American population NWT is responsible for: In Canada, the species breeds or migrates through every province and territory.
NWT General Status Ranks: Sensitive
NatureServe Conservation Rank (NWT): S1S3
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Special Concern
Reasons for assessment or population trends: This bird has declined over the last 40 years in an important staging area; however, overall population trends during the last three generations are unknown. The species faces potential threats on its breeding grounds including habitat degradation associated with climate change. It is also susceptible to pollutants and oil exposure on migration and during the winter. This is because birds gather in larger numbers on the ocean, especially where currents concentrate pollutants.
Sources used for assessments: COSEWIC (2014b)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[273] = 2.7		
Dependence on habitats that are sensitive to climate change[274]	While migrating and during the winter months, this bird concentrates at sea in areas where prey is forced to the surface (e.g. convergences and upwellings). To a lesser extent, migrants may also stop at lakes and ponds in interior North America, especially saline lakes with abundant aquatic invertebrates. Red-necked phalaropes breed in low- and subarctic wetlands, near freshwater ponds, lakes, or streams. The drying of freshwater ponds and the expansion of shrubs and trees into low- and subarctic wetland habitats, with a changing climate, is expected to have a significant impact on habitat quality and availability for the species. A change in climate and associated habitat and food-web effects is likely the single greatest threat to red-necked phalaropes on their breeding grounds.	3 – Depends on sensitive habitats that are not rare.

[273] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.
[274] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

Sensitivity to climate-relevant abiotic factors[275]	Red-necked phalaropes exhibit a strong affinity for water. Most foraging and social interactions take place in aquatic habitats. Aquatic habitats are also crucial for chicks that must undergo rapid weight gain in preparation for fall migration. Other information on physiological requirements is largely lacking.	3 – Likely very sensitive.
Sensitivity to climate-relevant biotic factors[276]	While at sea, red-necked phalaropes form large flocks and prey almost exclusively on zooplankton. During the breeding season, red-necked phalaropes feed primarily on larval flies and fly eggs, beetles and spiders. Red-necked phalaropes are visual foragers, plucking prey from the water as they ramble or spin. Climate change on the breeding grounds could affect prey availability through changes in abundance, phenology and/or composition. Not only could birds be affected by a reduction in prey, but changes in climate may also cause a shift in arthropod emergence to earlier in the year resulting in a mismatch between the annual peak abundance of arthropods and the hatch of shorebird chicks. Red-necked phalaropes may not be able to shift their breeding phenology to adapt to the new timing of arthropod emergence. These mismatch events are an important mechanism through which climate change might adversely affect reproductive success.	2 – Somewhat sensitive or possibly very sensitive.
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	The most severe threat to red-necked phalarope is likely climate change-related (i.e., changes to habitat and storm surges/flooding).	1 – No pressures.
Adaptive capacity[277] = 1.5		
Reproductive capacity[278]	Generation time estimated at four years. Both sexes nest as early as their first year. Although males will re-nest following predation early in the season,	1 – Early reproduction/many offspring

[275] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.
[276] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).
[277] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[278] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.

	sequential nesting following a successful clutch is not possible due to the short breeding season. Females, on the other hand, are sequentially polyandrous and seek other mates and lay additional clutches where possible. Nest success varies by site and year (18-76%). Longevity is unknown, although may be ten years. Survival rates are likely comparable to those of other shorebirds. Clutch size is typically four eggs.	
Dispersal capacity[279]	Long-distance migrant, travelling 6,000 km from wintering to breeding grounds. Unlike most other shorebirds, red-necked phalaropes do not defend territories. Chicks are precocial and generally leave the nest within a day of hatching. During this time, the male continues to brood and rarely travels farther than 10 m from his chicks. Little is known about red-necked phalarope dispersal. The highest site fidelity reported for phalaropes is from a breeding site in Iceland, with a 100% return rate to the same area in consecutive years.	2 – 1-10km
Genetic diversity		N/A
Phenotypic plasticity		N/A

[279] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	**Overall level of concern**
1. Residential and commercial development								
1.1 Housing and urban areas	One study summarized an account of 'untold thousands of red-necked phalaropes colliding with brilliantly lit casinos in downtown Reno, NV. Additional accounts include birds attracted to lit stadiums (Florida) and a lighthouse (NY). Reports such as this are rare, with uncertain population-level impacts.							**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**

3. Energy production and mining								
3.1 Oil and gas drilling	Industrial activities, in particular oil and gas exploration and mineral extraction, are becoming increasingly common in the north.							**Neg.**
3.2 Mining and quarrying	Habitat alteration caused by development in the north could also contribute to a decrease in suitable habitat. The cumulative impact of various local perturbations to habitat could have substantial consequences, particularly in the face of landscape-scale habitat trends. Some forms of development, such as mines, airstrips and outfitter camps effectively remove natural habitat, whereas other forms of development, including exploration activities and seismic surveys can alter the vegetative structure. Because of the sensitivity of permafrost soils and slow-growing nature of tundra vegetation, seemingly minor impacts to soil and vegetation can persist for decades. Other forms of development may have a null impact on the species, or could even be beneficial. Chaplin Lake, SK, is an important stop-over site. Chaplin is a saline lake that is actively mined for sodium sulfate. This activity maintains consistent water levels across years that effectively protects shorebird habitat in a system that is otherwise quite variable.	L	U	S	N	H	L	**Low**
3.3 Renewable energy								**Neg.**
4. Transportation and service corridors								
4.1 Roads and railroads	Indirect impacts such as road dust may also impact the species, but no reductions in density were seen in the vicinity of Ekati, where effects of dust on habitat have been observed.							**Neg.**
4.2 Utility and service lines	In the Mackenzie Delta, seismic lines have a density of 6 km/km^2, the greatest anywhere in the Canadian north. One study found a non-significant tendency for red-necked phalaropes to be less							**Neg.**

	abundant along seismic lines (average 0.27 birds/transect) than along reference lines (average 0.67 birds/transect) in suitable habitat in the Kendall Island Bird Sanctuary, suggesting the possibility of adverse effects of seismic exploration on bird abundance. While habitat removal or degradation can have clear detrimental effects at a local scale, the range-wide effects are unlikely to be pronounced given the limited footprint of development within the range of the species.							
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals								**N/A**
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression								**N/A**
7.2 Dams and								**N/A**

water management/use								
7.3 Other ecosystem modifications	Threats to migrating phalaropes may include declines in prey availability. Some possible explanations for the change in prey abundance include: increased disturbance (e.g. rise in shipping traffic), increased consumption of *C. finmarchicus* by fish (e.g. salmon aquaculture) and/or changes in water quality (e.g. increased levels of pesticide run-off). A decrease in the intensity of sunlight reaching the water's surface, possibly caused by changes in fog, may also be having an impact. Alternatively, changes in biological or physical oceanography (e.g. changing ocean currents, salinity and temperature due to climate change) and/or changes to *C. finmarchicus* phenology may make them unavailable to foraging phalaropes.							**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases								**N/A**
8.2 Problematic native species/diseases	Overabundant geese, especially the midcontinent lesser snow goose and to a lesser extent the Ross's goose, are agents of profound habitat change in some localized areas of the north. Through repeated overgrazing of graminoid forage plants and grubbing of the below-ground parts, geese are fostering a shift towards habitats with more exposed substrate and reduced vegetative concealment. As a result, once densely vegetated sedge meadows have become denuded. This habitat alteration could be detrimental to shorebirds by, for example, reducing the vegetative concealment of nests, but studies have shown mixed effects. Aside from the loss of suitable nesting sites, the composition of prey and the structure of ponds are also likely impacted by the foraging behaviour of snow geese, with potential adverse effects on breeding red-necked phalaropes and their young that depend on freshwater ponds to forage. Comprehensive studies to evaluate the impacts are lacking. Within							**Neg.**

	the range of red-necked phalaropes, habitat degradation caused by geese is known to be pronounced along the west coasts of Hudson and James Bay, in the Queen Maud Gulf Bird Sanctuary and across much of Southampton Island.							
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents	Like other birds that spend all or part of their life cycle at sea, red-necked phalaropes are vulnerable to oiling. When exposed to oil, feathers become matted, wet and lose their insulative value. In an attempt to clean their feathers, birds preen themselves, further spreading and ingesting oil. As such, even a slight exposure to oil can increase mortality risk through hypothermia and organ damage. Furthermore, oil in the environment can indirectly impact birds at sea through contamination of prey. Red-necked phalaropes gather in large numbers at sea, with hundreds of thousands aggregating in small areas. As such, point-source oil contamination from a marine spill could have catastrophic effects on the species. Chronic oiling, caused by minor events such as leakage from boats, runoff from streets and parking lots and natural seeps, may also be detrimental to phalaropes. The cumulative impact of chronic oiling may be similar to that of a small-scale oil spill. Phalaropes may be particularly susceptible to oiling because they tend to forage in the same area where oil accumulates; along fronts, in tidal rips and							**N/A**

	eddies. In general, minor oiling events appear to be in decline; however, recent findings indicate that there is a relatively high level of hazard from oiling in a portion of the lower Bay of Fundy that encompasses some stopover locations. There may also be indirect impacts of oil spills on red-necked phalaropes through alteration of habitat. *Sargassum* mats, used by foraging red-necked phalaropes at sea, can be damaged by oil spills. This could be particularly troubling in areas (e.g. off the coast of California) where red-necked phalaropes are considered *sargassum* specialists. Birds travelling inland may be susceptible to oiling at tailings ponds, particularly those lacking bird deterrents. Although there is no documentation of red-necked phalaropes using tailings ponds, impacts are possible, as has been documented for other species of shorebirds. Risks are likely greatest during inclement weather.							
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste	There is evidence of plastic ingestion by red-necked phalaropes. Microplastics (width <5 mm) are the largest increasing class of plastics in the marine environment and so it is possible that rates of plastic ingestion may be higher today. We do not know though whether there are patterns to plastic ingestion or how plastic is impacting phalarope health and survival (e.g. through blockages, starvation and absorption of contaminants).							**N/A**
9.5 Airborne pollutants	Many contaminants travel over long distances and become concentrated in the north. In the NWT, mercury contamination in freshwater systems is on the rise, with the greatest increases in smaller waterbodies. One study found that the levels of mercury in	W	U	C	N	H	L	**Low**

	the blood of three species of Arctic-nesting shorebirds (ruddy turnstone, black-bellied plover and semipalmated plover) were approaching thresholds associated with toxicological effects in other birds. In particular, the study found that blood mercury was as much as ten times higher than that of samples from sites with more direct pollution input. The authors found a weak negative relationship between mercury and lead levels in tissue and reproductive success. There is also evidence of DDT and PCBs accumulating in Arctic-nesting shorebirds. Foraging strategy may be partly responsible for observed variation in contaminant levels detected in a suite of shorebirds, with surface feeders being more at risk than others among the species studied (which did not include red-necked phalaropes). However, it is unknown to what degree contaminants threaten the species. With Arctic shorebirds spending the majority of their lives south of their breeding grounds, the source of contaminants is also uncertain.							
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	A change in climate and associated habitat and food-web effects is likely the single greatest threat to red-necked phalaropes on their breeding grounds. The general increase in global temperature observed since about 1880 has been and will continue to be most extreme at high latitudes. Already, observations of freshwater lakes indicate that many are shrinking, drying earlier in the season, or disappearing altogether (Siberia, subarctic Alaska). The shallow	W	M	C	N	M	L	**Medium**

	wetlands preferred by phalaropes are susceptible to small changes in water levels and could be lost as permafrost recedes with rising temperatures. Alongside changes to freshwater lakes and wetlands, many researchers predict a northward shift in the tree line and expansion of shrub habitat into northern latitudes. To date, the shrub line is not only advancing, but sparse shrubs are experiencing improved growth and infilling resulting in denser and larger areas of shrubby habitat. In some areas of the Alaskan Arctic, shrub cover has already increased as much as twofold. The conversion of grass-sedge wetland into habitats dominated by shrubs or even trees would result in a reduction in the total amount of available breeding habitats. Conversely, there is also the potential for a lengthened breeding season in a milder Arctic. Changes in ocean temperature, salinity and currents due to climate change are also likely to affect the species during the non-breeding season. A decline in the availability of prey at traditional staging areas and over-wintering sites could also have an impact on the species.							
11.2 Droughts	Some parts of the range may experience increasingly dry conditions, while others remain moist. Alterations such as these to aquatic habitats could negatively impact prey and social interactions.	L	U	S	LT F	M	L	**Low**
11.3 Temperature extremes								**N/A**
11.4 Storms and flooding	Significant amounts of habitat could be lost to inundation by seawater. Thawing of perennial sea ice, coupled with the melting of glaciers, is predicted to result in rising sea levels and flooding of substantial areas of low-lying coastal tundra. In 2012, sea ice cover in the Arctic reached an all-time low. Concurrent with melting sea ice, models project increasing intensity and severity of storm surges and these surges can push sea water well inland. In the short term, even minor flooding can lead to widespread reproductive	L	M	C	N	M	M	**Med.**

	failure (as observed in the Mackenzie Delta in 2006). In the longer term, this salinization can adversely affect habitats.							
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Rusty Blackbird (*Euphagus carolinus*)
Populations (if applicable):
Percentage of North American population NWT is responsible for: 85% of breeding range in Canada. The NWT and NU have approximately 4% of the Canadian population of rusty blackbirds.
NWT General Status Ranks: Sensitive
NatureServe Conservation Rank (NWT): S3B
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Special Concern
Reasons for assessment or population trends: Factors that threaten the persistence of this species in Canada have not been reversed or effectively managed since it was assessed as Special Concern in 2006. This species experienced steep population declines through the 20th century, which may have stabilized recently. This may only be a temporary reprieve, as many important threats contributing to these declines have not been corrected, particularly on the United States wintering range. These problems include loss and degradation of wintering habitat due to wetland conversion and dam construction, blackbird control programs in agricultural areas and impacts from the use of agricultural pesticides. Continuing threats on Canadian breeding grounds include mercury contamination and degradation of wetland habitat due to warming, acidification and drying climates.
Sources used for assessments: COSEWIC status report (2017b), Government of Canada (2020)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[280] = 2.5		
Dependence on habitats that are sensitive to climate change[281]	Breeding range in Canada is almost entirely within the boreal forest. It is predicted that climate change in the boreal region will result in a substantial increase in mean annual temperatures by 2100, which will have negative impacts on the rusty blackbird, including a contraction of its breeding range. The probability of local extirpation is likely greatest in the southern portion of the species' breeding range and the southern boundary of the rusty blackbird's breeding range has	3 – Depends on sensitive habitats that are not rare.

[280] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.
[281] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	contracted northward by about 143 km since 1966. Range contraction may be less significant in the Canadian northwest, particularly along the Mackenzie River valley, where occupancy of wetlands monitored in the early 1970s and in 2006 has remained the same. Several climate modeling scenarios based on change in the climate envelope and existing distribution of habitat predict a 64-90% reduction in core habitat for rusty blackbirds by the year 2100. One study incorporated climatic data and point count data for 80 Canadian boreal-breeding bird species across Canada, to model potential population impacts of climate change. According to their models, the projected future decline in the abundance of the rusty blackbird could be 55% by the year 2100. The rusty blackbird appears to use habitats created by natural disturbances that occur frequently and on large spatial scales, including floods, insect outbreaks and forest fires. Rusty blackbirds forage in shallow water, where they probe for aquatic prey in leaf litter. It is strongly suspected that the area of shallow water (≤6 cm deep) is an important driver of habitat selection. Shallow water unconnected to flowing tributaries often teems with prey items, presumably because of a lack of predatory fish and evaporation by seasonal drying.	
Sensitivity to climate-relevant abiotic factors[282]	Precipitation may affect interannual variations in the distribution of the rusty blackbird in the Mississippi Valley. No other information on physiological limits was noted.	Not known
Sensitivity to climate-relevant biotic factors[283]	Between 2000 and 2009, the total area of shallow ponds and boreal lakes in Canada decreased by 6,700 km^2. This reduction in boreal wetlands is due in part to permafrost melting caused by increases in temperature. This drying of boreal wetlands is causing changes in communities of aquatic invertebrates, which could include a reduction in the biomass of food resources important to rusty blackbirds, such as snails, amphipods and chironomid larvae. It has also been hypothesized that climate change and the drying of	2 – Somewhat sensitive or possibly very sensitive.

[282] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.
[283] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

	wetlands in the boreal forest could shift the timing of emergence of insect prey, particularly odonates, out of phase with the phenology of breeding rusty blackbirds. Monitoring in Quebec suggests that the species follows a five-year abundance cycle in the boreal forest. This cycle appears to be positively correlated with the North Atlantic Oscillation. Creation of wetlands by beavers is known to influence invertebrate community structure by replacing fast running-water taxa such as dragonflies, one of the main prey items consumed by rusty blackbirds. Beaver presence may increase the probability of rusty blackbird occupancy. Beavers create both foraging and nesting habitat for rusty blackbirds by selectively removing hardwoods, which increases light gaps and encourages growth of trees such as spruces. Beavers may also increase the density of coarse particulate organic matter and the biomass of invertebrates by two to five times, including four of their main prey items: dragonflies, damselflies, caddis flies and snails. Given the recent predictions of warming and drying trends for boreal regions, beavers will likely play an important role in maintaining open water and mitigating the impact of drought. Acorns may be consumed, but they must have had their husks removed by squirrels, or larger birds such as Common Grackle or Blue Jay. Pecans may also be eaten and may be helpful when wetland invertebrates are less available in the wintering grounds. However, they must first be crushed, for example by cars, people, or deer. On its migration routes and wintering areas, the rusty blackbird regularly joins mixed flocks composed of other blackbirds, such as red-winged blackbirds, European starlings and common grackles. The formation of mixed groups is believed to reduce the risk of predation to individual birds.	
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	The only significant threat to rusty blackbirds in the NWT is climate change and associated habitat effects.	1 – No pressures.

Adaptive capacity[284] = 1		
Reproductive capacity[285]	Females lay three to seven eggs (average 4.5); usually monogamous. Produce one clutch/year, but replacement nests may be built if the first nest is destroyed. Generation time two to three years. There are no Canadian studies on nest survival, but in Alaska, it is generally high. This is much higher than nest success for other blackbird species. Adult survival is likely comparable to other North American songbirds. It is currently unclear why these relatively high survival rates do not translate into an increase in population. Maximum known lifespan was almost nine years. Age at first reproduction not noted.	1 – Early reproduction/many offspring
Dispersal capacity[286]	Migrant, average 4,400 km. Some evidence of breeding site fidelity. The same foraging sites appear to be regularly used by groups of rusty blackbirds within and between wintering seasons. There are not data available on natal dispersal.	1 - >10km.
Genetic diversity		N/A
Phenotypic plasticity		N/A

[284] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[285] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.
[286] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas	See 2.2.							**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops	On the breeding range, habitat loss is occurring at a slow but increasing rate in parts of Canada. For example, in the southern portion of the species' Canadian breeding range, large areas of wetlands have been converted for agricultural and industrial operations. In total, breeding habitat in Canada is believed to have decreased by 5% since European settlement and a further reduction of 4% by 2050 is projected. It is estimated that 73% of the boreal transition zone in Saskatchewan has been converted to agricultural land since European settlement. Similar levels of habitat change are reported for AB. Habitat loss of wetland forests in the United States has been significant, particularly between 1970 and 1990, owing to the conversion to agricultural land for the production of soybeans, when that crop became highly profitable. In the late-1980s, when soybean prices fell below the threshold for profitability,							**N/A**

	reforestation efforts were undertaken in the southeastern United States and it is estimated that 162,000 ha of unprofitable agricultural land was converted back to forested wetland habitats between 1990 and 2005. At the same time, carbon sequestration programs were introduced, which also encouraged the restoration of large areas of forested wetlands in the southeastern US.							
2.2 Wood and pulp plantations	Conversion of wetland forests in wintering areas in the southern US is considered one of the most significant factors in the decline of this species. Forested wetlands have been converted to pine plantations and residential development. It is estimated that between 1780 and 1980, approximately 57% of wetlands in rusty blackbird wintering grounds were lost in the Mississippi Lowlands, while in the South Atlantic Coastal Plain, wetland loss was 36%. Wetland loss in the southeastern US between 1950 and 1980 owing to conversion to agricultural land or plantation forests was estimated at 1.3 million ha and is recognized as a significant factor in the decline of the rusty blackbird.							**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling	It is estimated that, as of 2003, 8% of the boreal forest biome in Canada has been affected to a fairly significant degree. The drainage and pumping of enormous quantities of freshwater from groundwater and surface water reserves for the purposes of oil and gas extraction can also affect rusty blackbird habitat.							**Neg.**
3.2 Mining and quarrying								**N/A**
3.3 Renewable								**N/A**

energy								
4. Transportation and service corridors								
4.1 Roads and railroads								**N/A**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	Bird control programs designed to reduce populations of 'nuisance' blackbirds that damage crops are a cause of mortality for overwintering populations of rusty blackbirds in the eastern United States. Between 1974-1992, Red-winged Blackbird and European starling control programs using PA-14 avian stressing agent at 83 roosts located in Kentucky, Tennessee and Alabama exterminated 38 million birds, including an estimated 120,000 rusty blackbirds. The period of use of this product, which has since been taken off the market, generally coincides with period of greatest decline of rusty blackbird populations. Migrating and wintering populations of rusty blackbirds could also be affected by bird control programs using DCR-1339, currently in use in the central and southeastern United States, particularly in sunflower and rice crops. In addition, the use of poison bait to control the presence of blackbirds in cattle feedlots in the US could adversely affect migrating and wintering rusty blackbirds.							**N/A**
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting	In New England, logging was identified as a threat to the rusty blackbird in one study. This study of 43 nests demonstrated that blackbirds that nested in wetlands with recent logging in the vicinity had 2.3 times greater probability of being preyed upon than those nesting in wetlands where there had been no logging in the							**N/A**

	past 20 years. However, another New England study demonstrated that rusty blackbird nest success was high in a managed forest landscape. It is therefore premature to conclude that logging has an overall negative impact on rusty blackbird breeding populations. Moreover, these two studies are not directly applicable to the different ecological context experienced by the rusty blackbird in the boreal forest of Canada.							
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities	Rusty blackbirds will frequent wetlands disturbed by human activities, sewage ponds in forest environments and banks of hydroelectric reservoirs, but breeding productivity in human-transformed habitats is unknown in Canada.							**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression	The rusty blackbird appears to use habitats created by natural disturbances that occur frequently and on large spatial scales, including floods, insect outbreaks and forest fires.							**Neg.**
7.2 Dams and water management/use	On its wintering sites, the rusty blackbird appears to be sensitive to changes in surface hydrology caused by activities that result in wetland drainage, stream diversion and water control and displacement of groundwater. Rusty blackbirds prefer wetlands that have water levels that fluctuate regularly; they are less commonly found in reservoirs that are flooded for long periods and have deep water. Industrial activities on the breeding and migratory grounds (e.g. oil sands development and hydroelectric projects) could also alter the hydrology in rusty blackbird habitat.							**N/A**

	One study estimated that more than 1 million ha of forested wetlands have been flooded in connection with the creation of hydroelectric reservoirs in northern Quebec.							
7.3 Other ecosystem modifications	Due to its close association with beaver ponds, rusty blackbird habitat might have been historically impacted by the large-scale loss of wetlands caused by commercial beaver harvesting activities, which drove that species almost to extinction across North America. Since the 1950s, beaver populations seem to have recovered well across Canada and this type of habitat for rusty blackbirds should therefore be increasing.							**Neg.**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases								**N/A**
8.2 Problematic native species/diseases	Recent analyses of blood samples of breeding adults from Alaska, Maine and on the wintering sites (Mississippi and Arkansas) reveal that prevalence of hematozoan infection (mainly Leucocytozoon) was 44% in Alaska and 67% in Maine. In winter, the overall prevalence was estimated at 49%, which is considered higher than the anticipated values for this period of the year, when parasite transmission is generally low. Although the parasites are not considered to be directly hazardous to the blackbirds' health, a high prevalence during winter suggests that rusty blackbirds may be stressed or have a compromised immune system. This could cause an increase in the impact of diseases and other, more harmful, parasitic infections. However, the extent to which this poses a bona fide threat versus a limiting factor is currently unknown.							**N/A**
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**

8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents								**N/A**
9.3 Agricultural and forestry effluents (including erosion)	The rusty blackbird migrates through and winters in heavily farmed areas, where it feeds on grains such as corn. A national analysis of the risk of bird mortality due to exposure to pesticides currently used in the United States indicated that the greatest number of bird kills likely occurs in the southeastern states, owing to the high proportion of farmlands there using pesticides. This region is in the center of the rusty blackbird wintering grounds. Between 1970-1980, the widespread use of granular carbofuran pesticides on row crops in the North American prairies resulted in an estimated annual loss of 17-91 million birds of various species in corn fields alone. Granular carbofuran formulations are no longer in use in Canada and the United States, but probably contributed to declines in rusty blackbird populations prior to their being taken off the market. DDT was used on a large scale, including in spruce budworm control programs in eastern Canada between 1952-1967. In Canada, an estimated 67 million ha of forest were treated with pesticides (mainly DDT) to control budworm outbreaks between 1952 and 1990, with the peak occurring in the mid-1970s. Even at low concentrations, DDT is very toxic to aquatic invertebrates, including larval odonates, on which rusty blackbirds mainly feed during the breeding period. Rusty blackbirds breeding throughout							**Neg.**

	the Canadian boreal forest could have been also affected by DDT, even in the northern part of the boreal forest where DDT was not historically used, due to DDT's tendency to enter the atmosphere through volatilization and contaminate food chains in areas far from the original source of emission. Studies have shown that forest soil that received DDT treatments may remain contaminated decades after treatment. DDT was also used extensively in the species' wintering range (especially in the Mississippi Valley) between 1947 and 1951 in order to eradicate malaria. Although DDT was banned in North America in the 1970s, it could have contributed to the species' decline. More recently, neonicotinoid insecticides were introduced in the 1990s. More than 11 million ha of agricultural lands have been treated with these insecticides in the Canadian prairies. These pesticides have been associated with the decline of several farmland bird species in Europe, owing to declines in the insect prey base that they cause. The effect of neonicotinoids on rusty blackbirds is unknown, but any effects would be expected to occur outside the breeding season.							
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants	The deposition of mercury by industrial activities and the release of methylmercury by permafrost melting in the boreal forest are a major source of contamination of aquatic environments in Canada. Exposure to mercury can reduce the reproductive success of birds by altering their immune response and can also cause behavioural and physiological impairments. Studies conducted in several parts of the rusty blackbird's range have found high mercury concentrations in the diet, due to the species' habit of feeding in acidic wetlands where mercury is readily converted to methylmercury, which is the more toxic form. Rusty blackbirds breeding in the boreal forest of Canada, Alaska and New England							**Neg.**

	also have significantly higher blood levels of mercury than birds wintering in the southern United States, suggesting that birds on the breeding grounds may be more subject to mercury exposure than wintering birds, owing to their stricter diets of insects during the breeding season. It is also believed that the rusty blackbird is negatively affected by acidification due to acid rain, particularly in the eastern part of its breeding range, potentially through loss of calcium and other minerals essential for eggshell and bone formation. Rusty blackbirds feed on snails and molluscs, which could make them sensitive to a lack of calcium in those food sources owing to acidification. Acidification also results in higher releases of mercury into wetland systems.							
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	It is predicted that climate change in the boreal region will result in a substantial increase in mean annual temperatures by 2100, which will have negative impacts on the rusty blackbird, including a contraction of its breeding range. The probability of local extirpation is likely greatest in the southern portion of the species' breeding range and the southern boundary of the rusty blackbird's breeding range has contracted northward by about 143 km since 1966. Range contraction may be less significant in the Canadian northwest, particularly along the Mackenzie River valley, where	W	M	C	N	M	L	**Medium**

	occupancy of wetlands monitored in the early 1970s and in 2006 has remained the same. However, with respect to breeding habitat, between 2000 and 2009, the total area of shallow ponds and boreal lakes in Canada decreased by 6700 km^2. This reduction in boreal wetlands is due in part to permafrost melting caused by increases in temperature. This drying of boreal wetlands is causing changes in communities of aquatic invertebrates, which could include a reduction in the biomass of food resources important to rusty blackbirds, such as snails, amphipods and chironomid larvae. It has also been hypothesized that climate change and the drying of wetlands in the boreal forest could shift the timing of emergence of insect prey, particularly odonates, out of phase with the phenology of breeding rusty blackbirds. Several climate modeling scenarios based on change in the climate envelope and existing distribution of habitat predict a 64-90% reduction in core habitat for rusty blackbirds by the year 2100. One study incorporated climatic data and point count data for 80 Canadian boreal-breeding bird species across Canada, to model potential population impacts of climate change. According to their models, the projected future decline in the abundance of the rusty blackbird could be 55% by the year 2100.							
11.2 Droughts	Some parts of the NWT may experience drought conditions (using the Climate Moisture Index). These conditions may negatively impact wetland habitat (Government of Canada 2020).	L	L	S	ST F	M	L	**Low**
11.3 Temperature extremes								**N/A**
11.4 Storms and flooding								**N/A**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Short-eared Owl (*Asio flammeus*)
Populations (if applicable):
Percentage of North American population NWT is responsible for: Short-eared owls have one of the largest ranges among owls.
NWT General Status Ranks: Sensitive
NatureServe Conservation Rank (NWT): SNRB
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Special Concern
Reasons for assessment or population trends: This owl has suffered a continuing population decline over the past 40 years, including a loss of 23% in the last decade alone. Habitat loss and degradation on its wintering grounds are most likely the major threat, while continuing habitat loss and degradation on its breeding grounds in southern Canada and pesticide use are secondary threats. This species nearly meets the criteria for Threatened status.
Sources used for assessments: COSEWIC status report (2008b)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[287] = 1		
Dependence on habitats that are sensitive to climate change[288]	Breed on many continents and on many islands. A wide variety of unforested habitats are used, including Arctic tundra, grasslands, sand-sage, fallow pastures and occasionally fields planted with row-crops. The species' ability to cue in on local food sources makes it relatively flexible in breeding and wintering habitat choice, with birds (often temporarily) settling into previously unused areas that support large small mammal populations.	1 – Broad generalist.
Sensitivity to climate-relevant abiotic factors[289]	None noted.	Unknown
Sensitivity to climate-relevant biotic factors[290]	Concentrations of short-eared owls occur during breeding and non-breeding at sites where rodent (typically *Microtus*) populations are high. However,	1 – Not sensitive.

[287] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.
[288] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.
[289] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

	short-eared owls also feed on a variety of other small mammals and sometimes birds. Clutch size is positively correlated with local food abundance.	
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	There are no known threats to short-eared owls in the NWT.	1 – No pressures.
Adaptive capacity[291] = 1		
Reproductive capacity[292]	Clutches of four to seven eggs. A single brood is typically raised, but a replacement clutch is laid if the first clutch is lost. Pre-fledging survival of nestlings is relatively high for a ground-nesting species, with most studies (four of seven) reporting over 50% fledging success. There is no information available on juvenile mortality post-fledging, or on adult survival rates. Generation time two years.	1 – Early reproduction/many offspring.
Dispersal capacity[293]	Nomadic species, wandering widely both seasonally and annually. Individuals on islands, however, appear to show higher philopatry to breeding sites.	1 - >10km.
Genetic diversity		N/A
Phenotypic plasticity		N/A

[290] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).
[291] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity or plasticity if known: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[292] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.
[293] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas	Habitat loss can occur as a result of urban expansion. Primarily a factor at coastal breeding and wintering areas.							**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas	Habitat loss can occur as a result of resort development. Primarily a factor at coastal breeding and wintering areas.							**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops	The primary form of habitat loss occurs when grasslands are converted to agricultural crops. They occasionally breed in agricultural fields, although their breeding success in such habitats is apparently low. Loss of native grasslands has been estimated at 39% throughout the range of the short-eared owl in Canadian prairie provinces between 1949-1986. The extensive loss of native grasslands throughout the central portions of the range have likely had a significant negative impact on short-eared owl abundance and population viability. Habitat conversion has probably been negligible in central and northern Canada. In areas where short-eared owls breed amid crop fields, mowing and harvesting of hay and grains can be a significant source of egg and nestling mortality.							**Neg.**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock	Grassland habitats also become unsuitable when heavily grazed by							**N/A**

farming and grazing	livestock. Widespread and intensive livestock grazing occurs over much of the remaining grasslands on the Canadian prairies and the United States Great Plains. Excessive livestock grazing is a direct threat to short-eared owl habitat, as relatively tall grasslands are typically preferred nesting areas. While programs aimed at reverting grasslands and agricultural fields to wildlife habitat have no doubt acted to increase the amount of foraging and roosting habitat available to short-eared owls, it is unclear how such programs may have affected breeding success.							
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling								**N/A**
3.2 Mining and quarrying								**N/A**
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads								**N/A**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	Although probably not a significant long-term factor in the species' decline, collisions with vehicles, barbed-wire fences and utility lines are known to contribute to (largely winter) mortality of adults.							**Neg.**
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and								**N/A**

wood harvesting								
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities	Habitat loss can occur as a result of recreational activities. Primarily a factor at coastal breeding and wintering areas.							**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression								**N/A**
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications								**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases	Although the extent to which West Nile virus is currently affecting short-eared owls is unknown, they are known to contract the virus.							**Neg.**
8.2 Problematic native species/diseases								**N/A**
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**

8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents								**N/A**
9.3 Agricultural and forestry effluents (including erosion)	Although elevated levels of DDE and heptachlor epoxide have been found in short-eared owl eggs, no negative effects on owl reproduction have been detected. The effects of toxic chemical on short-eared owl prey populations have not been studied.							**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration								**N/A**
11.2 Droughts								**N/A**
11.3 Temperature								**N/A**

extremes								
11.4 Storms and flooding								**N/A**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Shortjaw Cisco (*Coregonus zenithicus*)
Populations (if applicable):
Percentage of North American population NWT is responsible for:
NWT General Status Ranks: At Risk
NatureServe Conservation Rank (NWT): G3
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Threatened
Reasons for assessment or population trends: This species has been extirpated from lakes Huron and Erie and is in decline in Lake Superior and Great Slave Lake. It is still present in Lake Nipigon and numerous smaller lakes where its status is not well known. Threats include fishing, introduction of exotics and climate change.
Sources used for assessments: COSEWIC (2003), Cline et al. (2014)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[294] = 1.7		
Dependence on habitats that are sensitive to climate change[295]	In lakes Superior, Michigan and Huron, the shortjaw cisco generally inhabits waters 55-144 m in depth, although they have been recorded from as deep as 183 m and occasionally in more shallow water. Seasonal differences were noted in Lake Superior. In Lake Nipigon, shortjaw ciscoes inhabit depths of ten to 60 m, although the occasional individual has been captured deeper than 60 m. Habitat preferences in smaller lakes are poorly known.	1 – Broad generalist.
Sensitivity to climate-relevant abiotic factors[296]	Abiotic factors such as weather and thermal changes in the lakes have been suspected to play a role in population destabilization. Such destabilization can favour one species over another, resulting in competitive displacement or hybridization. In Lake Erie, profound ecological changes have occurred that have shifted the lake to a more mesotrophic condition, to the detriment of the deep water, oligotrophic community that historically existed there. Length of egg development depends on temperature.	2 – Somewhat sensitive or possibly very sensitive.

[294] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.
[295] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.
[296] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

Sensitivity to climate-relevant biotic factors[297]	Coregonines are opportunistic, particulate feeders that generally ingest prey one item at a time. Availability is important and seasonal prey such as insects show up in the diets of fish in small lakes. Because shortjaw ciscoes may live in the deeper parts of lakes, terrestrial input is limited and limnetic crustacean (copepods and cladocerans) and benthic organisms dominate their diets. Biological communities in the Great Lakes have become altered, however, there is no discussion linking this to climate. It is likely that the species became vulnerable to predation from sea lampreys in the Great Lakes as favoured individuals of larger species became depleted. Sea lamprey predation continues to take a toll on Great Lakes species and affects smaller species such as chubs in addition to larger species such as lake trout, burbot and lake whitefish. Sea lamprey predation also resulted in the extinction of nearly all lake trout and consequential ecological changes. Increased sea lamprey fecundity is expected under the effects of climate change (Cline et al. 2014).	2 – Somewhat sensitive or possibly very sensitive.
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	No significant non-climate stressors in the NWT, at this time.	1 – No pressures.
Adaptive capacity[298] = 2.5		
Reproductive capacity[299]	Fecundity is likely similar to that of other deep-water species such as the bloater, ranging from 3,230-18,768 eggs. Maturity occurs in about the fifth year. Generation time is five years.	3 – Late reproduction/many offspring
Dispersal capacity[300]	Not noted in status report; however, movement between lakes also not noted.	2 – 1-10km.
Genetic diversity	Exhibits morphological and genetic variability throughout its range. Presumably, its morphological	N/A

[297] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).
[298] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[299] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.
[300] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

	differences from the lake herring group of ciscoes 'adapt' it in some unique, but as yet unrevealed, manner to survival in northern aquatic ecosystems because of its persistence throughout the past millennia.	
Phenotypic plasticity		N/A

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	**Overall level of concern**
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling								**N/A**
3.2 Mining and quarrying								**N/A**
3.3 Renewable								**N/A**

energy								
4. Transportation and service corridors								
4.1 Roads and railroads								**N/A**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals								**N/A**
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources	Shortjaw ciscoes have been an important part of the food fishery in the Great Lakes since at least the mid-1800s. The species undoubtedly forms a portion of food-fishery captures in some of the larger lakes, such as Great Slave Lake, that have either assessment programs or fishery statistical officers, but, in the past, identification of such catches to individual species was apparently not done. The food fisheries had a negative impact earlier in the 1900s, especially on the larger individuals, at first, then on smaller individuals as mesh sizes were reduced to maintain catch levels. All species of deepwater ciscoes (chubs) in Lake Superior are managed by quota as a group. And, while exploitation in Lake Superior is not currently a threat with the absence of a commercial chub fishery, the quotas could protect the species if the fishery resumes. The lake whitefish fishery of Lake Nipigon takes some shortjaw ciscoes as by-catch, but this by-catch is not regulated by quota. Other							**Neg.**

	populations in Canada are not specifically protected and are not subject to fishery exploitation either.							
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression								**N/A**
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications	In Lake Erie, profound ecological changes have occurred that have shifted the lake to a more mesotrophic condition (although the lake has rebounded from eutrophy because of phosphorus controls and the effects of zebra mussels), to the detriment of the deep-water, more oligotrophic community that historically existed there.							**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases	Rainbow trout have been introduced into many cisco lakes, including Lake Nipigon, ON and have had a noticeable effect on the ecological makeup of those systems. The effects that rainbow smelt have on reducing and altering zooplankton populations have apparently not resulted in the extirpation of populations of shortjaw ciscoes, but alarm should be taken in situations of sympatric occurrence of rainbow smelt and shortjaw ciscoes in small lacustrine systems because of the potential for ecological destabilization. The introduction of smelt into at least some of the remaining habitat of the shortjaw cisco in Canada could ultimately be detrimental to the species.							**N/A**

	It is likely that the species became vulnerable to predation from sea lampreys in the Great Lakes as favoured individuals of larger species became depleted. Sea lamprey predation continues to take a toll on Great Lakes species and affects smaller species such as chubs in addition to larger species such as lake trout, lake whitefish. Sea lamprey predation also resulted in the extinction of nearly all lake trout and consequential ecological changes. Sea lamprey fecundity is expected to increase with a warming climate (Cline et al. 2014).							
8.2 Problematic native species/diseases								**N/A**
8.3 Introduced genetic material	As a further consequence of the population destabilizations noted above, hybridization became a factor in the final demise of these species.							**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents								**N/A**
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and								**N/A**

solid waste								
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Abiotic factors such as weather and thermal changes in the lakes (shift from oligotrophic conditions to mesotrophic conditions) have been suspected to play a role in population destabilization. Such destabilization can favour one species over another, resulting in competitive displacement or hybridization.	L	M	C	LTF	H	L	**Medium**
11.2 Droughts								**N/A**
11.3 Temperature extremes	Fecundity of invasive sea lamprey is expected to increase under a warming climate (Cline et al. 2014).	L	L	C	LTF	L	L	**Low**
11.4 Storms and flooding								**N/A**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Transverse Lady Beetle (*Coccinella transversoguttata*)
Populations (if applicable):
Percentage of North American population NWT is responsible for: Occurs coast-to-coast across Canada and the United States. Approximately 65% of its historical global range is within Canada.
NWT General Status Ranks: Secure
NatureServe Conservation Rank (NWT):
***Species at Risk (NWT) Act*:** Not assessed
***Species at Risk Act* (Canada):** Special Concern (under consideration for listing)
Reasons for assessment or population trends: This species was once common and broadly distributed throughout most of Canada. Declines started in the 1970s and the species is now absent in southern ON and the Maritimes. In some parts of its western and northern range, the species is still commonly recorded. The spread of non-native lady beetles is considered one of the possible threats to this species through competition, intraguild predation, or introduction of pathogens. Non-native lady beetles are less commonly found in places where this species remains.
Sources used for assessments: COSEWIC (2016a)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[301] = 1		
Dependence on habitats that are sensitive to climate change[302]	Habitat generalists. Inhabits agricultural areas, suburban gardens, parks, coniferous forests, deciduous forests, prairie grasslands, meadows, riparian areas and other natural areas. This species occupies a wide ecological niche across a wide variety of habitats and temperature regimes in Canada. Distribution driven to a large extent by prey availability rather than habitat type. Overwintering adults tend to aggregate in well ventilated microhabitats such as under stones, rock crevices, in grass tussocks, in leaf litter, or in tree bark.	1 – Broad generalist.

[301] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.
[302] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

Sensitivity to climate-relevant abiotic factors[303]	Adults of the spring generation can undergo aestivation to avoid high summer temperatures and lay eggs in early autumn. Adults of the autumn generation congregate to overwinter and undergo diapause; becoming active and reproducing when temperatures warm in the early spring. Development times are highly affected by prey availability and temperature. There can be variability in body size and weight, depending on food availability and regional climatic conditions. Smaller body sizes and weights are correlated to decreased survivorship over winter. Transverse lady beetles occupy a wide ecological niche across a variety of temperature regimes in Canada; they are cold-tolerant and adults are able to overwinter.	1 – Not sensitive.
Sensitivity to climate-relevant biotic factors[304]	Generalists. Both adult and larval stages are predatory. Primarily feed on aphids occurring across a wide range of habitats, although they also feed on other small insects and eggs. Ability to exploit changes in prey availability across different vegetation types. Drivers of dispersal are a combination of prey density and environmental variables such as temperature, wind speed and rainfall.	1 – Not sensitive.
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	The transverse lady beetle is subject to a number of potentially important threats across its range, however, threats in the NWT are considered to be negligible.	1 – No pressures.
Adaptive capacity[305] = 1		
Reproductive capacity[306]	Can have two generations per year. In general, little is known on the biology of transverse lady beetles. No studies have been conducted regarding the lifespans of adult transverse lady beetles, but closely related species generally have a lifespan of 20-60 days. The eggs of lady beetles are typically tightly packed in an upright position in clusters of 20-30 eggs. Over 14	1 – Early reproduction/many offspring

[303] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.
[304] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).
[305] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[306] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.

	days, female transverse lady beetles can lay approximately 267 eggs. Many females also lay unfertilized eggs, along with fertile eggs, as another food source for young larvae. Mating begins shortly after adult emergence. The transverse lady beetle is polygynandrous, with both sexes mating with multiple partners.	
Dispersal capacity[307]	The dispersal ability of transverse lady beetle is unknown. In general, lady beetles are very mobile, display low site fidelity and readily engage in short (few hundred meters) and long (18-120 km) distance dispersal in a single flight (extrapolated). This species does not migrate.	1 - >10km.
Genetic diversity	Limited genetic studies have occurred on this species and its genetic structure. There are likely high rates of gene flow and little detectable subpopulation subdivision.	N/A
Phenotypic plasticity		N/A

[307] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas	Habitat loss and declines in habitat quality from expansion of residential and commercial developments may be contributing to local declines of this species in some parts of its range, particularly southern ON. Green areas and local gardens within smaller urbanized areas, however, may also still provide habitat.							**Neg.**
1.2 Commercial and industrial areas	See 1.1.							**Neg.**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops	In recent decades, the capacity of agricultural landscapes to provide habitat for wildlife has declined significantly across Canada's ecozones. One cause for this is more intensive use of agricultural land. This includes heavier reliance on chemicals for pest control, which presumably negatively affect transverse lady beetles directly, or indirectly by impacting their prey (see 9.3). Planting of genetically modified insect-resistant crops (e.g. GM corn engineered to express *Bacillus thuringiensis* (Bt) toxins) was considered a potential risk to lady beetles because the toxin was present in pollen, but not present in aphids. While most studies have found no effect of Bt corn pollen consumption on fitness parameters of lady beetles, others have detected reduced fecundity and developmental delays.							**N/A**

	While large scale changes in habitat and prey availability suggest a possible explanation, there are no data to demonstrate causality between a changing landscape and lady beetle densities.							
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling								**N/A**
3.2 Mining and quarrying								**N/A**
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads								**N/A**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals								**N/A**
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**

5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression								**N/A**
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications	Conversion of managed lands and farms resulting in regrowth of forest could also result in less favourable foraging for the transverse lady beetle. This slow natural succession has mainly occurred in areas of eastern Canada. While large scale changes in habitat and prey availability suggest a possible explanation, there are no data to demonstrate causality between a changing landscape and lady beetle densities.							**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases	In North America alone, at least 179 non-native lady beetle species have been introduced, leading to nine non-native species becoming well-established in Canada, including the seven-spotted lady beetle and the multicolored Asian lady beetle. These non-native species continue to be widely available and released for biocontrol. Significant declines in geographic range and abundance of native lady beetles are frequently due to changes in habitat or interactions with non-native species.							**Neg.**

	In YT, NWT and BC, this species seems to be abundant and common. These regions also have a smaller proportion of non-native lady beetle species, which are considered one of the potential threats to this species and other native lady beetles. There is a broad coincidence between shrinkage of geographic range and subpopulation declines for native lady beetles with the introduction and spread of the seven-spotted lady beetle and the multicolored Asian lady beetle. A direct causal link is not obvious, though potential mechanisms include direct competition for food, intraguild predation and spread of new parasitoids or pathogens. Competition is also suspected to have led to declines in the body size of other native lady beetles, likely reducing their survivorship over winter. From 1916-1975, the relative abundance of the transverse lady beetle gradually increased each decade, dropping marginally in 1976-1985, corresponding to the same time period the non-native seven-spotted lady beetle increased in abundance. During subsequent decades, the transverse lady beetle declined significantly, concurrent with significant increases in abundance of non-native lady beetles, such as the seven-spotted lady beetle and the multicolored Asian lady beetle. The same trend is seen in the US. In support of scramble competition, where a finite resource is available to all competitors, it has been shown that seven-spotted lady beetles were more voracious, had a higher aphid attack rate and lower aphid handling time, under a wide variety of conditions, compared with other native lady beetles. Competition with seven-spotted lady beetles has resulted in limited prey availability and decreased body size of other native lady beetles. Furthermore, other studies have shown seven-spotted lady beetles and							

	multicolored Asian lady beetles reduce survivorship of transverse lady beetles and other native lady beetles, as a result of higher predation rates on their eggs and larvae. Intraguild predation also plays a major role in preventing recolonization by native lady beetles and females avoid oviposition sites where intraguild predators are present. However, the links between the non-native species and causes of the declines are not clear. Non-native species may also affect native lady beetles indirectly through the introduction and transmission of new natural enemies such as exotic parasites and pathogens. Although the effect of these exotic parasites and pathogens on the transverse lady beetle is uncertain, native species typically have a greater susceptibility. Greater susceptibility to exotic pathogens may therefore provide an intraguild advantage to non-native lady beetles and could have been a contributing factor in declines of transverse lady beetles.							
8.2 Problematic native species/diseases								**N/A**
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin	The brachonid wasp can likely cause substantial reductions in subpopulations of the transverse lady beetle. This brachonid wasp currently has a cosmopolitan distribution covering all continents except Antarctica and many islands. The natural geographic range of this wasp is difficult to reconstruct as it is believed this species arrived in some parts of its present distribution with ladybirds released for biological control purposes.							**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								

9.1 Domestic and urban wastewater							**N/A**
9.2 Industrial and military effluents							**N/A**
9.3 Agricultural and forestry effluents (including erosion)	While lady beetles can be more tolerant of pesticides than their prey, pollution via agrochemicals to reduce insect pests can impact non-target lady beetles directly through topical contact; residual contact; inhalation of volatiles; and ingestion of insecticide-contaminated prey, nectar, or pollen; and indirectly through eliminating their food supply. Zoophytophagy, omnivorous feeding behaviour that occurs when plant material (pollen, nectar, leaf tissue) is consumed by primarily predaceous species, increases fecundity and reduces development time. However, zoophytophagy can also be harmful if the plant material is chemically protected by insecticides. Lady beetle susceptibility to insecticides varies with the species and the type of pesticide and can range from acute lethal effects to reduction in fecundity, behaviourally or reproductively by non-lethal concentrations of insecticides. Many insect predators exposed to more than one compound suffer synergistic detrimental effects, even for compounds that were equitably harmless when tested separately. In urban and agricultural landscapes, lady beetle subpopulations may be threatened by a variety of pesticides including neonicotinoids, insect growth regulators and broad-spectrum pyrethroids, which tend to be more destructive to lady beetles than organophosphates. Insect growth regulators such as buprofenzen and pyriproxyfen generally lack acute toxicity to lady beetles, but may impair development and fecundity. Neonicotinoids are a class of systematic pesticides that travel and accumulate throughout the plant, including pollen and nectar. While very effective against plant pests, especially aphids, these pesticides have proven to be detrimental to insects at concentrations in the ppb. Neonicotinoids							**N/A**

	can also be applied to seeds prior to planting to protect seedlings from early-season root and leaf feeding. In one study, 72% of multicolored Asian lady beetle larvae exposed to seedlings treated with neonicotinoids developed neurotoxic symptoms (trembling, paralysis and loss of coordination) from which only 7% recovered. Therefore, the use of neonicotinoids may have negative effects on non-target species especially if zoophytophagy occurs.							
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration								**N/A**
11.2 Droughts								**N/A**
11.3 Temperature extremes								**N/A**
11.4 Storms and flooding								**N/A**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Western Toad (*Anaxyrus boreas boreas*)
Populations (if applicable): Non-calling population
Percentage of North American population NWT is responsible for:
NWT General Status Ranks: At Risk
NatureServe Conservation Rank (NWT): SNR
***Species at Risk (NWT) Act*:** Threatened
***Species at Risk Act* (Canada):** Special Concern
Reasons for assessment or population trends: The population of western toads in the NWT is small and its range is limited. There is evidence that chytrid fungus and ranavirus are already present in the NWT. This could be detrimental to the western toad population, particularly if coupled with additional stressors or threats that reduce immunity to diseases. Disease transmission can be facilitated by humans collecting and releasing toads or tadpoles between water bodies. Additional threats include habitat degradation, wildfires, resource exploration and development and increased UV-B radiation. All of these threats can have complex interactions with each other and be challenging to manage. Life history characteristics (e.g. long lifespan, delayed maturity of females and females breeding only once a lifetime) make populations especially vulnerable to threats and declines. Since threats to western toads in BC and YT are similar to those present in the NWT, future rescue effect for the NWT population may be unlikely.
Sources used for assessments: SARC (2014a, 2015)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[308] = 2		
Dependence on habitats that are sensitive to climate change[309]	It has been suggested that early deep snow accumulation, providing insulation for hibernating sites, is a requirement for survival of western toads in northern BC. The northern limit of the species in BC and YT corresponds with deep snow regions of the coast and Rocky Mountains and the presence of geothermal springs. Climate models project increases in temperature and precipitation in Canada. Precipitation is likely to increase in winter and spring, but decrease in summer.	2 – Generalist, but some sensitive habitats are important.

[308] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores
[309] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	Western toad has three primary habitat requirements: aquatic habitat for breeding, egg laying and tadpole development; foraging habitat; and hibernating habitat. These habitats, often in close proximity, must be connected by suitable corridors. Western toads show strong site fidelity (up to 90%) to sites used seasonally and/or annually for breeding, summer foraging and hibernation. Site fidelity and communal breeding may result in the selection of only one or a few of many potential breeding sites in a given area. Microsites providing thermal or protective cover and moist soil patches are repeatedly used. These refugia likely represent habitat critical to the western toad. Typical breeding sites include shallow, sandy, or silty margins of lakes, ponds, streams, rivers, stream deltas, river backwaters, floodplain marshes and geothermal springs. Human-made habitats such as ditches, road ruts, tailings ponds and borrow pits are also commonly used. There is a very weak correlation between western toad abundance and local sites with higher dissolved oxygen. Water may be clear or silty. Breeding sites are sometimes extremely open and unprotected by vegetation, woody debris, rocks, or undercut banks. They may dig shallow scrapes or their own burrows in loose soils such as sand. The availability of summer habitats is likely not limiting western toads in this highly productive region. Natural breeding sites are essential habitat components that are expected to be common in the Liard Valley. Typical breeding sites are no doubt available in the area. The western toad is at the northern edge of its range in the NWT, where separation of breeding, hibernation and foraging sites might limit population stability and the northern extent of the range.	
Sensitivity to climate-relevant abiotic factors[310]	There is a positive correlation between western toad abundance and locally higher water temperatures (with a difference in local mean water temperature between breeding and non-breeding sites of 13.4°C and 11.0°C, respectively, possibly). Egg and larval	2 – Somewhat sensitive or possibly very sensitive.

[310] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

	development are dependent upon water temperature. Western toad tadpoles aggregate in warm shallow margins of waterbodies during the day, a behaviour that accelerates their rate of development. They may disperse to deeper waters at night. Western toads congregate to breed in the spring, when minimum and maximum temperatures rise above 0°C and 10°C, respectively, or shortly after ice breakup. The western toad is not freeze-tolerant. Western toads hibernate underground, below the frost line to prevent freezing and near water to prevent desiccation. Activity patterns are likely behavioural adaptations to ambient temperatures since some toads switch from diurnal activity in spring, to nocturnal activity in summer and back to diurnal activity in fall. Reasons for this may include attainment of higher daytime body temperatures and improved access to prey species that are primarily diurnal. It is unknown whether western toads in the NWT are diurnal or nocturnal. Western toads are ectotherms, exchanging heat with their surroundings rather than producing body heat internally. Western toads thermoregulate behaviourally, by moving among habitats or microsites with suitable ambient temperatures, by basking and by evaporative cooling from the skin and lungs. Western toads are not normally active if their body temperatures are below 3.0°C or above 29.5°C. This wide thermal tolerance allows western toads to exploit a wide range of habitats. Western toads are moderately resistant to desiccation with relatively dry, thick, warty skin on their backs. Western toads reach a critical activity point, losing the ability to right themselves, when dehydrated to 41.4% of their initial hydrated body mass. Western toads are frequently found far from standing water in relatively dry habitats, but moist microsites are required for rehydration. Metamorphs and smaller juveniles have a higher surface area to volume ratio than adults, making them more vulnerable to desiccation. Drainages are used as dispersal corridors by metamorphs and juveniles. Dispersal distances may be limited by the availability of moist habitats and by time between metamorphosis and hibernation. There is a grey pelvic	

	path in the groin area that is used to absorb moisture from the ground. Water depths up to 2 m can be used for oviposition, but shallow water (10 cm-1 m) is preferred. Permanent water bodies are usually preferred over ephemeral ponds, which may dry up in times of drought before metamorphosis. Climate models predict increases in temperature and precipitation in Canada. Precipitation is likely to increase in winter and spring, but decrease in summer. It has been suggested that early deep snow accumulation, providing insulation for hibernating sites, is a requirement for survival of western toads in northern BC. The northern limit of the species in BC and YT corresponds with deep snow regions of the coast and Rocky Mountains and the presence of geothermal springs. There is little information on range limiting factors in the NWT.	
Sensitivity to climate-relevant biotic factors[311]	Diseases caused by Bd and ranavirus are an immediate threat but magnitude of the impact is likely small at this time. Co-stressors may act together to reduce immunity to disease. These diseases are considered to be the most serious plausible threat to western toad, being global in nature and having the capacity to spread rapidly across all sub-populations in the NWT. These diseases have resulted in high mortality rates and population declines elsewhere. These diseases are already present. Other co-stressors such as habitat degradation, climate change, water mold and increased UV-B radiation may act synergistically to cause immunosuppression and vulnerability to Bd. Ranavirus is widespread in the Dehcho and Sahtú regions; it was detected in wood frogs but not in western toads or boreal chorus frogs. Amphibian die-offs have been attributed to this disease. Infections and mortalities due to ranavirus have been reported for western toads in captive and wild populations. Co-stressors may have an effect on ranavirus dynamics. A warmer climate may benefit toads by possibly reducing the incidence of Bd, which can be cleared	2 – Somewhat sensitive or possibly very sensitive.

[311] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

	from infected individuals at elevated body temperatures. Conversely, increased maximum temperatures may decrease environmental constraints on Bd and permit it to expand into higher elevations. Climate change-associated extreme climatic events may be linked to increased UV-B exposure due to drought and to the outbreak of pathogens. Non-native species pose very little threat to western toads in the NWT at the present time. There are no introduced predators, competitors, or diseases associated with fish stocking as there are elsewhere in the species' range in Canada. The invasive plant species white and yellow sweet clover have invaded the NWT in the western toad range, but are not expected to impact western toad habitat or impede the toads' behaviour. One study found higher western toad abundance in lakes with rainbow trout than in lakes without trout in the southern interior of BC. The presence of fish may help to depress the abundance of invertebrate tadpole predators.	
Non-climate stressors = 2		
Sensitivity to potentially interacting non-climate pressures	Non-climate stressors primarily relate to disease and the potential for mass mortality during aggregation events. These include chytrid fungus and ranavirus, which are already present in the although they are not currently showing themselves as highly pathogenic, the impact of co-stressors, including UV-B radiation, could increase the potential for lethal or sublethal impacts to the species. Mass mortality resulting from forest fires is particularly concerning, given the species presence in a forested region that has not burned in some time. Mass mortality resulting from road collisions is often cited as a primary concern, but given road density and traffic in the NWT, doesn't appear to be as substantial a threat here.	2 – Moderate pressures or possibly major pressures.
Adaptive capacity[312] = 2		
Reproductive capacity[313]	Western toads show explosive breeding at communal breeding sites, where adults aggregate over a one to two week period, to ensure reproductive success. Male	3 – Late reproduction/many offspring

[312] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[313] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.

	western toads reach sexual maturity at three to four years of age and live up to 11 years. Males may mate more than once per season. Females reach sexual maturity at four to six years of age and live up to nine years. In southern populations, female western toads produce clutches containing 1,200-20,000 eggs; however, observations in the north suggest that smaller clutches of less than 3,000 eggs are laid. Clutch size is believed to be correlated with female body size, which is related to age. The high energy costs of reproduction appear to limit most females to breed once in their lifetimes. Data on breeding patterns of female toads is lacking for northern populations; nonetheless, the long time to maturity for females and the fact that most females breed only once in their lifetime, makes northern populations especially vulnerable to threats and declines. Mortality rates between egg deposition and adult life stage may be as high as 99%. Estimated generation time is 7.25 years for males and seven years for females.	
Dispersal capacity[314]	Toads move on land by walking and hopping. The western toad is capable of undertaking directional long-distance movements of at least up to 15 km, especially along water courses. Females tend to travel further to reach foraging grounds. Males are more closely associated with water and move shorter distances. Movements and habitat use by juvenile western toads remain a large gap in knowledge. In Oregon however, dispersal by metamorphs and juveniles was up to 2.7 km from breeding sites within eight weeks of metamorphosis at an average rate of 84 m/day. Pond breeding amphibians such as the western toad are assumed to have strong breeding site fidelity, high vagility (ability to move) within home ranges, limited dispersal abilities and spatially disjunct breeding sites. The dispersal ability of western toads however, appears to be relatively high among amphibian species.	1 - >10km

[314] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Genetic diversity	Aggregate breeding ensures genetic mixing.	N/A
Phenotypic plasticity	Body size appears to be smaller in northern BC, YT and NWT compared to southern BC and the United States.	N/A

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling	Seismic line density is 0.51-1.50 km/km^2 in the western toad's range of the Liard Valley, which is high compared to most of the NWT; this is a minimum estimate and includes coal seismic data only to 2005.	L	L	C	N	H	L	**Low**

	There has been a considerable amount of oil and gas exploration and development, as well as some coal exploration activity, in the portion of the western toad's range around Fort Liard. Roads, trails and seismic lines alter toad habitats and represent obstacles to dispersal and migration. However, western toads are able to forage in and cross open areas, so habitat fragmentation is not believed to be a major issue.							
3.2 Mining and quarrying	Around Fort Simpson there are active mineral claims and prospecting permits.							**Neg.**
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads	Roads, trails and seismic lines alter toad habitats and represent obstacles to dispersal and migration. Mass mortality from roadkill during aggregation events and particularly related to the use of man-made ponds near roads, is by far a more serious threat. However, western toads are able to forage in and cross open areas, so habitat fragmentation is not believed to be a major issue. Western toads in AB have been observed using grass/dirt roads and seismic lines, which facilitate movements. The Taiga Plains ecozone has the highest density of roads in the NWT, at 0.49 km of road per 100 km^2. The main road running along the Liard River is the Liard Highway. The density of all semi-permanent linear features (including secondary roads, transmission lines and pipelines but excluding seismic lines) in the Taiga Plains is 0.75 km/100 km^2. In contrast, the road density in parts of BC where impacts on western toads (from habitat fragmentation and road kill) are cumulative to other human-related impacts (such as pollution, introduced diseases and competitors) is greater than 100 km/100 km^2. ATV use in and around toad breeding ponds at the Muskeg River gravel pit near Fort Liard has	L	U	S	N	L	L	**Low**

	been reported. Mortality of toads at this site was not observed but can be inferred. However, lack of information on toad breeding sites, seasonal toad movements and dispersal in the area precludes an assessment of the risk that the roads pose. It is the juxtaposition of roads and breeding sites and the volume and seasonal timing of traffic that determines the level of threat, not road density itself.							
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	In the NWT, a wildlife research permit is required for the study of western toads, but they can be harvested without a permit. Western toads are not typically used for bait or food. There was one recorded incidence of people collecting tadpoles at the Muskeg River gravel pit in 2008. This suggests that collection does occur in the NWT, but likely at a low level. These pets may or may not be released back to the wild and if they are it may be in unsuitable habitat. This activity has the potential to impact local populations. The loss of tadpoles at a low level would have much less impact on a population than the removal of breeding adults. Releasing individuals at novel ponds could result in the spread of pathogens.							**Neg.**
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting	Clearcuts and edges of clearcuts are used by western toads depending on the seasonal risk of desiccation. Clearcuts under 0.05 km^2 in size were not impediments to movements by western toads in spring. However, larger clearcuts and smaller clearcuts later in summer when temperatures are relatively high, may be inhospitable to western toads. [Note that FMAs do not overlap with known range of western toads in the NWT.]							**Neg.**

5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities	There is concern than humans may be agents of Bd transmission between wetland sites on recreational gear such as waders and research equipment.	L	L	S	N	L	M	**Low**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities	There is concern than humans may be agents of Bd transmission between wetland sites on recreational gear such as waders and research equipment. [Note that amphibian research in the NWT is managed via wildlife research permits, which can stipulate disease transmission protocols.]	L	L	S	N	L	M	**Low**
7. Natural system modifications								
7.1 Fire and fire suppression	In Montana, western toads preferred recent burns where they increased their breeding activity, providing further evidence of use of open terrestrial habitats. One study found that western toads were resistant to wildfire and benefited over the short-term by colonizing wetlands after burns. However, the selection of open habitat and recent burn areas is tempered by the seasonal risk of desiccation (see 5.3). Western toads are vulnerable to events occurring at sites where individuals are concentrated, such as breeding sites (adults, eggs, tadpoles and metamorphs) and terrestrial migration routes to and from breeding sites. Random events can have major impacts on cohorts or even an entire population, resulting in local extirpation. The Liard Valley is an area that has not burned in some time; therefore, the potential for wildfires resulting in habitat loss is an important consideration.	L	L	S	ST F	M	M	**Low**
7.2 Dams and water								**N/A**

management/use								
7.3 Other ecosystem modifications								**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases	Introduced plant species such as white and yellow sweet clover are invading western toad shoreline habitat. However, the plants are not expected to impact western toad habitat or impede the toads' behaviour. There are no introduced predators, competitors, or diseases associated with fish stocking as there are elsewhere in the species' range in Canada.							**Neg.**
8.2 Problematic native species/diseases								**N/A**
8.3 Introduced genetic material	Amplexus (a mating embrace) has been observed between mismatched pairs of the western toad and Canadian toad in west-central AB. One hybrid was identified based on morphology. The viability and fertility of hybrids are unknown, but these factors presumably contribute to reproductive isolation of the two species along with the low abundance of one of the two species in the zone of overlap. No evidence of gene flow between the two species was found in AB. The known ranges of the western toad and Canadian toad do not overlap in the NWT.							**Neg.**
8.4 Problematic species/diseases of unknown origin	Diseases caused by chytrid fungus and ranavirus are an immediate threat: magnitude of the impact is likely small at this time. Co-stressors may act together to reduce immunity to disease. These diseases are considered to be the most serious plausible threat to western toad, being global in nature and having the capacity to spread rapidly across all subpopulations in the NWT. These diseases are already present. The magnitude of the impact is unknown but believed to be minor at this time. Regardless, western	W	H	S	N-LTF	M	M	**Medium**

	toads are susceptible to these diseases, which have resulted in high mortality rates and population declines elsewhere. The emerging infectious disease chytridiomycosis is caused by the fungus Bd. First described in the late 1990s, the pathogen has been found in western toads as well as other amphibians across the Canadian range of the road, including the NWT. Infected wood frogs and boreal chorus frogs were also found in the NWT. The Bd population in some North American amphibians (including western toads from Colorado) has been found to be a highly infectious lineage that resulted from the anthropogenic mixing of two other lineages and subsequent anthropogenic spread. Other co-stressors such as habitat degradation, climate change, water mold and increased UV-B radiation may act synergistically to cause immunosuppression and vulnerability to Bd. There is some evidence that some amphibian species are able to survive Bd epidemics. While there is evidence that Bd is a spreading pathogen that can have negative consequences for amphibian populations, there is also evidence that Bd is widespread in areas where there is little evidence of harm or where Bd has become endemic in apparently stabilized populations. Past and future declines of western toads due to Bd cannot be ruled out. Ranavirus is widespread in the Dehcho and Sahtú regions; it was detected in wood frogs but not in western toads or boreal chorus frogs. Amphibian die-offs have been attributed to this disease. Infections and mortalities due to ranavirus have been reported for western toads in captive and wild populations. Co-stressors may have an effect on ranavirus dynamics.							
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of								**N/A**

unknown cause								
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents	While amphibians are known to be sensitive to chemical contaminants from industrial wastes, agricultural effluents and other sources that are transported by water and air, very little research has been undertaken on the effects of specific contaminants on the western toad. Spills of fuel oil, various chemicals such as antifreeze and glycol-based products for vehicles, lube oil and other hydrocarbons have increased in recent years, but impacts of these chemicals on western toads is unknown. Road salts can produce lethal or sublethal effects on amphibians. Sublethal effects may include reduced tadpole activity and weight and physical abnormalities. Road salt use is planned and monitored in the NWT. The roads in the Liard valley are primarily gravel and therefore do not require the application of sodium chloride. A very low level of calcium chloride is used for dust control on selected roads in the NWT to create a thin and dust-free crust on the highway surface. There is no known synergistic effect between road deicing salt and water molds, two known sources of mortality for amphibian embryos.	L	U	C	N	M	L	**Low**
9.3 Agricultural and forestry effluents (including erosion)	While amphibians are known to be sensitive to chemical contaminants from industrial wastes, agricultural effluents and other sources that are transported by water and air, very little research has been undertaken on the effects of specific contaminants on the western toad. Amphibians are vulnerable to environmental contaminants including pesticides, herbicides and fertilizers. The pesticide							**Neg.**

	malathion kills the plankton that tadpoles feed on. Many compounds such as atrazine, DDT, dieldrin and acids cause immunosuppression in amphibians at low concentrations. Atrazine can disrupt sexual development. In the NWT, permits are required for non-domestic pesticide or herbicide use. There are no current pesticide or herbicide permits in the known range of western toads; the closest are in Fort Simpson. Pesticides are generally only used in buildings. Herbicides are occasionally used; for example, along railway corridors and at certain locations along the Enbridge pipeline. There is no agriculture in the NWT range of the western toad and agricultural development in the NWT is unlikely in the future.							
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants	The acidification of wetlands from airborne sources may be a source of developmental abnormalities and increased mortality of embryos and tadpoles. Acidification from airborne sulphur is associated with oil and gas extraction in northeast BC and AB. Heavy metals are also transported by air. UV-B radiation may not be a serious threat to western toads, but heavy metals and UV-B radiation may act synergistically with other environmental stressors and suppress the immune system of western toads, making them vulnerable to pathogens. Heavy metals including zinc, cadmium and copper can have negative effects on amphibian growth, development and survival. Airborne environmental contaminants have been found in wildlife in the Dehcho, including very low levels of DDT and Chlordane, perfluorinated and brominated compounds, as well as radionuclides from the Fukushima accident.	W	U	C	N	M	L	**Low**
9.6 Excess energy (noise/light pollution)	UV-B radiation is a threat of low magnitude, but it may be higher in combination with other stressors such as extreme climatic events (e.g. drought). Bd may require other co-stressors such as increased UV-B radiation for the disease to become pathogenic.	W	U	S	LTF	L	L	**Low**

	UV-B radiation is a current threat to western toads in the NWT. A thinner stratospheric ozone layer is allowing more biologically damaging UV-B radiation to reach the Earth's surface. The magnitude of the impact is believed to be low, but may be higher in combination with other environmental stressors. One study found no effect of UV-B radiation on western toad distribution in western North America. UV-B radiation has been shown to reduce the survival of western toad embryos and tadpoles in Oregon, whereas studies in Colorado did not detect a UV-B effect. Western toad juveniles also experienced elevated mortality when exposed to ambient levels of UV-B radiation. The western toad may be vulnerable to UV-B radiation because it lays eggs in open shallow water subjected to solar radiation and has a poor ability to repair UV-induced DNA damage. Other stressors may act in combination with UV-B to encourage infection by pathogens or to induce lethal and sublethal effects such as reduced anti-predator behaviour. For example, western toad embryos and larvae were susceptible to a complex interaction between UV-B radiation, water mold and low water levels caused by lower precipitation.							
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Climate change could have either positive or negative impacts. Climate change may permit earlier breeding due to earlier snow and ice melt and subsequent range expansion by amphibians, which are presently excluded from habitats beyond their northern	W	U	C	N	H	L	**Low**

	limit by the brief ice-free period. Western toad hibernation may be limited by snow depth in the north (snow depth has a positive influence on western toad hibernation); therefore, increased snow depths as predicted by the Intergovernmental Panel on Climate Change may permit range expansion. A warmer climate with greater amounts of atmospheric moisture would benefit toads by reducing physiological costs of crossing landscapes and possibly reduce the incidence of Bd, which can be cleared from infected individuals at elevated body temperatures. Warm winter or spring days may entice western toads to emerge early, making them vulnerable to freezing temperatures. Climate models project increases in temperature and precipitation in Canada, with the largest warming projected for northern Canada. Precipitation is likely to increase in winter and spring, but decrease in summer. Snow season length is predicted to decrease, but increased snowfalls will more than make up for the shorter snow season, resulting in increased snow accumulation. The magnitude of the impact is believed to be minor in both negative and positive aspects at this time but observed effects are expected to increase in the coming decades.							
11.2 Droughts	Climate change-associated extreme climatic events may be linked to increased UV-B exposure due to drought and to the outbreak of pathogens. Random events such as drought can have major impacts on cohorts or even an entire population, resulting in local extirpation. A decrease in summer precipitation might increase the frequency and duration of droughts, affecting the persistence of smaller wetlands used for breeding, decreasing connectivity across the landscape and decreasing the availability of moist microsites used for rehydration.	L	M	S	ST F	H	L	**Low**

11.3 Temperature extremes	Random events such as freezing temperatures can have major impacts on cohorts or even an entire population, resulting in local extirpation. Increased maximum temperatures may decrease environmental constraints on Bd and permit it to expand into higher elevations.	L	M	S	LTF	M	L	**Low**
11.4 Storms and flooding								**N/A**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Whooping Crane (*Grus americana*)
Populations (if applicable): Aransas-Wood Buffalo population
Percentage of North American population NWT is responsible for: 100% of natural breeding population in Canada. Canadian range includes NWT, AB, SK and Manitoba. The only self-sustaining wild population breeds in WBNP in the NWT and AB.
NWT General Status Ranks: At Risk
NatureServe Conservation Rank (NWT): S1
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Endangered
Reasons for assessment or population trends: Canada is home to 100% of the naturally occurring global breeding population of this species. Although never common, its population dipped to only 14 birds early in the last century, at which point the species was at the brink of extinction. Conservation efforts in Canada and the United States not only rescued the remnant population from extinction, but later resulted in population increases. To help ensure persistence of the species, efforts to establish wild flocks of captive-bred individuals outside Canada have been underway for several decades. Nevertheless, Canada's breeding population is still very small and is confined to a limited breeding area and only one wintering location. This situation exposes it to catastrophic natural events (e.g. droughts, hurricanes) and a variety of ongoing anthropogenic threats (e.g. loss and degradation of coastal wetland habitats on the wintering grounds, oil spills in coastal areas and collisions with power lines and structures during migration). Last, because of delayed sexual maturity and a naturally low annual reproductive output, the population of this species has an inherently weak capacity to rebound from pressures that reduce survivorship or reproductive success.
Sources used for assessments: COSEWIC (2010b)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[315] = 2.3		
Dependence on habitats that are sensitive to climate change[316]	Whooping crane breed in a unique wetland complex in Wood Buffalo National Park, characterized by relatively small ponds with extremely soft substrate. These ponds are relatively small and fed by groundwater, though they can become interconnected	3 – Depends on sensitive habitats that are not rare.

[315] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.
[316] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	during spring flooding of rivers in the area. A substantial amount of open water is present, allowing for easy detection of predators. Generally speaking, there is little terrestrial vegetation. During migration, whooping crane use a variety of wetlands and croplands along their migration corridor for feeding and roosting. Wetlands are more important feeding areas for family groups than non-family groups. Wintering habitat on the Texas Gulf Coast consists of estuarine marshes and salt flats. Whooping crane favour temporary and seasonal wetlands in spring and prefer semi-permanent and permanent wetlands in fall. About 900 km^2 of wintering habitat exists in the Aransas National Wildlife Refuge and surrounding lands on the Texas Gulf Coast. The area consists of estuarine marshes and salt flats.	
Sensitivity to climate-relevant abiotic factors[317]	There are wet-dry cycles on the breeding grounds, where fewer young are produced during dry years. Behavioural mechanisms are used to regulate body temperature. Upon hatching, the insulative properties of the chick's plumage appear to allow sufficient thermoregulation in most conditions. However, rain events on the breeding grounds immediately following hatching may result in increased chick mortality.	2 – Somewhat sensitive or possibly very sensitive.
Sensitivity to climate-relevant biotic factors[318]	Omnivorous throughout the year. On the Texas wintering grounds, blue crabs and a variety of clams were found to be the most important food items. Water level is believed to influence which species are most accessible for capture and consumption (i.e., periods of flooding/high tides v/ periods of tidal flat drainage). Although omnivorous, the importance of blue crab in the winter diet of the whooping crane suggests that factors affecting crab populations may have major consequences for cranes. Food shortages on the wintering grounds can seriously impact nesting effort in Wood Buffalo National Park. However, the vulnerability of food sources discussed in the status	2 – Somewhat sensitive or possibly very sensitive.

[317] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.
[318] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

	report is primarily related to human water uses. Natural drought conditions are discussed, but not whether these patterns are out of the norm or changing over time as a result of climate change.	
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	No non-climate stressors in the NWT.	1 – No pressures.
Adaptive capacity[319] = 2.5 plus 0.5 for low genetic diversity = 3		
Reproductive capacity[320]	Delayed sexual maturity and a naturally low annual reproductive output. Not all birds nest each year. The population of this species has an inherently weak capacity to rebound from pressures that reduce survivorship or reproductive success. Breeding begins at four to five years and occurs annually thereafter. Perennially monogamous pairs typically lay two eggs per clutch but rarely fledge more than a single young. One brood per season. Longevity in the wild estimated at 22-30+ years. Overall mortality for the Aransas-Wood Buffalo population is 9.9%/year, while juvenile mortality is 26.7% in year one and 9.1% in year two. Generation time ~ 12 years.	4 – Late reproduction/few offspring
Dispersal capacity[321]	Seasonally migratory. Migration between Wood Buffalo National Park and Aransas National Wildlife Refuge is usually direct and rapid. Home ranges vary in size and have been estimated to be 3.2-12 km^2. Following chick hatching on the breeding grounds, pedestrian movements of family groups occur entirely within the breeding territory. Chicks grow rapidly and begin sustained flights in mid-August, at which point family groups move farther from the natal territory, but the distance is still minimal. Fall migration is often of longer duration than in spring (~50 days compared to ~10).	1 - >10km.
Genetic diversity	The Whooping Crane reached a bottleneck in 1938, with only 14 surviving adults in the Aransas-Wood	0.5

[319] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.

[320] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.

[321] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

	Buffalo population. Mitochondrial DNA collected before and after the population bottleneck showed a 66% reduction in haplotypes. The most common haplotype today was the rarest haplotype at the time of the bottleneck. Genetic diversity of whooping cranes is much less than that of other cranes, including the Mississippi subspecies of the sandhill crane, which experienced a similar genetic bottleneck. While 87% of the genetic variability present after the bottleneck was still present in the wild in 1990, only 33% of the genetic material present prior to the bottleneck is present in today's population of whooping cranes, which was derived from six to eight birds. To prevent continued loss of genetic material, the Aransas-Wood Buffalo population must increase to a population size where the loss of genetic diversity will be offset by the creation of new alleles. If attempts fail to establish both the introduced Florida and eastern migratory population, then the international recovery team has set a target of a minimum population of 1000 individuals (250 breeding pairs) in the Aransas-Wood Buffalo population.	
Phenotypic plasticity		N/A

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas	About 90% of the population disappeared between 1870 and 1900 due to the encroachment of civilization on its breeding grounds south of Wood Buffalo National Park. Wintering sites on the east coast of the United States disappeared around this time as well, due to greatly increasing human populations and subsequent drainage of marsh habitats. In the early 20th century, the population reached an all-time low of only 14 known adults. Ongoing coastal development in the wintering grounds is bringing people into closer contact with the cranes.							**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and								**N/A**

freshwater aquaculture								
3. Energy production and mining								
3.1 Oil and gas drilling								**N/A**
3.2 Mining and quarrying								**N/A**
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads								**N/A**
4.2 Utility and service lines	Perils faced during migration largely include strikes with power lines; guy lines at telecommunications towers pose another threat. Habitat along the migration corridor is being degraded through the proliferation of power lines and tall structures (e.g. telecommunication towers).							**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	Hunting and shooting contributed to whooping crane declines up to about 1920. Some whooping cranes are still shot inadvertently or as deliberate acts of vandalism. Subsistence hunting, fishing and trapping still occur in Wood Buffalo National Park by local Aboriginal groups. These activities are considered an important part of the park's cultural history, but they take place outside the breeding season and are not considered to be a threat to nesting whooping crane.							**Neg.**
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**

5.4 Fishing and harvesting aquatic resources	On the wintering grounds, whooping cranes compete with humans for harvesting crabs.							**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities	In winter, increasing amounts of boat traffic through the Aransas National Wildlife Refuge area is a source of human disturbance.							**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression								**N/A**
7.2 Dams and water management/use	One of the major concerns on the wintering grounds has focused around the Gulf Intracoastal Waterway (GIW), which protects boats from wind and high seas. Construction of this waterway in the early 1940s caused some initial loss of wetland habitat. Moreover, 15% of whooping crane wintering habitat has been lost since the early 1940s due to erosion from boat traffic along the GIW. It is estimated that 1.6 ha of wintering habitat per year is lost. The United States Army Corps of Engineers began installing concrete slabs along portions of the GIW to reduce erosion, but this was not completed until 2002. Both natural drought conditions and diversion of the San Antonio and Guadalupe rivers are also major threats to wintering whooping crane and can seriously impact nesting effort in Canada. Without the major freshwater inflow these rivers provide to the bay ecosystems where the whooping crane winter, the salt marsh becomes too saline and unsuitable for drinking. Not only are the cranes forced to fly inland to find fresh water, but the availability of their food sources in the bay may also change as a result of							**N/A**

	increased salinity (blue crabs). Drought conditions during winter 2008-2009 are believed to have had detrimental impacts on the whooping crane population.							
7.3 Other ecosystem modifications								**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases								**N/A**
8.2 Problematic native species/diseases	Slight population decreases have been noted, likely owing to a ten-year cycle in recruitment that has been linked to predation by carnivores, but overall, the population has been mostly increasing since intensive population monitoring was initiated in 1938.							**Neg.**
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents	The concentration of whooping crane in Texas makes them vulnerable to catastrophic events such as chemical spillage. The heavy barge traffic along the GIW is composed largely of petrochemical products. Relatively small chemical spills have occurred in this region in the past and there is potential for catastrophic spills in the future. Such spills can negatively affect water quality and crane food supplies.							**N/A**

9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration								**N/A**
11.2 Droughts	See 7.2. However, the status report only notes that whooping cranes may be vulnerable to drought conditions and doesn't discuss whether natural drought conditions are changing over time.							**N/A**
11.3 Temperature extremes								**N/A**
11.4 Storms and flooding	The concentration of whooping crane in Texas makes them vulnerable to catastrophic events such as hurricanes. Although hurricanes occur at Aransas National Wildlife Refuge, the hurricane season is generally complete by the time the cranes arrive in November. Nevertheless, severe weather can have devastating effects. A hurricane in 1940 was believed to be a factor in the							**N/A**

	deaths of seven of the remaining 13 whooping crane in the Louisiana flock, which led to the extirpation of this population 1948. In 2006, a lightning strike during a severe thunderstorm in Chassahowitzka National Wildlife Refuge killed 17 birds from the eastern migratory population that were in a pen.							
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Wolverine (*Gulo gulo*)
Populations (if applicable): 1 population.
Percentage of North American population NWT is responsible for: Wolverines are found across northern Eurasia and North America. In Canada, they are found in northern and western ecologically intact forested areas, in alpine tundra of the western mountains and in the Arctic tundra. They are found across the NWT in all habitats, although they are thought to be absent from most Arctic islands in the NWT except Victoria and Banks Islands.
NWT General Status Ranks: Sensitive
NatureServe Conservation Rank (NWT): S3
***Species at Risk (NWT) Act*:** N/A (assessed as Not at Risk in 2014)
***Species at Risk Act* (Canada):** Special Concern
Reasons for assessment or population trends: Wolverines range throughout the NWT and are well-suited to many different habitats and conditions. Habitat availability and fragmentation are currently not considered to be major issues for wolverines in the NWT. Wolverines naturally occur at low population density and there is evidence that the population is stable or increasing across much of the NWT; however, there is some indication that populations may be declining in the central barrens, potentially related to declines in barren-ground caribou. There is a general consensus that wolverines are found in the same areas they were historically found and may even be expanding their range northward. Wolverines are effective predators and scavengers, capable of utilizing many alternate food sources during times of prey/carrion scarcity. The possibility of rescue from other northern jurisdictions is considered high, as neighbouring populations are deemed to be healthy and mobile. While the main threats to wolverines were identified to be harvesting, decreasing food availability and sensitivity to noise, the individual threats were all deemed to be low to negligible at this time. Wolverines generally avoid areas of human activity; disturbances near denning sites have adverse effects on wolverine reproduction in the long term. Increasing frequency and magnitude of threats, as well as their cumulative effects, could cause wolverines to be considered a species of Special Concern in the NWT.
Sources used for assessments: SARC (2014b)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[322] = 1		
Dependence on habitats that are	Wolverines range throughout the NWT and are well-suited to many different habitats and conditions.	1 – Broad generalist

[322] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.

sensitive to climate change[323]	Wolverines can be found in a wide variety of habitats, but seem to prefer the treeline, higher areas, or rocky and hilly areas where there are no trees. Females den under snow-covered rocks, logs, or within snow tunnels without additional structure. The snow cover, in areas where wolverines reproduce, persists at least into April or early summer at higher latitudes. Although there is a clear relationship to snow/cold conditions, the impact of climate change is overall expected to be negligible/beneficial in the northern parts of their range.	
Sensitivity to climate-relevant abiotic factors[324]	Wolverines range throughout the NWT and are well-suited to many different habitats and conditions. Some knowledge holders indicate that wolverines thrive in even the coldest weather.	1 – Not sensitive.
Sensitivity to climate-relevant biotic factors[325]	Wolverines are effective predators and scavengers, capable of utilizing many alternate food sources during times of prey/carrion scarcity. The skull structure is robust, allowing it to crush bones and eat frozen carcasses. Their diet is extremely varied; however, BGC are a main food source. BGC have been experiencing significant decline throughout most of their North American range. Diets of wolverines typically vary over time, as they switch between food sources depending on availability, according to a generalist feeding strategy.	1 – Not sensitive.
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	All non-climate stressors are considered to have a low to negligible impact in the NWT at this time.	1 – No pressures.
Adaptive capacity[326] = 2.5		

[323] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.
[324] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.
[325] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

Reproductive capacity[327]	There is low survivorship in the first year. Most females do not breed until they are two to three years old and may not breed every year. Litter sizes average about two kits. The ability of wolverine populations to recover and repopulate vacant habitats is naturally low because of low fecundity. However, they also demonstrated population recovery following the close of a wolf control program. The maximum age reported for wolverines in North America is currently 16 years old, for an individual harvested in the Inuvik region. Generation time is likely 7.5 years.	4 – Late reproduction/few offspring
Dispersal capacity[328]	Wolverines are able to traverse most terrains. Wolverines can move quickly (10-30 mi/hr), cover long distances and are described as being constantly on the move, looking for food. Home ranges can be 50-400 km^2 for females and 230-1,580 km^2 for males. Dispersing juveniles may have even larger ranges. Because of their characteristics, wolverines may have the potential to travel large distances to find good habitat. Wolverines can travel up to 75-80 mi in a day. Male dispersal records include >200 km, 378 km over eight months, 874 km in 42 days, 541 km in 55 days and 73-326 km. A dispersal distance of 100 km was reported for a juvenile male in ON. Movements by females have been documented at >483 km over two months (total distance moved ~280 km), a 300 km movement by a female of unknown age and 69-225 km. Wolverines are able to traverse rugged terrain, including tundra and glaciers that would act as barriers to the dispersal of many other species of mammals.	1 - >10km
Genetic diversity		N/A
Phenotypic plasticity		N/A

[326] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
[327] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.
[328] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops								**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing								**N/A**
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling	Oil and gas exploration and development may present a threat in the future. However, habitat loss (permanent, temporary and/or functional) and fragmentation due to oil and gas development is presently low in magnitude.	L	U	C	LTF	L	L	**Low**

3.2 Mining and quarrying	Current developments in the NWT affecting the wolverines population include diamond mines. However, habitat loss (permanent, temporary and/or functional) and fragmentation due to mining is presently low in magnitude. It was suggested that wolverine fidelity to denning sites be considered in regards to increased mineral exploration occurring in the NWT. A study of the cumulative effects of developments on Arctic wildlife found that mines and other major developments had the largest negative effect on species occurrence, followed by exploration activities and outfitters camps. The species most affected were grizzly bears and wolves, followed by BGC and wolverines. In the central barrens, wolverines experienced a 2.4% decrease in functional summer habitat even though there were few disturbance features present. This apparent loss may in part reflect partial avoidance by caribou of active diamond mine sites by up to 14 km; wolverines likely concentrated their habitat use where the main sources of prey or carrion were most abundant.	L	L	C	N	M	L	**Low**
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads	Habitat loss (permanent, temporary and/or functional) and fragmentation due to roads is presently low in magnitude. The Mackenzie Valley Highway was the only active threat identified. It was felt that it would increase access to the Travaillant Lake watershed and Caribou Lake area (which is predicted to increase the harvesting pressure on wolverines), increase levels of disturbance (e.g. noise pollution) and increase incidents of wolverines being hit by vehicles. In the Rocky Mountain region, a decline in the occurrence of	L	L	C	N	M	M	**Low**

	wolverines was predicted when road densities exceeded approximately 1.7 km/km^2. The mean road density in wolverine home ranges was 0.43 km/km^2 in Ontario and individuals whose home ranges had a higher road density than the mean had a higher risk of mortality due to anthropogenic factors. In another study, wolverines avoided areas with human activities, including roads (mean road density of 0.37 km/km^2) and logging (i.e., temporary and functional habitat losses). Road density is not only associated with avoidance behaviour by wolverines, but there is an increased mortality risk due to trapping, hunting and collisions. Road density in the NWT is extremely low when compared to areas where impacts on wolverine behaviour have been observed. As of 2007, the Taiga Plains ecoregion, which contains most NWT communities, has a density of main roads of 0.0049 km/km^2. Total road density in the ecoregion, including winter and recreational roads is 0.0074 km/km^2. The scale of this analysis though is too large to detect road densities that might have an impact on wolverines at the landscape/home range scale. It is unlikely that any but the busiest roads around communities in the NWT cause any disturbance to wolverines and the disturbance is probably temporary only. Highway mortalities are also believed to be negligible in the NWT due to low traffic volumes. Increased resource development interest in the NWT has led to an increase in winter road activity, which provides the public with better access to more remote areas, which in turn is expected to potential improve opportunities for harvesting wolverines.							
4.2 Utility and service lines								**N/A**

4.3 Shipping lanes								**N/A**
4.4 Flight paths	Responses of wolverines to flying aircraft are variable, ranging from no response to running away and hiding. No response was most common in YT with respect to flights.							**Neg.**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	Since 1992, the mean annual harvest of wolverines, based on fur auction data for the NWT, is 109. Corrected for furs not exported in the Inuvik region, other regions and adding the reported harvest by SK hunters, the mean annual harvest is ~200 individuals. The unreported harvest from regions other than Inuvik is difficult to estimate from available data and so was not used. The harvest rate is therefore 3.3-6.7% of the population, likely sustainable assuming an intrinsic growth rate of 6.4%/year in untrapped populations. The proportion of lands currently untrapped in the NWT is unknown. Harvest is biased to young animals, suggesting the population is not being overharvested. The local overharvest of wolverines may occur in some areas, but this harvest is largely replenished by immigrants from untrapped refugia. The unreported harvest may be underestimated by about 35% across the NWT, with about 80% being kept for domestic use within Inuvialuit coastal communities. In NU, the actual harvest was reported to have been underestimated by 50-90% in the Coppermine, Bay Chimo and Bathurst Inlet areas. Although wolverine trapping and hunting are a potential threat in the NWT, harvest levels have remained stable. Harvest management, including quotas for some harvesters, limited seasons and the persistence of untrapped refugia act to reduce the threat. Attraction to food sources at camps and other areas of human	W	L	S	N	H	M	**Low**

	activities may result in the habituation of animals and increased vulnerability to problem wildlife and collisions with vehicles. Incidents involving wolverine-human interactions at diamond mines in the NWT and NU usually result in deterrence and only occasionally in relocation or mortality. Wolverine mortalities and relocations as a result of diamond mining activities appear minor, but in conjunction with trapping and hunting and barren-ground caribou declines, may be contributing to population declines.							
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting	Habitat loss (permanent, temporary and/or functional) and fragmentation due to forestry is presently low in magnitude. The effects of logging are not necessarily permanent or necessarily negative. Logging that mimics natural processes, such as fire, windthrow and insect outbreaks and creates a landscape matric of uneven aged forest stands, may actually diversify the prey base and maintain or improve wolverine habitat.							**Neg.**
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities	Habitat avoidance results from human activities such as backcountry recreation, which may impact wolverine behaviour patterns such as denning, kit rearing, travel and foraging. Disturbance of wolverine maternal den sites may lead to den relocation or litter abandonment. Evidence for direct impacts of winter recreation on denning wolverines is conflicting, but heli-skiing and backcountry skiing has been shown to reduce functional habitat values for wolverines, especially adult females, whose reproductive success may be affected.							**Neg.**
6.2 War, civil								**N/A**

unrest and military exercises								
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression	Some types of landscape disturbance, such as wildfires, may be considered beneficial to wolverines as regeneration attracts prey species. Wildfires are a natural occurrence in northern forests and are assumed to be beneficial, since populations of prey and carrion species such as moose, beaver and snowshoe hare thrive in regenerating burns.							**Neg.**
7.2 Dams and water management/use								**N/A**
7.3 Other ecosystem modifications	Wolverine density declined in the central barrens by between approximately 39-66%. These declines were likely due to concurrent declines in the Bathurst caribou herd. However, these densities, even at their reduced levels, are in the range of moderate to high densities relative to other areas where wolverines have been studied in North America. Declining ungulate populations, especially barren-ground caribou in the NWT, has the potential to initiate wolverine population declines or fluctuations. Viable populations of large carnivores such as grizzly bears and wolves are important as involuntary providers of ungulate carrion. Wolverines in boreal habitat appear to consume a more diverse range of species in their winter diet and consume less caribou. This would support the view that wolverines that are less reliant on caribou may not be as susceptible to population decline as those wolverine populations on the central barrens.	L	H	C	N	H	M	**Medium**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien								**N/A**

species/diseases								
8.2 Problematic native species/diseases								**N/A**
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents								**N/A**
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)	Wolverines are reportedly sensitive to noise disturbance, especially females about to have their young. While caribou and muskoxen can become less sensitive to noise with exposure over time, it seems that wolverines remain sensitive. The individual threat from noise was deemed by SARC to be low to negligible at this time.	L	U	C	N	H	L	**Low**

10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Climate models predict increases in temperature and precipitation in Canada, with the largest warming projected for northern Canada. Precipitation is likely to increase in winter and spring, but decrease in summer. Snow season length is predicted to decrease, but a net increase in snowfall should make up for the shorter snow season, resulting in increased snow accumulation. Since spring snow cover during the denning period is a critical habitat requirement of wolverines, the impact on wolverines should be negligible in the Arctic. Earlier snowmelt could actually benefit wolverines by improving primary (plant) productivity. Some concerns were raised in terms of the effect of climate change on hunting ability, seasonality (which could affect mating and rearing of young), fur quality and forest fire and flood patterns. Ultimately, although there is a relationship between wolverines and snow/cold climate, a climate-driven population decline in Canada is not evident, since wolverine population trends, while largely unknown, are believed to be stable or increasing in many areas. Reductions in spring snow cover associated with climatic warming will likely reduce the extent of wolverine habitat in southern mountainous areas of the US, whereas in northern							**Neg.**

	areas these climatic factors represent less important limits. Reductions in spring snow cover have not been assessed for lowland or mountain habitats in Canada.							
11.2 Droughts								**N/A**
11.3 Temperature extremes								**N/A**
11.4 Storms and flooding								**N/A**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Wood Bison (*Bison bison athabascae*)
Populations (if applicable): Greater Wood Buffalo Ecosystem (GWBE), Mackenzie, Nahanni
Percentage of range NWT is responsible for: The proportion of the global and/or continental population occurring in the NWT is approximately 32%.
NWT General Status Ranks: At Risk
NatureServe Conservation Rank (NWT): S2
***Species at Risk (NWT) Act*:** Threatened
***Species at Risk Act* (Canada):** Threatened (down-listing to Special Concern being considered)
Reasons for assessment or population trends: The entire wood bison population in the NWT is estimated at about 2,500 animals in three disjunct populations (GWBE, Mackenzie and Nahanni). An overall decline of at least 10% was estimated over the past three bison generations. An overall decline of 50% was estimated over the most recent bison generation. In the most recent bison generation, only the small Nahanni population has shown an increase. The main threats are: (1) Three infectious bacterial diseases are currently of concern to the conservation of wood bison in the NWT (anthrax (*Bacillus anthracis*), bovine tuberculosis (*Mycobacterium bovis*)and bovine brucellosis (*Brucella abortus*)). The 2012 anthrax outbreak is of particular concern for the Mackenzie population. (2) Predation primarily by wolves and bears, especially on newborn calves. (3) Human-caused mortality, including bison-vehicle collisions, disease management actions and harvest contribute cumulative threats to wood bison. (4) Various factors may contribute to a loss of meadow habitat (e.g. changes in floods/drawdowns, fire, snow pack and water levels and increased shrub encroachment). Future road encroachment in wood bison habitat may increase the zone of influence of human activity, especially for the GWBE and Mackenzie populations. Anticipate future industrial development and corridors within certain segments of wood bison habitat may adversely impact wood bison populations in the NWT. The NWT is home to an estimated 32% of the global/continental population of wood bison.
Sources used for assessments: SARC (2016, 2019).

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[329] = 1.3		
Dependence on habitats that are	Wood bison are generalist herbivores that specialize in grazing, meaning that they usually select sedge-grass	2 – Generalist, but some sensitive

[329] Overall sensitivity score is based on the average of habitat, abiotic and biotic factor scores.

sensitive to climate change[330]	food patches and then consume a variety of herbaceous plants according to their abundance. Sedges and grasses may be sensitive to changes in temperature and precipitation. 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. The main landscape features in the NWT providing the highest forage biomass for wood bison are marl lake basins, fens, floodplains and salt plains. All are wetlands. There has been a net loss of marl lake bison habitat since the 1970s-1980s. If drying occurs in the future, this may be reversed. Early seral stages of vegetation must be revitalized and maintained by frequent cycles of high amplitude floods/drawdowns and fires. Shifts in these disturbance regimes are likely to influence wood bison habitat.	habitats are important.
Sensitivity to climate-relevant abiotic factors[331]	Neither the upper physiological limit of heat tolerance in summer, nor the lower limit of cold tolerance in winter has ever been determined. Beringian bison were able to thrive in periglacial environments where the winters were colder than where wood bison live today; however, snow was shallow and exceptional summer growing conditions produced an abundance of food. Heat tolerance is likely to be high if plains bison inhabiting the American southwest are any indication. Bison have a dense, woolly undercoat overlain by longer guard hairs, which makes them resistant to cold temperatures. The climatic thresholds of wood bison physiology for higher latitudes are unknown. Wood bison can suffer impaired movement in some snow conditions (deep, hard).	1 – No significant limits to physiological tolerances.
Sensitivity to climate-relevant biotic factors[332]	*Carex atherodes*-dominated wetlands are one of the most important habitat components for wood bison. However, wood bison are nonetheless considered a	1 – Not sensitive.

[330] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.
[331] For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.

	generalist herbivore. No information was presented indicating that disease or predation would become worse under a changing climate. No information was presented on the introduction of novel pests and pathogens, although it's generally agreed that warming temperatures may create conditions more favourable for pathogens.	
Non-climate stressors		
Sensitivity to potentially interacting non-climate pressures	The most important non-climate stressors for wood bison include disease, upstream water regulation (disruption of high amplitude flood/drawdown cycles) and vehicle collisions.	3 – Likely major pressures.
Adaptive capacity[333] = 2.5 plus 0.5 for low genetic diversity = 3		
Reproductive capacity[334]	Female bison reach maximum body weight at ten years, while males reach theirs by 13 years. Males do not generally begin to breed until they are five to six years old. Unlikely that many animals in the wild live past 20 years; however, longevity has not been determined. Likely only a single ovulation per year, with a gestation period ~285 days (9.5 months). The majority of females produce calves every other year. The highest reproductive success for females is between three to 12 years of age. The age of first successful reproduction is expected to be delayed by brucellosis in bison of the GWBE. Most animals abort the first pregnancy following infection but will usually carry subsequent pregnancies to term.	4 – Late reproduction/few offspring
Dispersal capacity[335]	Bison can tolerate shallow, soft snow, but hard or crusted snow and deeper, longer lasting snow and ice layers within the snowpack tip the energetic balance against them. Bison have a lower morphological index for snow-coping ability than wolves, making them easy prey in winter. However, wood bison have longer limbs than plains bison, providing an advantage in deep	1 = >10km

[332] Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).

[333] Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.

[334] Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.

[335] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

	snow. Dispersal ability is impeded by the bison control area, which was put in place to prevent spread of tuberculosis and brucellosis among populations.	
Genetic diversity	The GWBE is the most genetically diverse wood bison population in the NWT. The Mackenzie and Nahanni populations have lower levels of genetic diversity as a result of being established by a small number of animals. Limited genetic diversity in bison populations is also an issue outside of the NWT. Low levels of genetic diversity in a population can result in a higher vulnerability to disease and lower reproductive success and/or survival. It can also result in a reduced ability to adapt to changes in the environment, such as those resulting from climate change.	0.5
Phenotypic plasticity		N/A

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops	Bison are particularly susceptible to agricultural development because both bison and farmers share a penchant for extensive level tracts of fertile soils. Although agriculture has been an important form of habitat loss for wood bison in western provinces, this activity is relatively undeveloped in the NWT. Dormant agricultural leases in the Mills Lake – Horn River Delta meadows are no longer a potential threat as the leases were bought out by Ducks Unlimited Canada. Anticipated that these leases will be transferred to the federal government under the NWT Protected Areas Strategy (Edéhzhie National Wildlife Area). Agricultural interests have been apparent in the Liard Valley and Slave River Lowlands since the 1960s, but there have never been large scale initiatives. In an effort to improve food security, the NWT has seen a rise in agricultural activities over the last decade. In 2015, the GNWT produced the first NWT Agriculture Strategy. One of the goals of the	L	L	S	LTF	M	H	**Low**

	strategy is to build a viable agriculture industry. Agriculture presents a number of challenges to wood bison recovery. Changing natural ecosystems into farmland reduces wildlife habitat. Crop or property damage caused by bison reduced local acceptance of wildlife and problem animals may be at risk of being killed by land owners.							
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing	The introduction of ranching in wood bison habitat in the NWT was considered a future threat (as of 1990). See above re: Agriculture Strategy. If diseases are undetected in livestock, domestic animals have the potential to spread diseases such as tuberculosis and brucellosis to wood bison. Disease transmission from domestic to wild animals is an emerging issue that is gaining importance as agriculture expands north. Sheep are of concern because they are carriers of the ovine herpes virus-2 infection (OHV-2) and show no signs or ill effects. The OHV-2 infection can spread to bison through direct or indirect contact with sheep. In bison, OHV-2 becomes malignant catarrhal fever (MCF). MCF is an infectious, viral disease to which bison tend to be very susceptible and which can result in exceptionally high mortality rates. Although this infection is a concern, the OHV-2 infection has not been detected in wood bison in the NWT. Johne's disease is mainly a chronic disease of domestic ruminants. The causative agent is evident in all NWT wood bison populations, although the disease has not been documented in any free-ranging wood bison. It is unlikely that Johne's disease causes a high level of mortality in wood bison, but such chronic diseases can have a debilitating impact on a population. Overall, diseases in domestic livestock that have the potential to infect wildlife are a concern for wildlife managers. NWT wildlife managers are addressing these concerns proactively through import, possession and export	L	H	C	LTF	M	H	**Medium**

	regulations. Risk mitigation also includes regulating the transport of domestic animals (including containment systems), fencing and disease testing. Crop or property damage caused by bison reduces local acceptance of wildlife and problem animals may be at risk of being killed by land owners.							
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling								**N/A**
3.2 Mining and quarrying	Seismic lines and other linear disturbance, while creating forage for wood bison, also increase hunting pressure through increased access. An increase in linear disturbances relating to development has served to greatly increase the ease of access to hunting areas that were previously remote and inaccessible in northern Alberta. This has increased hunting pressure on wood bison in the area, in particular in the later winter and early spring.	L	L	C	N	H	M	**Low**
3.3 Renewable energy								**N/A**
4. Transportation and service corridors								
4.1 Roads and railroads	Future road encroachment in wood bison habitat may increase the zone of influence of human activity, especially for the GWBE and Mackenzie populations. Members of the Dehcho First Nations and the Tłı̨chǫ noted concern with the number of wood bison being killed on highways, with some knowledge holders in these regions indicating that they considered this the most important threat facing wood bison. They noted this appeared to be related, in part, to the use of road salt on highways, which attracts bison. Collisions between bison and vehicles are an important cause of mortality for wood bison populations in the NWT. Wood bison use road right-of-	L	M	C	N	H	H	**Medium**

	ways for grazing and movement and are frequently found along roads. An average of about 20 collisions are reported to police every year. Collisions are most frequent from August to December. Most collisions involve the Mackenzie population (84%). 400 recorded mortalities on NWT highways since 1989. The development of roads, access trails and ice crossings for timber harvesting (associated with forest management agreements) may modify wood bison habitat and movements, hunter and predator access and bison-vehicle collisions. It remains unclear how significant these potential impacts will be on wood bison populations.							
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes	Boat and barge traffic have also been noted as a potential threat to wood bison in the NWT, given the waves and wakes this type of traffic can create. Wood bison sit quite low in the water while swimming, with their noses just a few centimeters above the water, which makes them vulnerable to drowning from any increase in wave action. Actual number of drownings associated with shipping activity not noted.							**Neg.**
4.4 Flight paths	Bison reaction to aircraft is 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 distance and others stopped after the aircraft headed away.	L	L	C	N	H	L	**Low**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and collecting terrestrial animals	Human-caused mortality, including harvesting and disease management actions like culls for disease control and vaccination round-ups, represents an important historical threat to wood bison; one that populations have not yet recovered from. Human-caused mortality, including collisions (addressed in 4.1), disease management actions and harvest contribute to cumulative threats to	W	L	C	N	H	H	**Low**

	wood bison. When hunting pressure increases, wood bison are known to move into the bush (poorer habitat) and away from access routes. Hunting pressure tends to increase in conjunction with increased access to wood bison habitat. WBNP bison in the NWT are protected from hunting by the Canada *National Parks Act*. Nahanni and Mackenzie populations also receive special protection from unrestricted hunting via the Game Declared in Danger of Becoming Extinct regulations and are carried over in the new *Wildlife Act*. Harvest is managed by quotas. All hunting of Mackenzie bison has been halted until the population shows recovery (with one four to five animal exception). Resident harvest in the Slave River Lowlands (part of the GWBE outside WBNP) is typically three to five animals/year, but Aboriginal harvest is not recorded.							
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting	Active logging causes wood bison to leave an area and regions with a greater amount of logging are less attractive to wood bison. Timber harvesting also has the potential to improve habitat on a small scale. Clearcuts examined in northern AB provided adequate forage for wood bison during the summer and capacity typically started decreasing eight years after the harvest. With two new forest management agreements in place, timber harvesting is expected to increase in the range of the Mackenzie and GWBE populations. Forest management agreements were recently signed in the Fort Providence and Fort Resolution areas and land use permits have been issued for timber harvesting in both areas.	L	L	S	STF	H	L	**Low**
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								

6.1 Recreational activities								**N/A**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities	Historically, disease eradication efforts in the late 1980s were considered a threat to wood bison; in terms of the way disease monitoring and prevention were carried out, including driving the animals by helicopter flights, herding, corralling and other techniques. Forcing wood bison to run using herding practices can also have disastrous consequences (e.g. injuries including trampling, drowning, collapse, abortions, death). The vaccine itself and the stress of corralling were noted as possibly increasing the likelihood of disease. Some Aboriginal hunters link the start of the anthrax vaccination program with the decline of the herds. The effects of the vaccine may also be lingering, as some hunters indicated that the flavour of the non-vaccinated herds outside the park is superior.							**Neg.**
7. Natural system modifications								
7.1 Fire and fire suppression	FIRE SUPPRESSION: Forest expansion due to fire control after the mid-1990s likely contributed to a regional reduction in carrying capacity. Forest fires are considered important in opening up habitat. Burns maintain high quality grassland open for use by wood bison and other wildlife. Frequent wildfires in bison range have produced the greatest results for habitat restoration. However, ignitions are impossible to predict and spread is often driven by weather. Wood bison may seek out burned areas soon after a fire, which provide good habitat. Although impacts from the severe 2014 fire season have not yet been assessed, Fort Providence harvesters have observed bison moving into these burn areas to consume the fresh plant growth. Although high fire frequencies produced optimal upland bison habitat before the implementation of organized fire suppression, several large fires in the mid-1990s have contributed to a net gain in upland bison habitat over the past three generations.	W	U	S	N	H	L	**Low**

	However, there are concerns that large fires may ultimately be detrimental. The large fires seen in recent years are seen by some as a potential threat to wood bison. These fires can destroy animals and habitats, resulting in immediate mortality and longer-term decline owing to a lack of food resources, increased vulnerability to predation and reduced capacity for movement as a result of deadfall within burn areas. These large fires are blamed on a combination of climate change and fire management decisions and it has been recommended that the focus should be on keeping fires small. In areas where lichen provides emergency food for wood bison during extreme weather (i.e., the Caribou Mountains in northern AB), forest fires can damage the soil and lichen supplies. Lichens do not regenerate quickly after a forest fire.							
7.2 Dams and water management/use	Since the early 1970s, there have been diminished flood/drawdown cycles in the range of the GWBE population, tied to the W.A.C. Bennett Dam and the Williston Reservoir. Runoff from the Rocky Mountains in BC is held in the Williston Reservoir during the spring freshet and summer for release back into the system during the autumn and winter when hydroelectricity demand is the greatest. By the end of winter, the reservoir is generally drawn down to its lowest level and the refilling cycle continues with each spring melt and summer precipitation. 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 and especially timing of the flood/drawdown cycle of the Slave River. This concern may be heightened with the recent approval of the Site C dam. Site C would result in changes to the entire river flow regime during the construction phase. Approximately 2/3 of the water in the Slave River flows from the Peace River and since the impoundment of the Peace River at the Bennett Dam, sediment loads in the Slave River have decreased by	W	M	C	N	H	L	**Medium**

	1/3, spring flow levels are lower and a general drying trend has occurred in the Slave River Lowlands and delta. Consequently, growth of the geomorphological structure of the delta has slowed and herbaceous riparian communities are being replaced by woody vegetation and mosses that are intolerant of the sediment loading that accompanies frequent flooding. Channel migration and climate variability have also had significant effects on the Slave River delta. Almost ¾ of the inflow to Great Slave Lake originates from the Slave River and Great Slave Lake is the source for nearly all of the water entering the upper Mackenzie River. If upstream regulation can affect seasonal levels in Great Slave Lake, outflows to the downstream Mackenzie River may also experience some degree of seasonal dampening from regulation. However, 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 longer-term studies are being carried out. Comparison of aerial photos of the Mills Lake – Beaver Lake area from 1970-present shows encroachment of willows and aspen into former sedge meadows, but the extent has never been measured.							
7.3 Other ecosystem modifications								**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases								**N/A**
8.2 Problematic native species/diseases	Historical population decline in the GWBE has been attributed, at least in part, to the cessation of wolf control in the NWT. Age structure of bison herds (with older animals boosting the wolf population) and alternate prey (e.g. muskrat) has possibly also contributed to heavy wolf predation. Wood bison are particularly							**Neg.**

	vulnerable to predation by wolves during the summer when the soft, moist ground forces the heavy bison to sink, making it difficult for them to maneuver. If the functional response of wolves is related to the number of bison groups and not the number of individual bison, the killing rate would be expected to stay high until bison reach very low numbers. Recruitment rates are very sensitive to predation levels. Larger wolf pack size does not result in more food/wolf/day. No indication in the status report that predation rates are outside of the normal.							
8.3 Introduced genetic material	Crossbreeding with cattle and plains bison (either of pure lineage or carrying some cattle heritage from past breeding experiments) are the primary forms of hybridization that potentially threaten the genetic integrity, fitness and evolutionary pathway of wood bison. The most imminent threat is between the expanding Nahanni herd and feral plains bison in BC (Pink Mountain herd). The growing commercial plains bison ranching industry in this province has also resulted in an increased number of escapees. The genetic integrity of every wood bison herd existing today is already compromised by some plains bison introgression. Hybridization with cattle has a low probability as the two species do not voluntarily interbreed. Where it does occur, fertility of the offspring is compromised.	L	U	S	LTF	M	H	**Low**
8.4 Problematic species/diseases of unknown origin	Three infectious bacterial diseases are currently of concern to the conservation of wood bison in the NWT: anthrax, bovine tuberculosis and bovine brucellosis. Brucellosis and TB likely originated from infected plains bison from Wainwright. The 2012 anthrax outbreak is of particular concern for the Mackenzie population. Brucellosis is considered a significant impediment to restoration. Johne's disease is also considered a medium impediment by some expert groups. Clinical cases have never been observed here, although the causal organism is evident in all NWT populations. The origin of infections in wood bison is uncertain. Johne's disease is unlikely to cause a high level of mortality in wood bison but such chronic diseases can have a debilitating impact on a	W	M	C	N	H	H	**Medium**

	population. Since 1962, there have been eight documented anthrax outbreaks in the Slave River Lowlands, 13 in WBNP and three in the Mackenzie. These outbreaks have killed at least 2,266 bison in total. Even though mortality was sudden, it was generally infrequent. In all WBNP subpopulations, the probability of pregnancy was 30% less likely for females with both brucellosis and TB, compared to females with one or neither disease. A risk assessment on the potential spread of TB and brucellosis from bison in and around WBNP predicted that the introduction of infection to wild healthy bison herds would occur perhaps once every eight years for brucellosis and once every six years for TB. A movement corridor analysis recommended additional aerial surveillance of specific areas within the bison control area based on the habits of bison. Unfortunately, the bison's gregarious behaviour facilitates greater opportunities for disease transmission. No highly effective vaccines are available for preventing diseases in free-roaming bison. The only feasible method for eradicating TB from a herd seems to be the removal of all infected animals, as well as all exposed susceptible animals. In the GWBE, we can assume that all bison have been potentially exposed and are susceptible to infection. Herd eradication is not being considered as an option moving forward at this time.							
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater	Environmental pollutants, for example, the pollution of the Peace River, are considered a threat and are linked by Cree hunters to	L	L	S	N	H	L	**Low**

	disease in wood bison.							
9.2 Industrial and military effluents								**N/A**
9.3 Agricultural and forestry effluents (including erosion)								**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne pollutants								**N/A**
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration	Sedge growth is particularly sensitive to mean monthly temperature. Coarse sedges, in particular awned sedge (*Carex atherodes*), are the main source of food for the Nahanni and GWBE populations. In the Mackenzie population, sedges constitute an important part of the winter diet. *C. atherodes* thrives best in areas that are seasonally flooded with shallow water and neutral to slightly alkaline pH. Reed grasses, especially bluejoint (*Calamagrostis canadensis*) and willows (*Salix* spp.), are highly preferred at certain times of the year and they are also associated with moist, fertile conditions.	W	U	C	STF	H	L	**Low**

	When Mackenzie and GWBE bison used treed habitats, they tended to select aspen and jackpine stands. Coniferous forests, which supply the greatest biomass of lichen, are heavily used by the Mackenzie bison in autumn. Conditions in which sedges and grasses thrive appear to be somewhat sensitive to climate variability and precipitation. Lichen-bearing forests are sensitive to increased fire frequency, predicted as a consequence of climate change.							
11.2 Droughts	Declining snowpacks in the catchments of other main tributaries since the mid-1970s and a shorter ice season since the 1961-1990 period compound the problem of upstream hydro. This trend may actually have begun in the late 19th century. Several recent dry years and the absence of natural flooding and spring freshet may improve wood bison habitat by promoting the growth of grassy meadows, or may adversely affect habitat as a result of tree and shrub encroachment. Since the time of optimal moisture levels and peak forage production in the 1970s and 1980s, there has been a net loss of marl lake bison habitat of unknown proportions. Although climatic oscillations cannot be predicted, a drying trend can be expected to recur in the future that could restore marl lake bison habitat.							**Neg.**
11.3 Temperature extremes	Climatic anomalies, such as harsh winters, can impact sedge growth and habitat availability.							**Neg.**
11.4 Storms and flooding	Increases in storms and flooding/wetter snow could impact sedge growth and habitat availability (Lee pers. comm. 2020).							**Neg.**
11.5 Other								**N/A**
12. Other threats								
								N/A

Species: Yellow Rail (*Coturnicops noveboracensis*)
Populations (if applicable): N/A
Percentage of North American population NWT is responsible for: 90% of breeding range in Canada. Canadian range is poorly known. In the NWT, recent records have extended the known summer range west and north of the yellow rail's previously known limit of Great Slave Lake, to as far as Nahanni National Park Reserve and the north and west shores of Great Slave Lake. Possibly 20-100 pairs in the breeding range of the NWT, out of a total of 5,000-6,000 pairs.
NWT General Status Ranks: Sensitive
NatureServe Conservation Rank (NWT):
***Species at Risk (NWT) Act*:** N/A
***Species at Risk Act* (Canada):** Special Concern
Reasons for assessment or population trends: Relatively little is known about this small, secretive rail. It is primarily restricted to shallow, dense, grassy marshes and wet meadows. Most of its breeding range (about 90%) is in Canada. It is relatively uncommon in most areas; populations are most widespread and common in coastal areas of Hudson and James Bay in northern Manitoba, ON and Quebec. It winters in shallow marshes that occur in a narrow band extending from Texas to the Carolinas. The species is close to meeting some criteria for Threatened status because of its relatively small population size, compressed winter range, ongoing threats to breeding and wintering wetland habitats and evidence for local declines in several parts of its breeding range.
Sources used for assessments: COSEWIC (2009d)

Climate change vulnerability assessment:

Category	Notes	Score/Rationale
Sensitivity[336] = 2		
Dependence on habitats that are sensitive to climate change[337]	Nest in wet, marshy areas of short, grass-like vegetation, usually sedge (esp. *Carex* spp.) that have an overlying dry mat of dead vegetation that they use to roof their nests. The habitat must remain wet throughout the breeding season, but have no more than 15 cm standing water during that period. Yellow rails are found in a variety of habitats that provide these needs. Thus, they inhabit not only sedge meadows, bogs, but also wet hay fields and grassy	3 – Depends on sensitive habitats that are not rare.

[336] Overall sensitivity score is based on the average of habitat, abioticand biotic factor scores.
[337] For example, wetlands, seasonal streams, alpine, coastal fringe. This factor captures complex interactions among abiotic and biotic factors that result in emergent patterns on the landscape, including natural disturbance regime. Includes specialists defined with a climate change lens. Dependence on sensitive habitats will also affect adaptive capacity. Specialist species will be vulnerable, even with large populations, because heritable variation for traits that lead to specialization is likely low, limiting the potential for evolution.

	meadows, floodplains, wet prairie, wet Montane meadows and the upper margins of estuaries, coastal salt marshes and, during winter, rice fields. Habitat needs are similar at other times of the year, although the tolerance for water levels and the presence of senescent mats of vegetation is broader. Hydrologic changes because of climate change are considered a threat but are not discussed in detail in the status report/assessment. The wintering population is exposed to relatively frequent catastrophic weather events (e.g. hurricanes) that occur in this region.	
Sensitivity to climate-relevant abiotic factors[338]		Unknown
Sensitivity to climate-relevant biotic factors[339]	Feed mainly on beetles and other small arthropods, as well as seeds of the grass-like vegetation that dominates their habitat.	1 – Not sensitive.
Non-climate stressors = 1		
Sensitivity to potentially interacting non-climate pressures	There are no significant non-climate stressors in the NWT.	1 – No pressures.
Adaptive capacity[340] = 1		
Reproductive capacity[341]	Clutches of about eight eggs. Incubated by both sexes. Age at first breeding is one year for other rail species but unknown for yellow rails. Most studies report high hatchability. Survival beyond hatching is unknown; adult return rates are believed to be less than 11% but, as is typical of rails, this low figure may reflect high dispersal rates, rather than high mortality. Lifespan unknown. Generation time likely over two years.	1 – Early reproduction/many offspring
Dispersal capacity[342]	Migratory. Most species of rail are highly dispersive, presumably as an adaptation to locally ephemeral	1 - >10km.

338 For example, temperature, desiccation, snowpack, dissolved oxygen, pH. This factor addresses physiological tolerances.
339 Sensitivity to climate-relevant biotic factors. Species with particular ecological relationships may be more sensitive if these relationships are altered by climate change (e.g. predator-prey relationships, phenology, disease).
340 Overall adaptive capacity is the mean of reproductive capacity and dispersal ability, modified by genetic diversity in some cases: >3.5 = very poor, 3 = poor, 2.5 = moderate-poor, 2 = moderate, 1.5 = moderate-good, 1 = good.
341 Describes life history strategy (along the continuum between r and K selection). Reproductive capacity ratings are based on averages provided in sources.

	water conditions. This is probably even truer of the yellow rail, which is more likely to inhabit seasonal and semi-permanent wetlands than most other rail species. After breeding, they appear to travel to particular areas to molt, a two-week period during which they are flightless.	
Genetic diversity		N/A
Phenotypic plasticity		N/A

[342] Dispersal distances are taken from maxima noted in sources. Distances do not necessarily reflect effective dispersal. Barriers to dispersal limit adaptive capacity; barriers are noted and included in the adaptive capacity rating.

Threats assessment:

Category	Notes	Extent	Severity	Temporality	Timing	Probability	Certainty	Overall level of concern
1. Residential and commercial development								
1.1 Housing and urban areas								**N/A**
1.2 Commercial and industrial areas								**N/A**
1.3 Tourism and recreation areas								**N/A**
2. Agriculture and aquaculture								
2.1 Annual and perennial non-timber crops	Mowing and haying (outside of nesting season) can be effective management tools for maintaining yellow rail habitat, but can be destructive if applied inappropriately. In particular, they can remove the senescent layer of vegetation that the birds need for nesting.							**N/A**
2.2 Wood and pulp plantations								**N/A**
2.3 Livestock farming and grazing	Grazing by livestock removes vegetation before it can form the dead mats needed for nesting and grazing animals might also increase direct disturbance of the birds' normal activities. If livestock are not fenced back from wet areas, they will graze the margins of wetlands, where yellow rails are most likely to occur. Grazing might account for the abandonment of several historically occupied yellow rail sites in AB. Extent of this threat is very likely negligible or n/a, however, it should be noted that farms in the southern NWT, where they abut a							**N/A**

	water body, may not be fenced (Cassidy pers. comm. 2019). Unclear whether this could have an impact (i.e., whether those water bodies are features such as rivers or also include wetlands).							
2.4 Marine and freshwater aquaculture								**N/A**
3. Energy production and mining								
3.1 Oil and gas drilling	In Alberta, fens are being lost to oil sands development and replaced, at best, by other wetlands types, although whether this has directly affected yellow rail habitat, per se, is unknown. Energy projects in AB and the NWT threaten habitat both through direct habitat destruction, for mines, pipelines and hydro lines, for example and indirectly through changes in hydrological regimes, particularly for oil sands extraction.							**Neg.**
3.2 Mining and quarrying	See 3.1.							**Neg.**
3.3 Renewable energy	See 3.1.							**Neg.**
4. Transportation and service corridors								
4.1 Roads and railroads	An occupied marsh in southern Manitoba was partly destroyed for highway development and between the 1960s and 1980s, 10-50% of township sections in that region lost wetlands. Wetlands in southern ON and Quebec are under heavy pressure from various forms of fragmentation and degradation. Over 50% of potential yellow rail habitat along the St. Lawrence and Saguenay rivers was lost during the last decades of the previous century to filling and construction projects, such as harbour infrastructure and highways.							**N/A**
4.2 Utility and service lines								**N/A**
4.3 Shipping lanes								**N/A**
4.4 Flight paths								**N/A**
5. Biological resource use (intentional, unintentional, or for control)								
5.1 Hunting and	A variety of accidental deaths occur frequently enough to be							**N/A**

collecting terrestrial animals	regarded as cumulative threats to the relatively small population. Yellow rails are sometimes killed and frequently disturbed by mowers and harvesters; indeed, watching rice harvesters is a main technique used by birders to see the species in its wintering range. Yellow rails are also frequently killed by colliding with tall structures during migration and with fences. Treading on birds and their nests by overeager birders has occurred at several sites, some of which used motorized 'rail buggies' to flush rails, which also sometimes killed birds and destroyed habitat. Accidental shooting of yellow rails has not been documented but might occur on occasion, given their similarity to immature soras, which are legal game birds in most United States. However, yellow rails are not targeted by hunters, nor are they of any other consumptive use.							
5.2 Gathering terrestrial plants								**N/A**
5.3 Logging and wood harvesting								**N/A**
5.4 Fishing and harvesting aquatic resources								**N/A**
6. Human intrusion and disturbance								
6.1 Recreational activities	ATVs have been identified as having the potential to disrupt wetland habitat and to disturb wetland birds.							**Neg.**
6.2 War, civil unrest and military exercises								**N/A**
6.3 Work and other activities								**N/A**
7. Natural system modifications								
7.1 Fire and fire suppression	Burning is an effective tool for arresting succession and stimulating dense growth of graminoid vegetation, but again can be destructive if it is done so infrequently as to produce destructively hot fires or so frequently that the senescent mat cannot form.							**Neg.**

7.2 Dams and water management/use	Habitat loss and degradation continues locally through drainage, dyking, infilling and diversion of wetlands.							**N/A**
7.3 Other ecosystem modifications	Estimates of historical wetland losses in different regions include 71% for Canadian prairies, 70% for southern Manitoba, 60% for southern ON, 80% for Quebec along the St. Lawrence River, 85% for the northeast reaches of the Bay of Fundy, 85% for the Upper Klamath Basin of Oregon and 50% for the conterminous US. Coastal marshes in the heart of the wintering range in Texas cover 52% less area than they did when Europeans first settled there and in Louisiana, 23-35% of coastal wetlands were lost between 1932 and 1990. Anecdotal reports suggests that small losses continue. On the wintering grounds, coastal habitat continues to decline in Louisiana, because of increases in sea levels, storms, geological subsidence and run-off. In Texas, however, the area of estuarine marsh may have stopped decreasing and even started increasing, since the 1950s.							**N/A**
8. Invasive and other problematic species, genes and diseases								
8.1 Invasive non-native/alien species/diseases	The invasive non-native form of common reed, *Phragmites australis*, has infiltrated rail habitat at Île aux Grues during the last 15 years and active management is needed to halt succession at Lac Saint-François National Wildlife Area. This invasive species threatens yellow rail breeding and moulting sites in some southern breeding areas, including the St. Lawrence River. Purple loosestrife is another invasive plant that could threaten yellow rail habitat in southern Canada, as it has in Michigan.							**N/A**
8.2 Problematic native species/diseases	Since the 1970s, coastal marsh habitat in parts of the Hudson Bay Lowlands, within the range of yellow rails, where snow geese breed or stage, has been destroyed or severely fragmented by heavy grazing by high numbers of geese, including sites where yellow rails formerly nested at LaPerouse Bay and Wapusk National Park. Their grazing particularly affects the graminoid species yellow rails							**N/A**

	prefer. Even in the absence of snow geese, recovery of the local ecosystem will take decades. The extent to which this threat actually comprises large areas of yellow rail breeding habitat, however, is unknown. The species is presumably subject to a variety of both generalist and specialist parasites, as are other species of rail, but these have not been studied.							
8.3 Introduced genetic material								**N/A**
8.4 Problematic species/diseases of unknown origin								**N/A**
8.5 Viral/prion-induced diseases								**N/A**
8.6 Diseases of unknown cause								**N/A**
9. Pollution								
9.1 Domestic and urban wastewater								**N/A**
9.2 Industrial and military effluents								**N/A**
9.3 Agricultural and forestry effluents (including erosion)	Yellow rails are indirectly exposed to pollution, because wetlands gather run-off. Given their occurrence in drier types of wetland habitats, they are also likely to be directly exposed to agricultural chemicals. No studies of pesticide effects have been done on yellow rails, but pesticides are known to reduce prey abundance and hatching success in other rail species. Intermittent wetlands, such as those occupied by yellow rails in the prairies, are also vulnerable to siltation and acidification.							**N/A**
9.4 Garbage and solid waste								**N/A**
9.5 Airborne								**N/A**

pollutants								
9.6 Excess energy (noise/light pollution)								**N/A**
10. Geological events								
10.1 Volcanoes								**N/A**
10.2 Earthquakes/ tsunamis								**N/A**
10.3 Avalanches/ landslides								**N/A**
11. Climate change and severe weather								
11.1 Habitat shifting and alteration								**N/A**
11.2 Droughts	Climate change is predicted to increase droughts and evaporation rates, which will first affect shallow and temporary wetlands in the prairies and Hudson Bay Lowlands and is expected to reduce and shift the configuration of wetlands on the Great Lakes and lower St. Lawrence River.	W	U	S	N	H	L	**Low**
11.3 Temperature extremes								**N/A**
11.4 Storms and flooding	Along the Gulf Coast, sea level rises and storms related to climate change have increased the rate of wetland loss. Because the wintering population is compressed into a relatively small area around the Gulf Coast, Florida and the coastal Carolinas, it is vulnerable to the region's frequent hurricanes that destroy coastal habitats and may directly kill unknown numbers of birds during particularly catastrophic storms.							**N/A**
11.5 Other								**N/A**
12. Other threats								
								N/A