Taiga Cordillera Ecozone+
Evidence for key findings summary

Canadian Biodiversity: Ecosystem Status and Trends 2010

Evidence for Key Findings Summary Report No. 1
Published by the Canadian Councils of Resource Ministers

Library and Archives Canada Cataloguing in Publication

Taiga Cordillera Ecozone+ evidence for key findings summary.

Issued also in French under title:
Sommaire des éléments probants relativement aux constatations clés pour l'écozone+ de la taïga de la Cordillère.
Electronic monograph in PDF format.
ISBN 978-1-100-19957-3
Cat. no.: En14-43/0-1-2011E-PDF

Cover photos: Mackenzie Mountains, © Parks Canada/J. Butterill; Caribou, Vuntut National Park of Canada, © Parks Canada/W. Lynch

This report should be cited as:
ESTR Secretariat. 2011. Taiga Cordillera Ecozone+ evidence for key findings summary. Canadian Biodiversity: Ecosystem Status and Trends 2010, Evidence for Key Findings Summary Report No. 1. Canadian Councils of Resource Ministers. Ottawa, ON. vi + 55 p.
http://www.biodivcanada.ca/default.asp?lang=En&n=137E1147-1

PREFACE

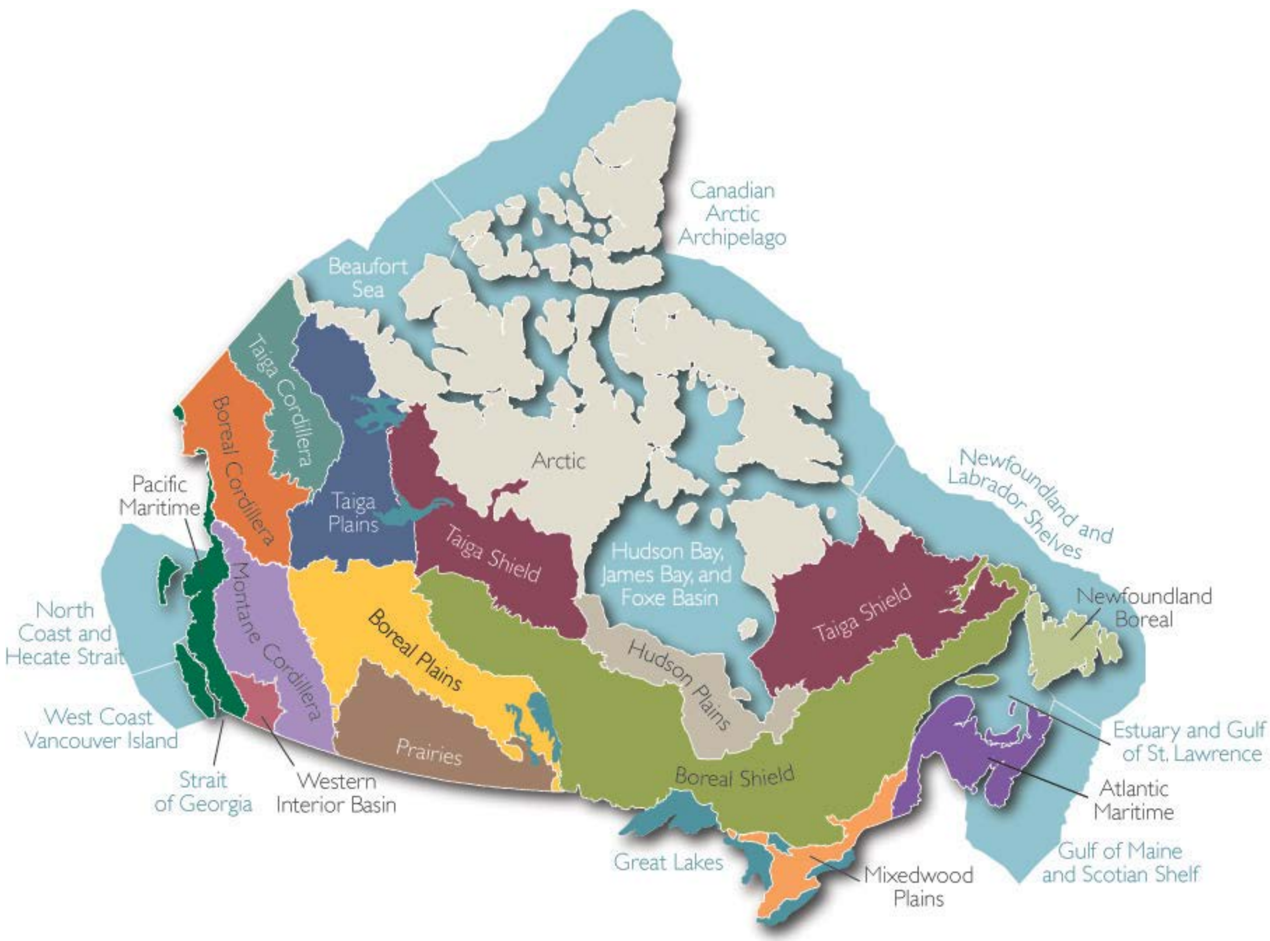
The Canadian Councils of Resource Ministers developed a Biodiversity Outcomes Framework[1] in 2006 to focus conservation and restoration actions under the *Canadian Biodiversity Strategy*.[2] *Canadian Biodiversity: Ecosystem Status and Trends 2010*[3] was the first report under this framework. It presents 22 key findings that emerged from synthesis and analysis of background technical reports prepared on the status and trends for many cross-cutting national themes (the Technical Thematic Report Series) and for individual terrestrial and marine ecozones⁺ of Canada (the Technical Ecozone⁺ Reports). More than 500 experts participated in data analysis, writing, and review of these foundation documents. Summary reports were also prepared for each terrestrial ecozone⁺ to present the ecozone⁺-specific evidence related to each of the 22 national key findings (the Evidence for Key Findings Summary Report Series). Together, the full complement of these products constitutes the 2010 Ecosystem Status and Trends Report (ESTR).

This report, *Taiga Cordillera Ecozone⁺ Evidence for Key Findings Summary*, presents evidence from the Taiga Cordillera Ecozone⁺ related to the 22 national key findings and highlights important trends specific to this ecozone⁺. It is not a comprehensive assessment of all ecosystem-related information. The level of detail presented on each key finding varies and important issues or datasets may have been missed. As in all ESTR products, the time frames over which trends are assessed vary – both because time frames that are meaningful for these diverse aspects of ecosystems vary and because the assessment is based on the best available information, which is over a range of time periods.

This summary report is based primarily on a draft *Taiga Cordillera Ecozone⁺ Status and Trends Assessment* Technical Ecozone⁺ Report that was prepared for this project and incorporates information from many of the Technical Thematic Reports. Additional material was prepared by the ESTR Secretariat, in consultation with experts. Many experts from a broad range of disciplines, including university researchers, government scientists, and renewable resource and wildlife managers, contributed to the draft *Taiga Cordillera Status and Trends Assessment* Technical Ecozone⁺ Report as authors and reviewers (see acknowledgements section on page iii). This key finding summary report was also reviewed by federal and territorial government scientists and managers and, in part or as a whole, by several university researchers. Additional relevant background information about this ecozone⁺ from the draft *Taiga Cordillera Status and Trends Assessment* Technical Ecozone⁺ Report can be found in the associated supplementary material.

Ecological classification system – ecozones+

A slightly modified version of the Terrestrial Ecozones of Canada, described in the *National Ecological Framework for Canada*,[4] provided the ecosystem-based units for all reports related to this project. Modifications from the original framework include: adjustments to terrestrial boundaries to reflect improvements from ground-truthing exercises; the combination of three Arctic ecozones into one; the use of two ecoprovinces – Western Interior Basin and Newfoundland Boreal; the addition of nine marine ecosystem-based units; and, the addition of the Great Lakes as a unit. This modified classification system is referred to as "ecozones+" throughout these reports to avoid confusion with the more familiar "ecozones" of the original framework.[5] For the Taiga Cordillera, extensive changes have been made along the eastern boundary, based on ground-truthing of the original boundaries.



Acknowledgements

This report was written by the ESTR Secretariat and is based on the draft *Taiga Cordillera Ecozone$^+$ Status and Trends Assessmen*t Technical Ecozone$^+$ Report. Additional reviews of this summary report were provided by federal and territorial government scientists and managers and, in part or as a whole, by several university researchers.

Draft Taiga Cordillera Ecozone$^+$ Status and Trends Assessment Technical Ecozone$^+$ Report acknowledgements

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Authors of ESTR Thematic Technical Reports from which material is drawn

Large-scale climate oscillations influencing Canada, 1900-2008: B. Bonsal and A. Shabbar[6]
Canadian climate trends, 1950-2007: X. Zhang, R. Brown, L. Vincent, W. Skinner, Y. Feng and E. Mekis[7]
Trends in large fires in Canada, 1959-2007: C.C. Krezek-Hanes, F. Ahern, A. Cantin and M.D. Flannigan[8]
Wildlife pathogens and diseases in Canada: F.A. Leighton[9]
Trends in permafrost conditions and ecology in northern Canada: S. Smith[10]
Northern caribou population trends in Canada: A. Gunn, D. Russell and J. Eamer[11]
Woodland caribou, boreal population, trends in Canada: C. Callaghan, S. Virc and J. Duffe[12]
Landbird trends in Canada, 1968-2006: C. Downes, P. Blancher and B. Collins[13]
Trends in Canadian shorebirds: C. Gratto-Trevor, R.I.G. Morrison, B. Collins, J. Rausch and V. Johnston[14]
Monitoring ecosystems remotely: a selection of trends measured from satellite observations of Canada: F. Ahern, J. Frisk, R. Latifovic and D. Pouliot[15]
Biodiversity in Canadian lakes and rivers: W.A. Monk and D.J. Baird[16]

Review conducted by scientists and renewable resource and wildlife managers from relevant territorial and federal government agencies through a review process recommended by the ESTR Steering Committee. Additional reviews of specific sections were conducted by university researchers in their field of expertise.

Direction provided by the ESTR Steering Committee composed of representatives of federal, provincial and territorial agencies.

Editing, synthesis, technical contributions, maps and graphics, and report production by the ESTR Secretariat.

Aboriginal Traditional Knowledge compiled from publicly available sources by D.D. Hurlburt.

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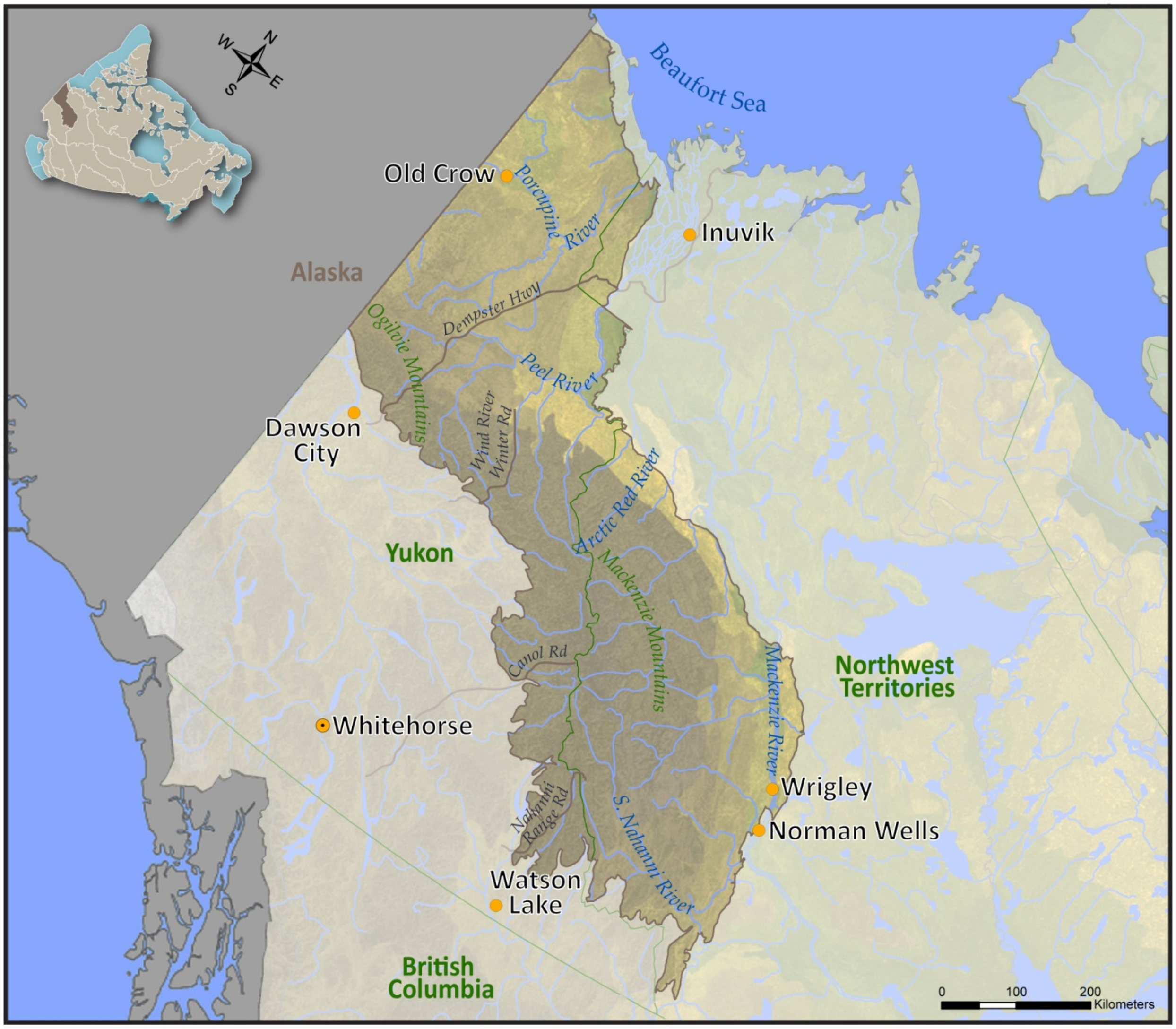


Figure 1. Overview map of the Taiga Cordillera Ecozone+.

ECOZONE+ BASICS

The Taiga Cordillera Ecozone+, shown in Figure 1 and summarized in Table 1, has been little altered by human activities; climate change is a widespread stressor though there is little information on current impacts. The ecozone+ is particularly important for both woodland and barren-ground caribou (*Rangifer tarandus*) and for the extensive, productive wetlands in the north. There are many critical information gaps.

Table 1. Taiga Cordillera Ecozone+ overview.

Area	352,089 km^2 (3.6% of Canada)
Topography	Mountainous In the north: foothills, broad river basins and large wetlands
Climate	Annual precipitation: from 300 mm in north to 700 mm in parts of the mountains Mean annual temperatures: from -10°C in north to -4.5°C in south[17] Has likely warmed about 2°C in past 50 years[7]
River basins	Yukon River flowing west to the Bering Sea Mackenzie and Peel rivers flowing east and north to the Beaufort Sea
Geology	The northwestern portion was not glaciated during the last ice age Northernmost extent of the Rocky Mountains Main surficial materials include colluvial rubble, rock and till
Permafrost	Continuous permafrost through most of the ecozone+ Extensive sporadic permafrost in the south and southeast
Settlement	Old Crow YT and Wrigley NT are the only communities
Economy	Mixed traditional (especially hunting and fishing) and wage-based economies
Development	Dempster Highway is the only all-season road There is no current industrial development
National/global significance	Old Crow Flats is a Ramsar site (a wetland of global significance) Nahanni National Park Reserve is a World Heritage Site

Jurisdictions: The Taiga Cordillera Ecozone+ includes much of northern Yukon and the western edge of the Northwest Territories. The Vuntut Gwitchin traditional territory is entirely in the Taiga Cordillera Ecozone+, while the Tetlit Gwich'in, Nacho Nyak Dun, Tr'ondëk Hwëch'in, Kaska, Selkirk, Sahtu, and Deh Cho First Nation traditional territories and the Inuvialuit Settlement Area are in and adjacent to it.

Land cover in 2005 and population trends for the ecozone+ are shown on Figure 2 and Figure 3 respectively.

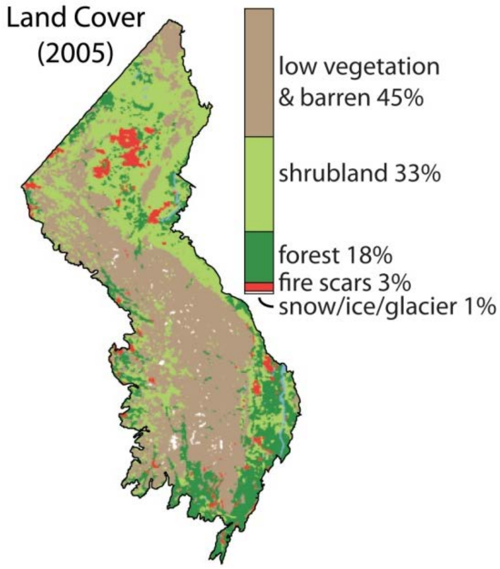


Figure 2. Land cover of the Taiga Cordillera Ecozone+, 2005.
Source: data for ecozone+ provided by authors of Ahern et al., 2011[15]

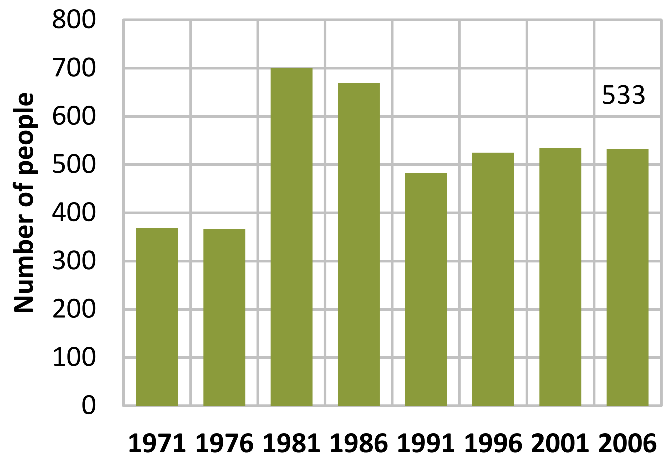


Figure 3. Human population trends, Taiga Cordillera Ecozone+, 1971-2006.
Source: population data for the ecozone compiled from Statistics Canada, 2000[18] *and 2008*[19] *and census reports for Wrigley.*

Backbone Ranges of the Mackenzie Mountains, © GNWT/D. Downing

KEY FINDINGS AT A GLANCE: NATIONAL AND ECOZONE+ LEVEL

Table 2 presents the national key findings from *Canadian Biodiversity: Ecosystem Status and Trends 2010*[3] together with a summary of the corresponding trends in the Taiga Cordillera Ecozone+. Topic numbers refer to the national key findings in *Canadian Biodiversity: Ecosystem Status and Trends 2010*. Topics that are greyed out were identified as key findings at a national level but were either not relevant or not assessed for this ecozone+ and do not appear in the body of this document. Evidence for the statements that appear in this table is found in the subsequent text organized by key finding. See the Preface on page i.

Table 2. Key findings overview

Themes and topics	Key findings: NATIONAL	Key findings: TAIGA CORDILLERA ECOZONE+
THEME: BIOMES		
1. Forests	At a national level, the extent of forests has changed little since 1990; at a regional level, loss of forest extent is significant in some places. The structure of some Canadian forests, including species composition, age classes, and size of intact patches of forest, has changed over longer time frames.	Changes in forests are related to increasing fire and to increased tree density at the treeline. The few studies on alpine treeline indicate that forest extent has not changed.
2. Grasslands	Native grasslands have been reduced to a fraction of their original extent. Although at a slower pace, declines continue in some areas. The health of many existing grasslands has also been compromised by a variety of stressors.	Not relevant
3. Wetlands	High loss of wetlands has occurred in southern Canada; loss and degradation continue due to a wide range of stressors. Some wetlands have been or are being restored.	Although Old Crow Flats, a large wetland complex in the northern part of the ecozone+, remains healthy and functioning, the results of two studies, one at Old Crow Flats and the other at Macmillan Pass, indicate that broad-scale changes in wetlands are occurring due to changes in water balance from warmer summers and to changes in permafrost. The results are mixed, with both increases and decreases in wetlands as increased temperatures lead to increases in wetland area from thawing permafrost and, at the same time, decreases in wetland area as ponds dry up.

Themes and topics	Key findings: NATIONAL	Key findings: TAIGA CORDILLERA ECOZONE+
4. Lakes and rivers	Trends over the past 40 years influencing biodiversity in lakes and rivers include seasonal changes in magnitude of stream flows, increases in river and lake temperatures, decreases in lake levels, and habitat loss and fragmentation.	There are not sufficient long-term records to draw general conclusions about streamflow trends and their causes. Reduced annual peak flows and increased winter flows were observed in several streams in northern Yukon, and increased winter flows were observed in the Nahanni region in recent years.
5. Coastal	Coastal ecosystems, such as estuaries, salt marshes, and mud flats, are believed to be healthy in less-developed coastal areas, although there are exceptions. In developed areas, extent and quality of coastal ecosystems are declining as a result of habitat modification, erosion, and sea-level rise.	Not relevant
6. Marine	Observed changes in marine biodiversity over the past 50 years have been driven by a combination of physical factors and human activities, such as oceanographic and climate variability and overexploitation. While certain marine mammals have recovered from past overharvesting, many commercial fisheries have not.	Not relevant
7. Ice across biomes	Declining extent and thickness of sea ice, warming and thawing of permafrost, accelerating loss of glacier mass, and shortening of lake-ice seasons are detected across Canada's biomes. Impacts, apparent now in some areas and likely to spread, include effects on species and food webs.	There is evidence of widespread change in ice: permafrost degradation at a rate of over 1% per year has led to complete loss or major reduction of permafrost landforms since the 1940s in the Mackenzie Mountains. Increasing permafrost temperature trends are recorded at two locations. The areal extent of glaciers in the Nahanni region decreased about 30% from 1982 to 2008. River ice seasons show no or only slight changes for the Porcupine, Old Crow, and Nahanni Rivers, with some indications of trends to earlier ice break-up.

THEME: HUMAN/ECOSYSTEM INTERACTIONS		
8. Protected areas	Both the extent and representativeness of the protected areas network have increased in recent years. In many places, the area protected is well above the United Nations 10% target. It is below the target in highly developed areas and the oceans.	Protected land area has expanded through parks and other conservation areas established through land claims settlements. The area protected approximately tripled between 1992 and May 2009 to 9.3% of the ecozone+ and has increased further since then with the 2009 extension of Nahanni National Park Reserve. Additional protected areas are under consideration.
9. Stewardship	Stewardship activity in Canada is increasing, both in number and types of initiatives and in participation rates. The overall effectiveness of these activities in conserving and improving biodiversity and ecosystem health has not been fully assessed.	An outcome of final land claim agreements has been a sharing of regulatory powers to include Inuvialuit and First Nations in land and resource management. This has led to a more integrated ecosystem approach to planning and resource management.
Ecosystem conversion*	Ecosystem conversion was initially identified as a nationally recurring key finding and information was subsequently compiled and assessed for the Taiga Cordillera Ecozone+. In the final version of the national report,[3] information related to ecosystem conversion was incorporated into other key findings. This information is maintained as a separate key finding for the Taiga Cordillera Ecozone+.	The ecozone+ has a very low human density and little infrastructure, with only two small communities and one all-season road, the Dempster Highway. Substantive mineral and oil and gas reserves in areas of the ecozone+ may lead to large increases in exploration activity such as roads and seismic lines.
10. Invasive non-native species	Invasive non-native species are a significant stressor on ecosystem functions, processes, and structure in terrestrial, freshwater, and marine environments. This impact is increasing as numbers of invasive non-native species continue to rise and their distributions continue to expand.	Several non-native species of vascular plants are present, but trends are unknown; the level and types of impacts are currently unassessed and liable to sudden change.
11. Contaminants	Concentrations of legacy contaminants in terrestrial, freshwater, and marine systems have generally declined over the past 10 to 40 years. Concentrations of many emerging contaminants are increasing in wildlife; mercury is increasing in some wildlife in some areas.	Peregrine falcons, driven almost to extinction by effects of DDT (a legacy contaminant) have recovered well in the ecozone+. Mercury, monitored in caribou since 1974, shows no change, remaining at levels that are not of concern for animal health nor for health of humans consuming caribou.

* This key finding is not numbered because it does not correspond to a key finding in the national report.[3]

12. Nutrient loading and algal blooms	Inputs of nutrients to both freshwater and marine systems, particularly in urban and agriculture-dominated landscapes, have led to algal blooms that may be a nuisance and/or may be harmful. Nutrient inputs have been increasing in some places and decreasing in others.	Not considered to be a concern for this ecozone[+]
13. Acid deposition	Thresholds related to ecological impact of acid deposition, including acid rain, are exceeded in some areas, acidifying emissions are increasing in some areas, and biological recovery has not kept pace with emission reductions in other areas.	Not considered to be a concern for this ecozone[+]
14. Climate change	Rising temperatures across Canada, along with changes in other climatic variables over the past 50 years, have had both direct and indirect impacts on biodiversity in terrestrial, freshwater, and marine systems.	With little monitoring, both the extent of climate change and the extent of current impacts are difficult to assess. The secondary effects of increasing summer temperatures on moisture may be of particular importance in this ecozone[+]. Studies of future ecological consequences of projected climate change conclude that major vegetation shifts will occur and fire frequency will increase.
15. Ecosystem services	Canada is well endowed with a natural environment that provides ecosystem services upon which our quality of life depends. In some areas where stressors have impaired ecosystem function, the cost of maintaining ecosystem services is high and deterioration in quantity, quality, and access to ecosystem services is evident.	Traditional country foods are harvested by First Nations and Inuvialuit resident in the ecozone[+] and in neighbouring ecozones[+]. Declines in some mountain caribou and fish populations are of concern. Wilderness tourism, which relies on healthy ecosystems, provides economic and cultural benefits.
THEME: HABITAT, WILDLIFE, AND ECOSYSTEM PROCESSES		
Intact landscapes and waterscapes[*]	Intact landscapes and waterscapes was initially identified as a nationally recurring key finding and information was subsequently compiled and assessed for the Taiga Cordillera Ecozone[+]. In the final version of the national report,[3] information related to intact landscapes and waterscapes was incorporated into other key findings. This information is maintained as a separate key finding for this ecozone[+].	Landscapes, including large wetlands, and mountain and river ecosystems of global significance, remain largely intact and healthy. The only major linear habitat alteration is the Dempster Highway, though there are also several seasonal roads.

[*] This key finding is not numbered because it does not correspond to a key finding in the national report.[3]

16. Agricultural landscapes as habitat	The potential capacity of agricultural landscapes to support wildlife in Canada has declined over the past 20 years, largely due to the intensification of agriculture and the loss of natural and semi-natural land cover.	Not relevant
17. Species of special interest: economic, cultural, or ecological	Many species of amphibians, fish, birds, and large mammals are of special economic, cultural, or ecological interest to Canadians. Some of these are declining in number and distribution, some are stable, and others are healthy or recovering.	Trends in northern mountain and boreal populations of woodland caribou are mainly declining or unknown, while the migratory Porcupine Caribou Herd has increased following a period of decline. Some species of taiga-breeding landbirds are declining steeply. Peregrine falcons have recovered due to regulation of DDT globally and re-introduction of captive-bred birds to the ecozone[+].
18. Primary productivity	Primary productivity has increased on more than 20% of the vegetated land area of Canada over the past 20 years, as well as in some freshwater systems. The magnitude and timing of primary productivity are changing throughout the marine system.	Thirty-five percent of the land area showed a significant increase in a vegetation index related to primary productivity from 1986 to 2006. Increasing temperatures resulting in drier conditions, however, are associated with reduced annual growth of white spruce in some treeline locations.
19. Natural disturbances	The dynamics of natural disturbance regimes, such as fire and native insect outbreaks, are changing and this is reshaping the landscape. The direction and degree of change vary.	Fire has increased, with the average annual area burned approximately doubling between the 1960s-1980s and the 1990s-2000s. The fire season has also extended longer in the fall. Insect outbreaks occur, but are not as significant a factor in forest disturbance.
20. Food webs	Fundamental changes in relationships among species have been observed in marine, freshwater, and terrestrial environments. The loss or reduction of important components of food webs has greatly altered some ecosystems.	Small mammal cycles are not monitored. Willow ptarmigan surveys conducted in the Ogilvie Mountains since 1971 indicate a change since 2001, with a flattening out of the cyclic fluctuations.

THEME: SCIENCE/POLICY INTERFACE		
21. Biodiversity monitoring, research, information management, and reporting	Long-term, standardized, spatially complete, and readily accessible monitoring information, complemented by ecosystem research, provides the most useful findings for policy-relevant assessments of status and trends. The lack of this type of information in many areas has hindered development of this assessment.	There is little long-term ecological monitoring and little integration of data into accessible, synthesized formats. Climate and hydrological monitoring is very weak. There are some important long-term datasets and collections of information and expertise for the ecozone[+] that are valuable, if maintained, for ongoing ecosystem assessment.
22. Rapid changes and thresholds	Growing understanding of rapid and unexpected changes, interactions, and thresholds, especially in relation to climate change, points to a need for policy that responds and adapts quickly to signals of environmental change in order to avert major and irreversible biodiversity losses.	Signals that may indicate abrupt ecological change in the Taiga Cordillera Ecozone[+], include: (1) at some point around 1972 the influence of warmer temperatures on evapotranspiration moved the Old Crow Flats into a negative water balance; (2) in the 1960s a summer temperature threshold, resulting in drier conditions, was exceeded for white spruce growth at a treeline site in the Ogilvies ;and (3) the ten-year population cycle of willow ptarmigan evident in monitoring since 1971 has flattened since 2001.

THEME: BIOMES

Key Finding 1 **Theme** Biomes

Forests

National key finding

At a national level, the extent of forests has changed little since 1990; at a regional level, loss of forest extent is significant in some places. The structure of some Canadian forests, including species composition, age classes, and size of intact patches of forest, has changed over longer time frames.

Changes in forests are related to increasing fire and to increased tree density at treeline; the few studies on alpine treeline indicate that forest extent has not changed.

Eighteen percent of the Taiga Cordillera Ecozone+ is classifed as forest.[15] Due to the mountainous terrain and cold, dry climate conditions, the forest is located in the lowland areas and is mainly low density, open forest.[15] Fire is the principal agent of large-scale change, with an average of 0.5% of the forested area burned annually and with no areas of intense fire suppression.[8] There is no commercial forestry, though wood is important for fuel and construction materials for the two communities. The main forest biome trends are an increase in forest fires in the past two decades (see section on natural disturbances on page 41) and changes in tree density at the alpine treeline (see below). Both trends affect forest structure rather than extent, though treeline may advance in the future with climate change.[20] Other trends, such as changes in frequency of forest insect outbreaks, may be occurring, but are not monitored.

Treeline

Limited information on forest change at the alpine treeline shows an increase in density of trees but only very minor advances in treeline. Szeicz and Macdonald (1995)[21] used dendrochronological (tree ring) dating of white spruce (*Picea glauca)* to examine changes near the alpine treeline at three study areas in the Taiga Cordillera Ecozone+. Live trees dated back to the late 18th century or earlier and dead trees dated back to the 16th century. They found that regeneration of spruce at the treeline has been episodic and related to summer temperature trends. Low rates of regeneration occurred from the late 18th century to the mid-19th century, consistent with findings in other forest-tundra areas. This was followed by increases in tree density over the past 100 to 150 years. There were, however, only minor advances in the treeline over this period. The authors conclude that this slow response of treeline to warming summers is inherent in the physiology of white spruce – treeline advance is constrained by factors such as very specific microenvironment requirements for germination of seeds. (See also the section on primary productivity on page 38.)

Global context: an analysis of 166 studies on alpine and latitudinal treeline change from around the world,[22] including the study in the Taiga Cordillera Ecozone+ described above, concluded that treeline advanced since 1900 at 52% of sites around the world and receded at only 1% of sites. Treeline at sites experiencing strong winter warming were more likely to have advanced over the past century – summer warming was not as strongly correlated with treeline advance.

Key Finding 3 **Theme** Biomes

Wetlands

National key finding

High loss of wetlands has occurred in southern Canada; loss and degradation continue due to a wide range of stressors. Some wetlands have been or are being restored.

Although Old Crow Flats, a large wetland complex in the northern part of the ecozone+, remains healthy and functioning, the results of two studies, one at Old Crow Flats and the other at Macmillan Pass, indicate that broad-scale changes in wetlands are occurring due to changes in water balance from warmer summers and to changes in permafrost. The results are mixed, with both increases and decreases in wetlands as increased temperatures lead to increases in wetland area from thawing permafrost and, at the same time, decreases in wetland area as ponds dry up.

Macmillan Pass

Ponds are increasing in the Macmillan Pass area in the Northwest Territories.[23] This is related to degradation of permafrost landforms – as ice lenses melt and permafrost collapses, new ponds are created and existing ponds become larger (see section on changes in permafrost on page 16).

Old Crow Flats

Vuntut Gwitchin residents of Old Crow who travel through and maintain seasonal camps on Old Crow Flats report that the Flats are drying – they see evidence of lower water levels in the lakes that they have been visiting for decades.[24] Old Crow Flats is a large (over 6,000 km^2) complex of over 2,000 lakes and wetlands formed by thawed permafrost. It provides exceptionally productive breeding grounds for half a million waterfowl from all four North American flyways.[25]

Trends in water area of Old Crow Flats lakes and ponds since 1951 were examined using air photos and satellite imagery.[26] The overall surface area of water in the Old Crow Flats decreased by 13 km^2 (3.5%) from 1951 to 2001. Over this 50-year period most large lakes decreased in extent while small ponds increased (Figure 4). Change was not uniform over the study period: 70% of the lakes increased in extent from 1951 to 1972 (a net increase of 6 km^2 of water surface); 45% of lakes decreased in extent from 1972 to 2001 (a net decrease of 19 km^2). A water balance simulation[26] indicated that most lakes experienced a water deficit in the latter part of the study period. Changes are attributed to a mix of interacting processes with some lakes forming or expanding, and some suddenly draining due to collapse of permafrost – along with an overall drying trend due to increased evaporation from hotter summers in recent years. Studies in neighbouring areas of Alaska note major losses in pond area.[27]

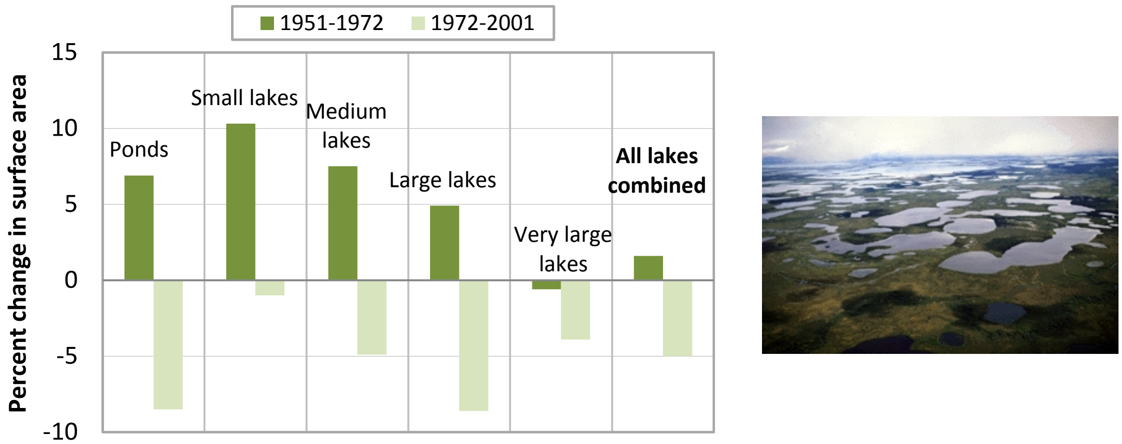
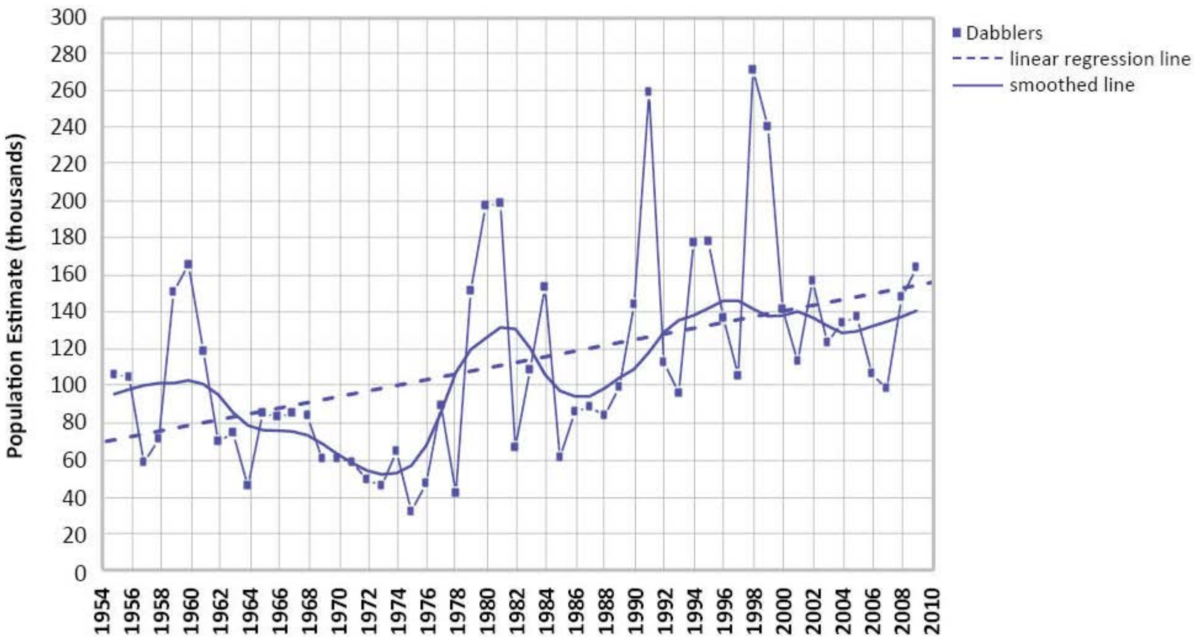


Figure 4. Change in surface water area for ponds and lakes of Old Crow Flats, 1951-1972 and 1972-2001. Source: based on Table 2 of Labrecque et al., 2009[26] Photo: Old Crow Flats, © Parks Canada/I.K. MacNeil

Waterfowl trends in Old Crow Flats

Waterfowl have been surveyed annually since 1955 on Old Crow Flats as part of North American breeding waterfowl surveys.[28] Long-term trends for most populations are stable to increasing,[29] though there have been declines in some species (for example, scaup) in the past 30 years (Figure 5). Variability from year to year is partially related to conditions in the prairies – in drought years, more waterfowl of some species travel north to Old Crow Flats, and is also influenced by timing of spring in relation to the survey timing. One species, the ring-necked duck, has recently expanded its range to Old Crow Flats, only appearing in surveys since 1983.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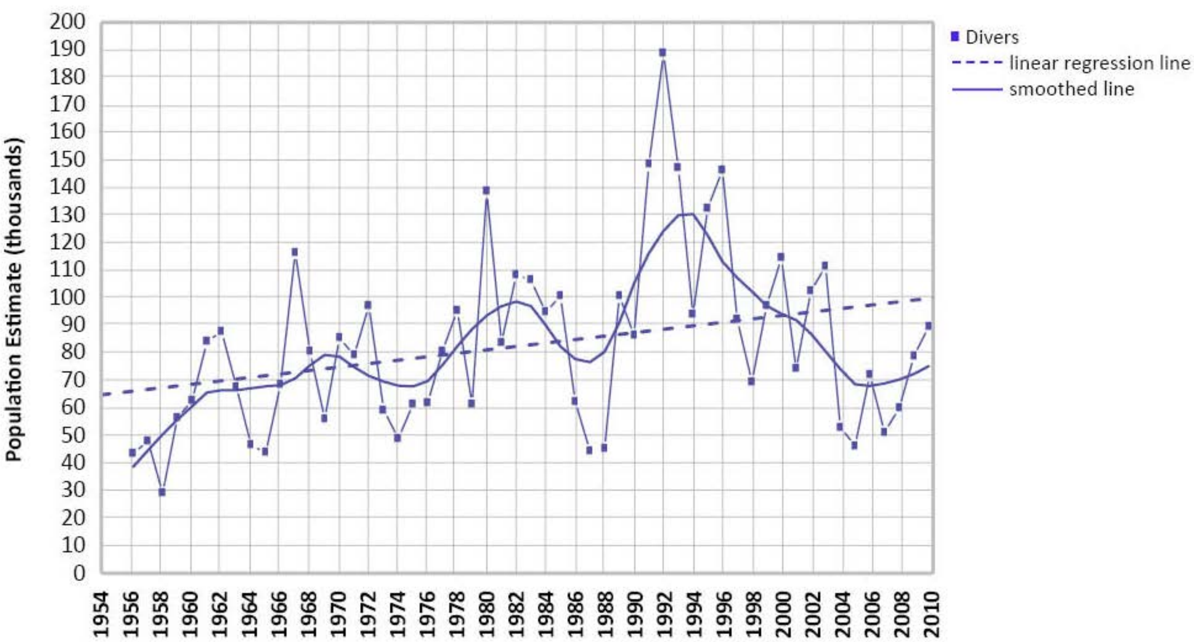
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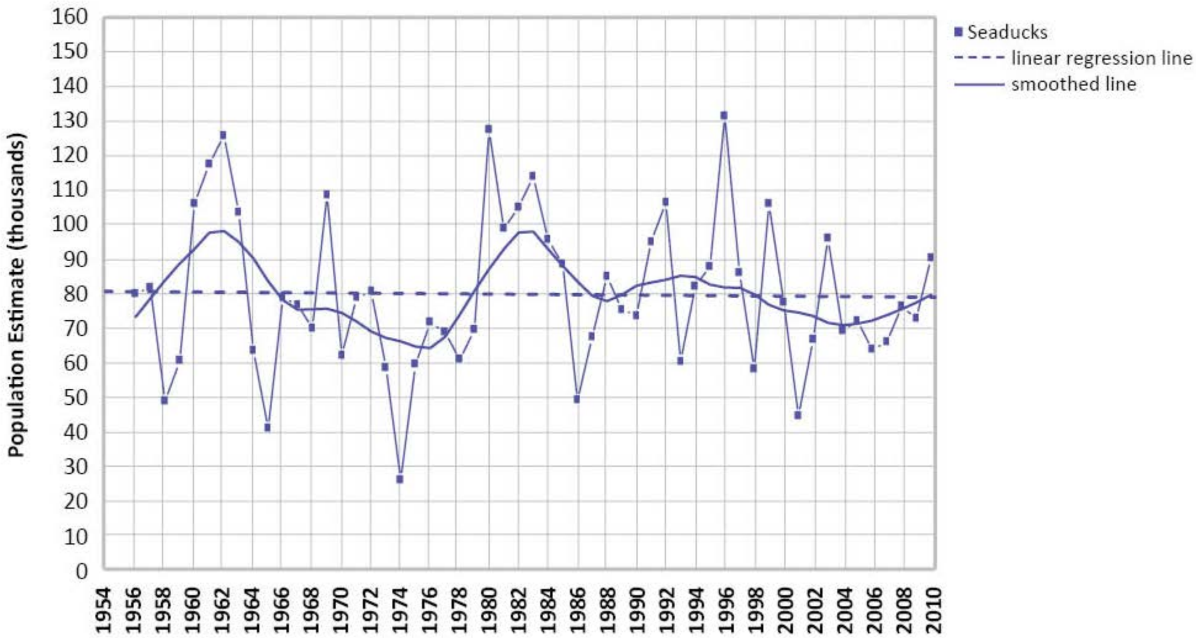


Figure 5. Population estimates for ducks, Old Crow Flats, 1955-2009.
*Dabbling ducks, top graph, include increasing trends for mallard (*Anas platyrhynchos*),*
*American wigeon (*Anas americana*), American green-winged teal (*Anas carolinensis*), and*
*northern shoveler (*Anas clypeata*). Diving ducks, middle graph, show an overall increase, but several species (particularly scaup,* Aythya *spp.) have declined since the early 1990s. Sea ducks, bottom graph, show little overall change, though long-tailed ducks (*Clangula hyemalis*) and goldeneyes (*Bucephala *spp.) have declined in recent years.*
Source: Hawkings, 2010[30]

Key Finding 4 **Theme** Biomes

Lakes and rivers

National key finding

Trends over the past 40 years influencing biodiversity in lakes and rivers include seasonal changes in magnitude of stream flows, increases in river and lake temperatures, decreases in lake levels, and habitat loss and fragmentation.

There are insufficient long-term monitoring records to draw conclusions about overall streamflow trends in this ecozone+. Analysis of available hydrological monitoring data for two regions of the Taiga Cordillera Ecozone+, Yukon and Nahanni, provides indications of trends that may be related to climate change, or may be, at least in part, related to climate oscillations.

Yukon

An analysis[31] of streamflow trends in the Yukon (various record periods up to 2006) found that streams in the continuous permafrost zone generally had increased winter baseflows and decreased annual peak flows (for example, Figure 6), while these trends were less consistent and less pronounced at stations in the discontinuous and sporadic permafrost zones south of the Taiga Cordillera Ecozone+. As winter baseflow consists of groundwater, increasing contribution of degrading permafrost to groundwater is likely to be a factor in this base-flow increase. As peak flows in most of these streams are a result of snowmelt, reduced peak flows may be related to changes in snowmelt characteristics and/or changes in ground infiltration resulting from less permafrost. With a thicker active layer (near-surface layer of unfrozen ground), more melting snow seeps into the ground rather than running directly into the stream, resulting in less of a peak in flow.

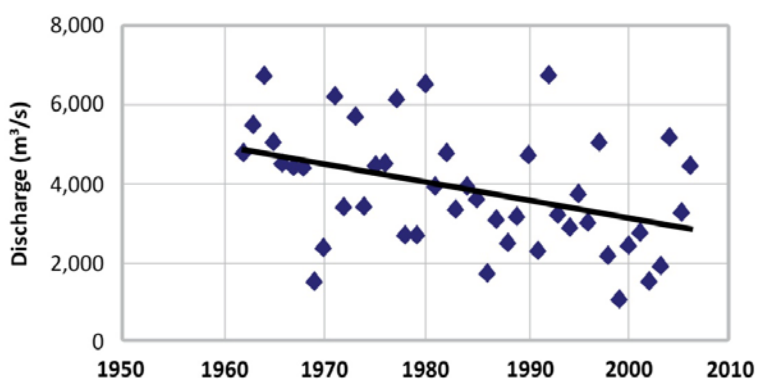


Figure 6. Annual maximum discharge, Porcupine River at Old Crow, 1962-2006.
The trend is statistically significant (p<0.001).
Source: Janowicz, 2008,[31] with permission from copyright holders, IWA Publishing

Nahanni region

Streamflow characteristics of the South Nahanni River above Virginia Falls and Flat River near its mouth (2000-2007) were compared with a 20-year baseline period (1973-1993).[32] The most pronounced difference in the recent period was an increase in winter baseflow, November through April, in both rivers. Winter baseflow in these rivers has been shown to be correlated with the Pacific Decadal Oscillation. The monitoring time series is not long enough to determine if the observed changes are part of this cyclical trend or are due to long-term trends such as thawing of permafrost or reduced amounts of water stored in river ice.

Key Finding 7 **Theme** Biomes

Ice across biomes

National key finding

Declining extent and thickness of sea ice, warming and thawing of permafrost, accelerating loss of glacier mass, and shortening of lake-ice seasons are detected across Canada's biomes. Impacts, apparent now in some areas and likely to spread, include effects on species and food webs.

There is evidence of widespread change in ice: permafrost degradation at a rate of over 1% per year has led to complete loss or major reduction of permafrost landforms since the 1940s in the Mackenzie Mountains. Increasing permafrost temperature trends are recorded at two locations. The areal extent of glaciers in the Nahanni region decreased about 30% from 1982 to 2008.

Permafrost

Observed changes in permafrost are landform changes related to permafrost collapse and increased permafrost temperatures.

Kershaw (2003)[23] used analysis of sequential air photos (beginning in the early 1940s) and field surveys (beginning in 1990) to examine permafrost changes in a broad corridor extending about 75 km and over an elevation range of 550 m in the Macmillan/Caribou Pass region. The area covered by frozen peat plateaus and palsas (peat mounds containing ice lenses) shrunk at a rate of more than 1% per year from 1944 to 2005 (Figure 7). Some palsas completely disappeared while others lost 50 to 75% of their area.[33] Temperatures measured at a depth of about 1 m into the permafrost at five locations rose from 0.75°C to 1.25°C from 1990 to 2009.[23, 33] (See also section on wetlands on page 11.)

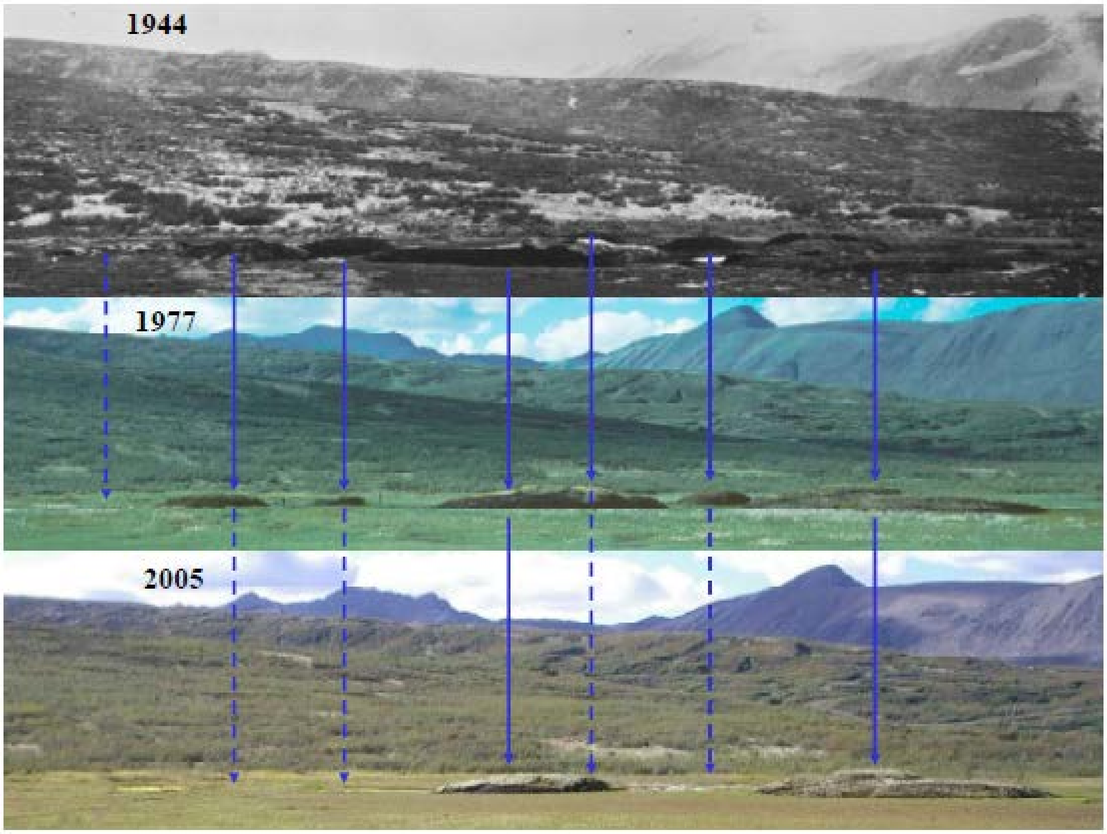


Figure 7. Degradation of permafrost landforms, Mackenzie Mountains, 1944-2005.
At this site in Macmillan Pass, five of seven palsas degraded completely while the remaining two shrunk by 50 to 60% from 1944 to 2005. Dotted lines indicate complete degradation of the palsa between two time periods.
Source: data and photos courtesy of P. Kershaw, University of Alberta, 2010[33]

Permafrost monitoring in the Mackenzie Valley includes a site at Wrigley, at the edge of the Taiga Cordillera Ecozone+. This site recorded an increase in permafrost temperature at 12 m depth of 0.1° C per decade from 1985 to 2007.[10]

Aboriginal Traditional Knowledge studies and community reports identify an accelerated rate of permafrost thawing throughout the northern part of the ecozone+,[34] with increased observations that permafrost changes are affecting water levels or river and stream banks in the Vuntut Gwitchin traditional territory.[35]

Based on the changes noted above and those observed in other regions,[10] it is likely that changes in permafrost are widespread in the ecozone+. Results from permafrost thermal monitoring sites indicate that warming of permafrost is occurring across the permafrost region[36, 37] although the magnitude of this warming varies regionally. With continuous permafrost underlying most of the ecozone+ (Figure 8), ecological consequences of permafrost change are a major consideration. Permafrost and the ice-rich soil associated with it provide the physical foundation for vegetation communities and ecosystems.[37] Frozen ground also plays an important role in northern hydrology.

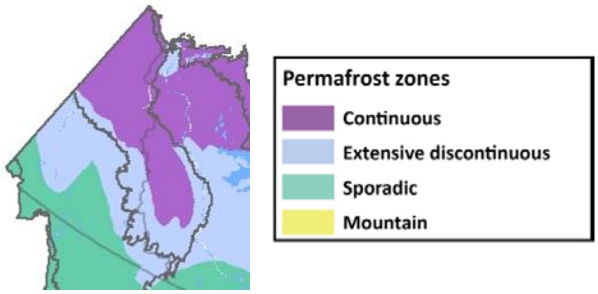


Figure 8. Permafrost distribution, Taiga Cordillera Ecozone+.
Source: adapted from Smith, 2011,[10] based on Heginbottom et al., 1995[38]

Glaciers

The areal extent of glaciers in the Nahanni National Park Reserve and surrounding area decreased about 30% from 1982 to 2008 (Figure 9). The rate and degree of change varied with the size of the glaciers and with elevation – the two large glaciers in the region did not change as much as the smaller glaciers. Some small, high elevation glaciers remained stable or increased slightly in size, while 57 of the smaller, lower elevation glaciers melted completely in the 26-year period.[32] Limited mass balance measurements (for the Bologna Glacier in 2007 and 2008) indicate that the annual net rate of loss of ice is similar to that of other Canadian and Alaskan cordilleran glaciers, reflecting the widespread trend towards accelerated glacier loss in recent decades.[39]

Changes in glaciers have ecological impacts both on hydrology and on terrestrial systems.[32, 40] Hydrological impacts include changes in timing and amount of river flow, as well as changes in water characteristics like temperature and sediment loads. The short-term effect of retreating glaciers may be an increase in seasonal river flows, reversing as the glaciers disappear to long-term flow reductions and loss of seasonal water storage. Terrestrial impacts from loss of glaciers, aside from the localized effect of changed land cover, include changes to microclimates and loss of wildlife passage areas through rough terrain. Glaciers and summer snow patches produce local winds of cold air flowing downhill, providing areas of refuge from biting insects for caribou and other ungulates.

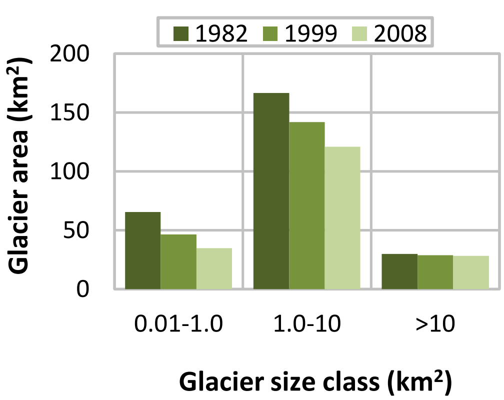


Figure 9. Change in total areal extent of glaciers, Greater Nahanni Ecosystem, 1982, 1999 and 2008. Area calculated from National Topographic Database permanent snow and ice layer (1982) and remote sensing imagery (1999 and 2008) for Nahanni National Park Reserve and surrounding area.
Source: data from Haggarty and Tate, 2009[32]

River ice

There are no significant trends in the dates of ice freeze-up, ice break-up, or length of the ice-free season in the Porcupine River at the U.S. border (1987 to 2009) and the Old Crow River at its mouth (1977 to 2008).[41] Janowicz (2009)[42] notes a shift to four days earlier for ice break-up in the Porcupine River at Old Crow (1961 to 2009) between the means of the first and last 20-year periods, but the trend is not statistically significant.[42] Dates of river freeze-up and the duration of ice cover show no change for the Nahanni River above Virginia Falls, 1998 to 2007, while the river ice break-up date was slightly earlier ($p<0.05$) over the same period.[32] River ice timing has changed more significantly in regions to the south of the Taiga Cordillera Ecozone+ in the Yukon and British Columbia.[42, 43]

THEME: HUMAN/ECOSYSTEM INTERACTIONS

Key Finding 8 **Theme** Human/ecosystem interactions

Protected areas

National key finding
Both the extent and representativeness of the protected areas network have increased in recent years. In many places, the area protected is well above the United Nations 10% target. It is below the target in highly developed areas and the oceans.

Protected land area has expanded through parks and other conservation areas established through land claims settlements. The area protected approximately tripled between 1992 and May 2009 and has increased further since then with the 2009 extension of Nahanni National Park Reserve.

Prior to 1992 (the signing of the Convention on Biological Diversity), 3.4% of the Taiga Cordillera Ecozone+ was protected. This was increased to 9.3% of the ecozone+ by May 2009 (Figure 10 and Figure 11), broken down as follows:

- 8.1% (eight protected areas) as IUCN categories I to IV, categories that include nature reserves, wilderness areas, and other parks and reserves managed for conservation of ecosystems and natural and cultural features, as well as those managed mainly for habitat and wildlife conservation.[44] These are listed on Figure 10.
- 0.3% (one protected area, the Canol Heritage Trail, established 1994) as IUCN category V, a category that focuses on sustainable use by established cultural tradition.[44]
- 0.9% (several protected areas established in 2003) not classified by IUCN category. The areas are: Rat River, Husky River, Black Mountain, James Creek, and Vittrekwa River, all protected through the Mackenzie Valley Resource Management Act.

These statistics do not include the recent expansion of Nahanni National Park Reserve (IUCN Category II) because they are based on a national analysis of protected areas by ecozone+ that was completed prior to the expansion.[45] In June 2009 the park reserve was expanded to more than six times its original size, from 4,766 km² to 30,055 km², most of this within the Taiga Cordillera Ecozone⁺ (Figure 12), effectively almost doubling the percentage of the ecozone⁺ that is afforded a high level of protection.[32]

Protected areas are clustered in the northwest and southeast of the ecozone⁺, with little protection in the central region. The Taiga Cordillera has a high potential for additional protection of intact ecosystems. Initiatives underway include consideration of candidate protected areas, for example Shúhtagot'ine Néné, a proposed 25,500 km² National Wildlife Area,[46] and Nááts'ihch'oh, a proposed 7,600 km² National Park.[47] Both are in the Sahtu Settlement Region, north of Nahanni National Park Reserve, largely within the Taiga Cordillera, and are identified in the Northwest Territories Protected Areas Strategy.[48]

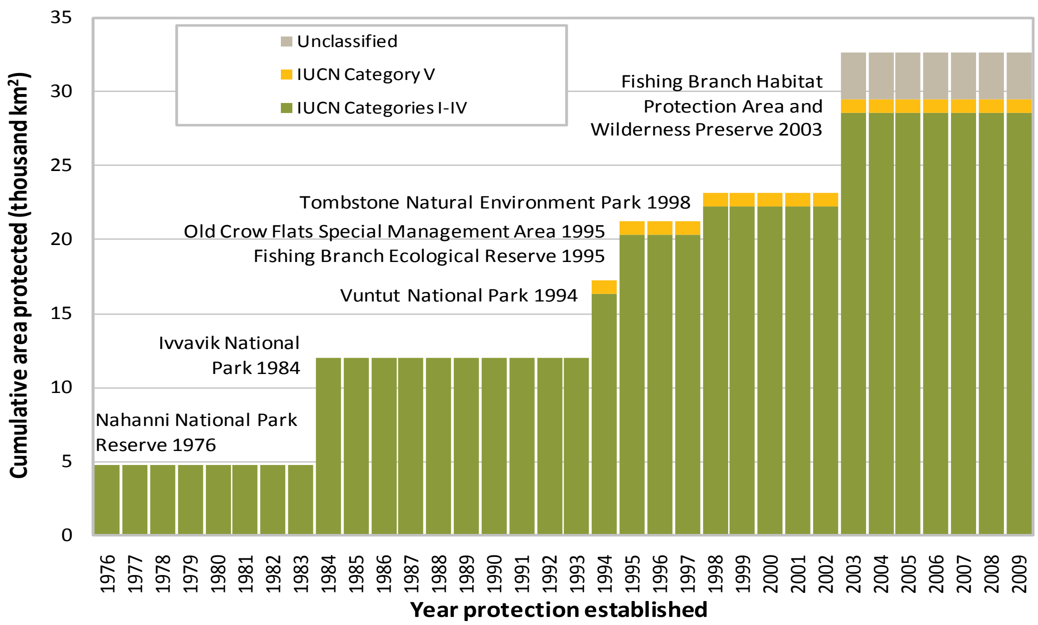


Figure 10. Growth of protected areas, Taiga Cordillera Ecozone⁺, 1976 to May 2009.
Data provided by federal and territorial jurisdictions, updated to May 2009 (prior to the expansion of Nahanni National Park Reserve). Only legally protected areas are included. IUCN (International Union for Conservation of Nature) categories of protected areas are based on primary management objectives (see text for more information). Labels are protected areas in IUCN Categories I-IV. Note: the grey 'unclassified' category represents protected areas for which the IUCN category was not provided.
Source: Environment Canada, 2009[49]; data from the Conservation Areas Reporting and Tracking System (CARTS), v.2009.05, 2009[45]

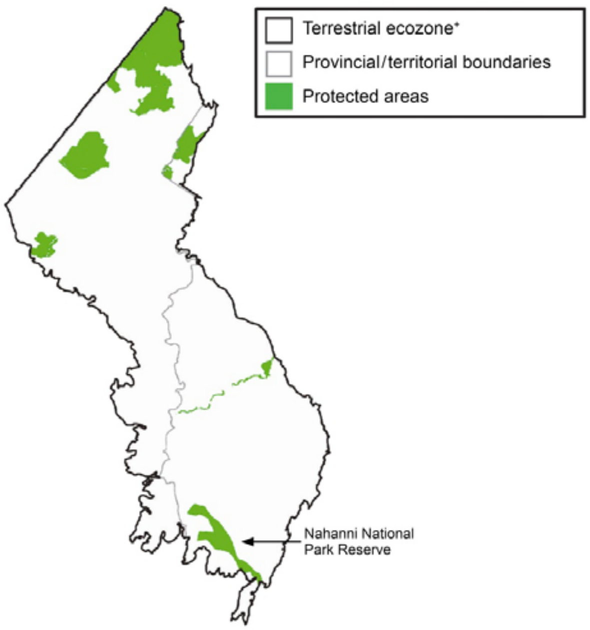


Figure 11. Map of Taiga Cordillera Ecozone+ protected areas, May 2009.
Source: Environment Canada, 2009[49]; data from the Conservation Areas Reporting and Tracking System (CARTS), v.2009.05, 2009[45]

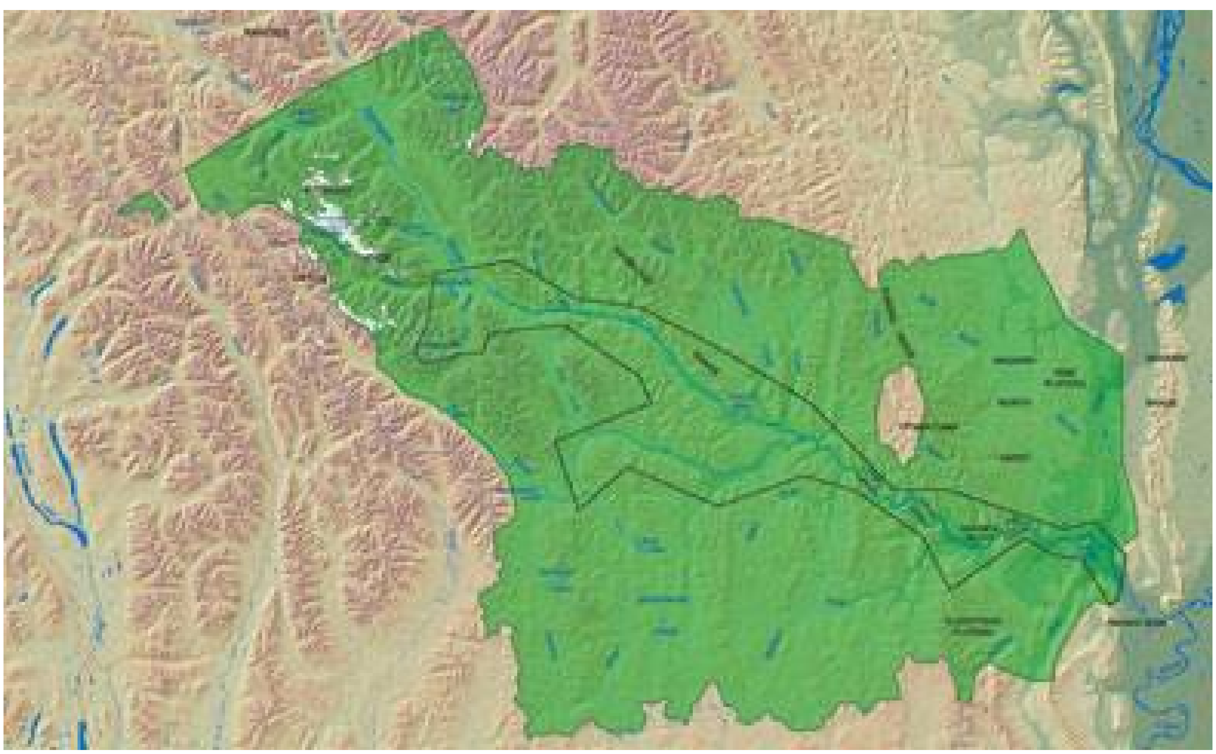


Figure 12. Nahanni National Park Reserve: new boundaries following expansion, June 2009.
This expansion (the total area shaded in green) is mainly within the Taiga Cordillera Ecozone+.
The old boundary (black line) is shown in Figure 11.
Source: Parks Canada, 2009[50]

Key Finding 9 **Theme** Human/ecosystem interactions

Stewardship

National key finding
Stewardship activity in Canada is increasing, both in number and types of initiatives and in participation rates. The overall effectiveness of these activities in conserving and improving biodiversity and ecosystem health has not been fully assessed.

First Nations and Inuvialuit have a regulatory role on selected lands and are shared land managers in their respective traditional territories, providing settlement beneficiaries with powers to determine the pace and scope of development and manage benefits on their lands. One outcome of land claim settlements has been the establishment of protected areas with co-management regimes – but it goes much further than that. Land claims settlements have led to a range of collaborative planning and management initiatives with a strong stewardship focus.

Joint land use planning is a requirement of most agreements. In 2009, the North Yukon Planning Commission delivered the final recommended land use plan for the Vuntut Gwitchin and Yukon governments' approval.[51] The Sahtu Land Use Board[52] and Deh Cho Land Use Board[53] have recommended additional conservation lands and stewardship measures for their respective jurisdictions. Planning for stewardship and conservation is also undertaken across land claim regions, on a watershed basis – for example, through the Peel Watershed Commission, composed of representatives from the Vuntut Gwitchin, Nacho Nyak Dun, and Tr'ondëk Hwëch'in First Nations, and the Yukon Government.[54]

The Old Crow Flats Special Management Area (see box below) demonstrates an application of integrated ecosystem management with its roots in land claims settlements. The Special Management Area connects protected areas and surrounding lands into a contiguous zone, managed as one ecological unit.

Conserving large ecosystems across multiple jurisdictions: Old Crow Flats Special Management Area

The Old Crow Flats Special Management Area (SMA) conserves and manages, through three jurisdictions, 12,099 km^2 of wetlands and surrounding mountains and valleys. Seventy percent of the area is permanently withdrawn from industrial development. The remaining 30%, land bracketing the wetlands with identified gas reserves, is under an interim withdrawal until 2026.[24]

The guiding management principle is to "strive to maintain the integrity of the SMA as one ecological unit." The wetlands are managed for the protection of ecological integrity and for harvesting of fish and wildlife. Concerns about the impacts of climate change on the Old Crow Flats are recognized in the plan and contributed to the management plan's priority of affording the highest level of protection to the wetlands and lakes in the Flats.[24] The establishment of the SMA completes a contiguous matrix of protected areas from the Beaufort Sea to Old Crow Flats (including Herschel Island Territorial Park and Ivvavik and Vuntut National Parks and, on the Alaskan side, the Arctic National Wildlife Refuge).

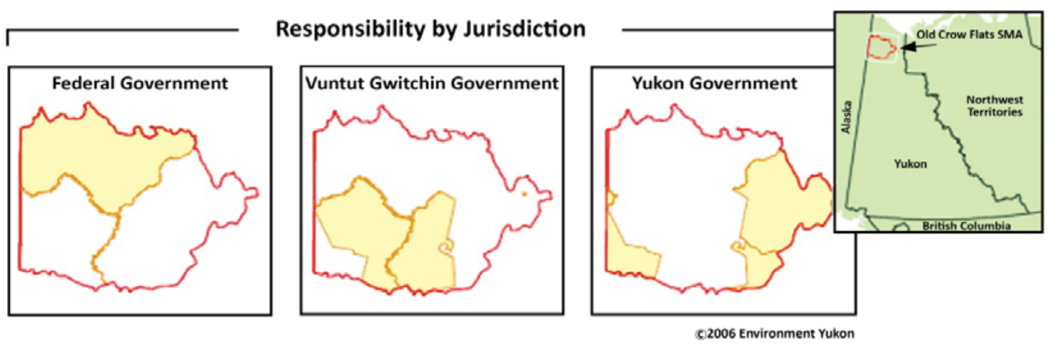


Figure 13. Old Crow Flats and surrounding regions: three jurisdictions with a common, ecosystem-based management regime.
Source: Yukon Department of Environment and Vuntut Gwitchin Government, 2006[24]

Theme Human/ecosystem interactions

Ecosystem conversion

Ecosystem conversion was initially identified as a nationally recurring key finding and information was subsequently compiled and assessed for the Taiga Cordillera Ecozone+. In the final version of the national report,[3] information related to ecosystem conversion was incorporated into other key findings. This information is maintained as a separate key finding for the Taiga Cordillera Ecozone+.

The Taiga Cordillera Ecozone+ has a very low human density and little infrastructure, with only two small communities and one all-season road, the Dempster Highway (see section on Intact landscapes on page 33). This situation is not assured in the long term, as the substantive mineral and petroleum reserves in areas of the ecozone+ may undergo more extensive exploration activity and infrastructure construction, potentially leading to extraction industry development in the future. Exploration itself has the potential for major ecosystem impacts as it results in land cover conversion, fragmentation of habitat, and creation of access routes that increase disturbance to wildlife and allow introduction and spread of non-native species.

Mineral development

Current mines and advanced exploration projects are in MacMillan Pass, Howard's Pass, and the Selwyn Range in the Northwest Territories, and in the Peel River area. The high level of interest in mining in the Peel River area is reflected by the 11,275 active quartz claims and 525 active iron-mica claims in the Yukon portion of the watershed as of February, 2009, a seven-fold increase since establishment of the watershed planning region in the fall of 2004.[55] A one-year interim withdrawal from further claim staking came into force February 4, 2010.[56] Commodity prices, existing road access, access to power, and transportation costs determine the economic feasibility of mineral extraction. Currently several large deposits identified in the ecozone+ have limited potential for development due to costs of access infrastructure and/or power required to mine the resource.[57]

Oil and gas development

Oil and natural gas basins are found in the northern portion of the ecozone+, with the Eagle Plain Basin being the area of highest interest and longest history of exploration.[57] In 2012, exploration and development activity levels are low, but they are linked to factors such as commodity prices and cost of developing infrastructure, including pipelines.[54, 57]

Key Finding 10 **Theme** Human/ecosystem interactions

Invasive non-native species

National key finding

Invasive non-native species are a significant stressor on ecosystem functions, processes, and structure in terrestrial, freshwater, and marine environments. This impact is increasing as numbers of invasive non-native species continue to rise and their distributions continue to expand.

Several non-native species of vascular plants are present in the ecozone+, but trends are unknown; the level and types of impacts are currently unassessed and liable to sudden change.

There is limited information on invasive non-native species in the ecozone+. Several non-native species of vascular plants, including meadow foxtail (*Alopecurus pratensis*), and white and yellow sweetclover (*Melilotus albus* and *officinalis*), are present in northern Yukon.[58, 59] Ten species of exotic vascular plants were collected in the 1960s and 1970s in the Northwest Territories portion of the ecozone+.[60] Of these, only yellow sweetclover is considered now to be moderately invasive.[60] Native plants can also become invasive when landcover changes. For example, foxtail barley (*Hordeum jubatum*), native to North America and present in the ecozone+, spreads rapidly and forms dense stands on disturbed land, especially road allowances.[58, 59]

If road access or industrial development were to increase, it is probable that the distribution and abundance of invasive species would increase due to higher traffic volumes and equipment coming in to construct roads or industrial infrastructure. Once an invasive species has been introduced, it may spread along natural corridors. In Alaska areas west of the ecozone+, white sweetclover has spread along many roadsides and, where roadsides intersect with river floodplains, has in some regions spread downriver. This has led to dense sweetclover stands along some river floodplains, with the potential to replace native plants and alter soil and other habitat characteristics.[61]

Key finding 11 **Theme** Human/ecosystem interactions

Contaminants

National key finding

Concentrations of legacy contaminants in terrestrial, freshwater, and marine systems have generally declined over the past 10 to 40 years. Concentrations of many emerging contaminants are increasing in wildlife; mercury is increasing in some wildlife in some areas.

There are few contaminants datasets for the ecozone+. Mercury, monitored in caribou since 1974, shows no change. Peregrine falcons (*Falco peregrinus*), driven almost to extinction by effects of DDT (a legacy contaminant) have recovered well in the ecozone+.

Territorial and federal governments have conducted contaminant monitoring in wildlife in the Canadian north since 1992 through the Northern Contaminants Program.[62] Some contaminants are associated with baseline conditions, originating from high levels of metals found naturally in the soils. Most wildlife contaminants, such as persistent organic pollutants (POPs) and mercury from industrial sources, are a result of human activities and are transported to northern ecosystems through the atmosphere from southern regions. POPs were present in fish from the Porcupine and Old Crow Rivers in samples collected from 1990 to 1994, but at lower levels than in fish from other Yukon locations, perhaps indicating lower levels of atmospheric deposition in this region.[63]

Mercury

Mercury has been monitored in the Porcupine Caribou Herd since 1994 to detect trends related to atmospheric deposition on land and bioaccumulation of mercury in terrestrial food chains. Based on hunter-submitted samples collected up to 2008, levels have remained stable, exhibiting cyclic fluctuations (Figure 14). Mercury is present in the caribou's forage (lichen, mushrooms, and vegetation).[64] Female caribou, as they process more food for their body weight, may be more sensitive to environmental mercury than males.[64] Current mercury levels are not considered to pose a risk to the health of the caribou or to humans who eat caribou.[65]

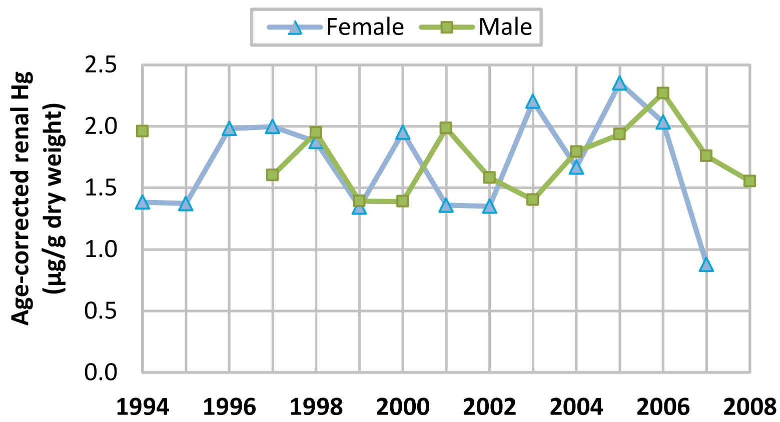


Figure 14. Trend in mercury in kidneys of Porcupine caribou, 1994-2008.
Source: data from Gamberg, 2009[65] and Gamberg, 2010[66]

Peregrine falcons and DDT

Although legacy persistent organic pollutants are not consistently monitored in wildlife in the ecozone+, there is evidence that their reduction in the global environment has had positive impacts on biodiversity. Peregrine falcon populations worldwide are recovering from near extinction due to the effects of DDT.[67] Recovery of peregrines breeding in the Taiga Cordillera Ecozone+ is attributed to the reduction of DDT in the environment, especially in the birds' wintering areas in southern regions of the Americas, through regulation and introduction of alternative pesticides, aided by programs to re-introduce captive-bred falcons to the wild.[67] Captive-raised young were fostered from 1978 to 1992 along the Peel River.[68] The numbers of territorial pairs of peregrines, monitored every five years along the Porcupine and Peel Rivers, increased about three-fold between the first surveys in 1975-80 to 1995; numbers have been fairly stable since then (Figure 15).

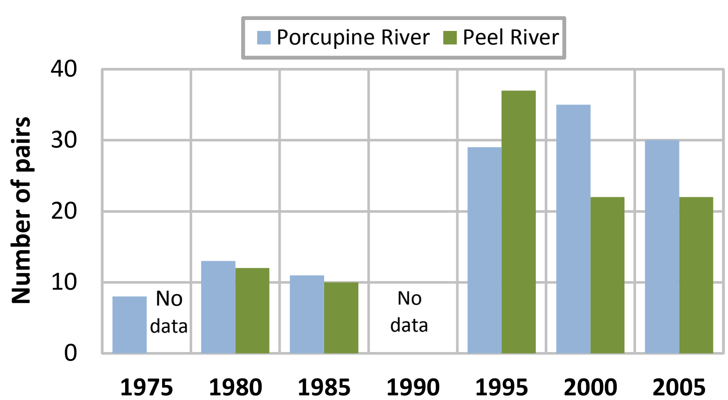


*Figure 15. Number of peregrine falcon (*anatum *subspecies) territorial pairs, Porcupine River and Peel River, Yukon, 1975-2005.*
A smaller section of the Peel was surveyed in 2000 and 2005 compared with previous years.
Source: data from Table 8 of COSEWIC, 2007[67]

Key finding 14 **Theme** Human/ecosystem interactions

Climate change

National key finding

Rising temperatures across Canada, along with changes in other climatic variables over the past 50 years, have had both direct and indirect impacts on biodiversity in terrestrial, freshwater, and marine systems.

With little monitoring, both the extent of climate change and the extent of current impacts are difficult to assess. The secondary effects of warmer summer temperatures on moisture may be of particular importance in this ecozone+. Studies of future ecological consequences of projected climate change conclude that major vegetation shifts will occur and fire frequency will increase.

Climate trends

It is likely that the annual mean temperature has increased in the Taiga Cordillera Ecozone+ by close to 2°C since the 1950s, based on inference from observed trends in neighbouring regions.[7] Records from Old Crow, the single climate monitoring station in the ecozone+, show increases in temperature and precipitation (Table 3) and strong, significant changes in the growing season from 1950 to 2007 (Figure 16). The growing season increased in length an average of 28 days, along with a start date 11 days earlier, and an end date 22 days later.

Table 3. Temperature and precipitation trends for Old Crow, 1951-2005.

Parameter	Summer	Winter	Annual
Temperature	Increase**** (34 years of record)	Increase** (26 years of record)	Increase** (26 years of record)
Precipitation	No significant trend (30 years of record)	Increase** (24 years of record)	Increase*** (23 years of record)

*Levels of statistical significance are **0.05; ***0.01; ****0.001.*
Source: Janowicz, 2009[42]

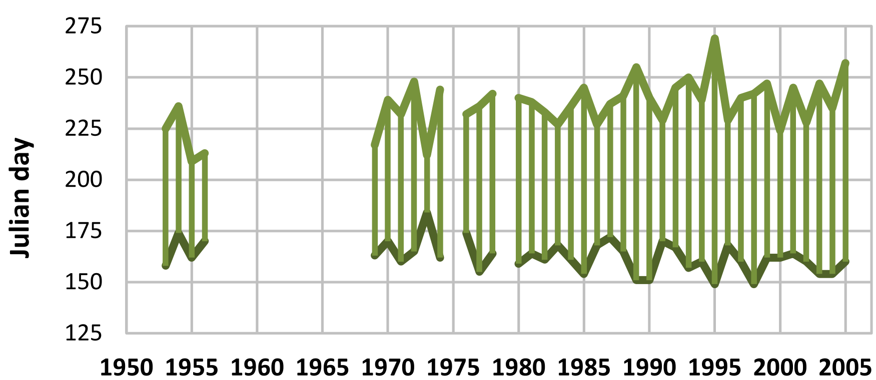


Figure 16. Start, end, and length of the growing season at Old Crow, 1950-2005.
The lower (dark green) line shows the start date, the upper (lighter green) line shows the end date, and the vertical lines show the length of the growing season. Growing season calculations are based on days with mean temperatures over 5 °C.
Source: data for ecozone+ provided by authors of Zhang et al., 2011[7]

Projected large-scale ecological change

Increased fire frequency and shifts in plant communities, including an expansion of shrubland to higher elevations and higher latitudes, are expected, based on climate change model projections and research and monitoring in northern and mountain ecosystems.

McCoy and Burn (2005)[69] modeled potential changes in the number of fires and area burned for the southern portion of the Taiga Cordillera Ecozone+ in the Yukon. They concluded that the fire regime will continue to vary from year to year and that the overall extent and occurrence of fires are both likely to increase. The magnitude of the increase depends on which climate scenarios are used in modeling, with future changes in forest moisture being both difficult to predict and particularly important. Projections for 2069 are up to a doubling of the average annual fire occurrence and area burned.

An analysis based on: 1) current vegetation maps of the northern portion of the ecozone+; 2) research on climate change impacts on boreal and tundra vegetation; and, 3) projected changes in temperature and precipitation from climate models, was undertaken for the North Yukon Planning Commission.[20] The author concluded that climate change is expected to cause an expansion of shrubs into alpine tundra, an increase in density of treeline forests, and the spread of low-density forests into tundra.

Some early warning indications

- There are some possible early indications of abrupt changes or crossing of thresholds related to the changing climate (page 46).
- Permafrost landforms, including frozen peat plateaus and thermokarst lakes, are likely to change greatly in the coming decades.
- Changes in disease and parasites of ungulates are expected both from changes in habitat conditions with a warming climate and with changes in ungulate ranges.[9, 70] Diseases that may change in virulence or range include brucellosis and besnoitosis. The former is a disease caused by *Brucella* bacteria, a species of which is present in barren-ground caribou populations across Canada.[9] Besnoitosis is a disease from a protozoan parasite that can infect caribou.[9]

Porcupine caribou and climate variability

The Porcupine Caribou Herd has been the subject of extensive research on the sometimes complex relationships between climate variables and caribou health and population trends. Within the range of the herd, the trends of global warming are marked. Spring strongly warmed over the last three decades. During late spring, after calving, this has resulted in early snowmelt and greater food availability for nursing mothers (in the southern Arctic and neighbouring Alaska). As a consequence, early calf survival improved.[71] In early spring, however, when the herd is on migration (through the Taiga Cordillera) warmer weather has resulted in more freeze-thaw cycles as temperatures rise above freezing during the day and fall below freezing at night. Specifically, the number of days where the temperature has risen above zero during spring migration doubled during the population decrease phase (1989 to 2001) compared with the population increase phase (1975 to 1988). The greater difficulty in traveling and feeding through ice crusts would result in higher energetic costs and alter migration paths. Moving to wind-blown ridges for ease of movement during migration could result in increased mortality from wolf predation as wolves are more successful when not disadvantaged by deep snow.[71]

Adapted from Gunn et al., 2011[11]

Key finding 15 **Theme** Human/ecosystem interactions

Ecosystem services

National key finding

Canada is well endowed with a natural environment that provides ecosystem services upon which our quality of life depends. In some areas where stressors have impaired ecosystem function, the cost of maintaining ecosystem services is high and deterioration in quantity, quality, and access to ecosystem services is evident.

Two aspects of ecosystem services are discussed for this ecozone+: country foods and wilderness tourism. Declines in caribou (see page 33) and in some fish populations (see page 38), along with expected impacts of climate change on both wildlife populations and on access to the land for hunting and fishing[72] pose risks to current and projected availability of important country foods. Wilderness tourism, which depends upon healthy ecosystems and intact wilderness landscapes, is an example of a cultural ecosystem service that is also a contributor to regional economies.

Traditional/country foods, a provisioning ecosystem service

Aboriginal people value the Taiga Cordillera's lands and waters for harvesting fish, wildlife, and plants that are a main form of sustenance to communities both within and close to the ecozone+, including communities of the Mackenzie Valley and Delta, and the central Yukon. Declines in some fish and caribou populations in the ecozone+ have led to planning or adopting management measures that temporarily restrict harvesting (see section on species of special interest on page 33) and there are concerns among Aboriginal communities across northern Canada about the long-term effects of climate change on the availability of traditional/country foods.[73]

Although caribou remain central to economies and societies associated with the ecozone+, consumption may have declined in recent decades for reasons not related to caribou availability. Tracy and Kramer (2000)[74] estimated average daily consumption of caribou by Old Crow residents in 1989-90 and compared this with a similar study conducted in the 1960s. This indicated about a four-fold decrease in the average amount of caribou consumed per person between the study periods. The Porcupine Caribou Herd approximately doubled in size over this period.[11]

While the importance of fish, wildlife, and plants for sustenance, ceremonial, or social purposes is high for all First Nations and Inuvialuit, the species of importance vary across the ecozone+. A dietary survey was conducted in Old Crow during 1991-1992, surveying 38% of Vuntut Gwitchin households. The average annual frequency of consumption of the top ten traditional food items is shown in Figure 17, highlighting the range of foods consumed and the importance of the Porcupine Caribou Herd to the Vuntut Gwitchin.

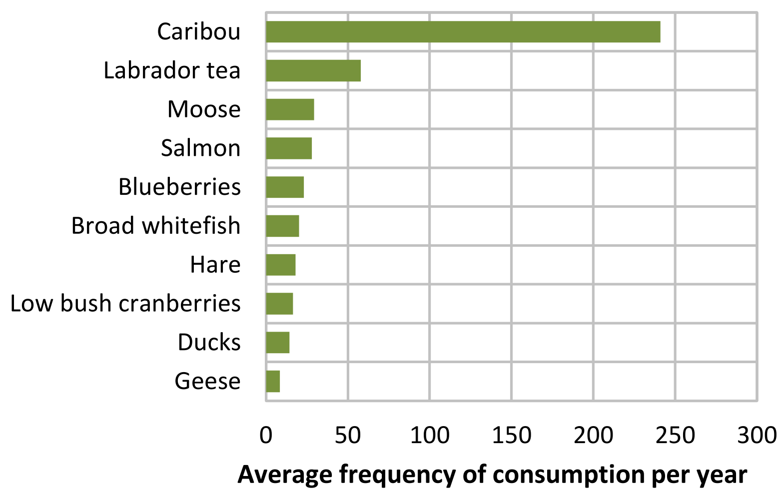


*Figure 17. Frequency of consumption of traditional foods per year by Old Crow households, 1991/92. Values shown are averages from a survey of 31 randomly selected households conducted 1991-1992. Species names: Labrador tea (*Ledum *sp.), moose (*Alces alces*), salmon (*Oncorhynchus *spp.), blueberries (*Vaccinium *sp.), broad whitefish (*Coregonus nasus*), hare (*Lepus americanus*), low bush cranberries (*Vaccinium vitis-idaea*)*

Source: data from Wein and Freeman, 1995[75] Photo: Labrador tea, © Parks Canada/J. Pleau/1998

Wilderness tourism, a cultural ecosystem service

Wilderness tourism occurs throughout the ecozone+ – both consumptive (hunting and fishing) and non-consumptive (for example, guided river trips). Limited trend data show that wilderness tourism has increased in some areas, but not in others. In 2008, the Peel River watershed supported 20 businesses related to wilderness tourism. The number of days spent in the watershed by guided clients (1999-2004) increased from 540 to 1,792. In the Tombstone region, however, guided visitor days did not increase over the same period.

Visits to Nahanni National Park Reserve (primarily river paddling excursions) are a significant component of the Northwest Territories tourism market. In 2006/07, 37% of people travelling to the Northwest Territories for outdoor adventure visited Nahanni.[32] Visitor numbers increased slightly for a period in the mid-1990s and then dropped back to previous levels of 700 to 1,000 visitors annually (Figure 18). A study of impacts of climate change on recreation in Nahanni conducted as part of the Mackenzie Basin Impact Study[76] concluded that, while projected hydrological changes are not likely to have a great impact on river recreation, ecological changes such as increased fires and shifts in vegetation communities and ranges of animals will likely have significant impacts on the quality of wilderness tourism in the park reserve.

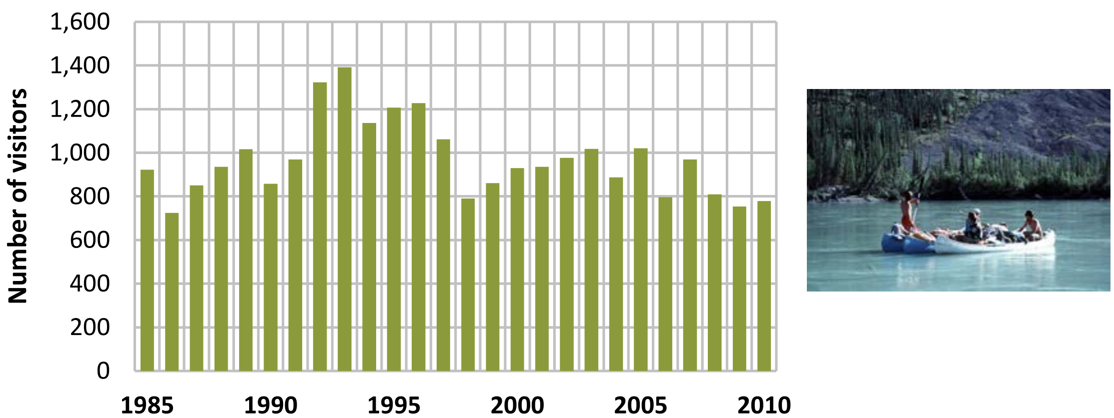


Figure 18. Number of visitors to Nahanni National Park Reserve, 1985-2010.
Source: data from Ann Ronald, 2008, Parks Canada (pers. comm.) cited in Northwest Territories Environment and Natural Resources, 2009,[77] updated by Northwest Territories Environment and Natural Resources. Photo: On the South Nahanni River © Parks Canada/M. Beedell/1981

THEME: HABITAT, WILDLIFE, AND ECOSYSTEM PROCESSES

Theme Habitat, wildlife, and ecosystem processes

Intact landscapes and waterscapes

Intact landscapes and waterscapes was initially identified as a nationally recurring key finding and information was subsequently compiled and assessed for the Taiga Cordillera Ecozone+. In the final version of the national report,[3] information related to intact landscapes and waterscapes was incorporated into other key findings. This information is maintained as a separate key finding for the Taiga Cordillera Ecozone+.

The Taiga Cordillera Ecozone+ has largely intact landscapes. Ecosystem processes have not been affected by fragmentation, being more likely influenced by climate change. This could change in the future if there is an increase in industrial and transportation infrastructure. See stewardship section on page 22 for discussion of measures to conserve large tracts of intact landscapes.

The Dempster Highway, the only year round road, connects the Klondike Highway in the Yukon to the community of Inuvik in the Northwest Territories over a distance of 736 km. Other seasonal or temporary roads include the North Canol Road, a gravel road that is maintained from spring to fall, the Nahanni Range Road, which provides access to the Tungsten mine in the Northwest Territories, and the Wind River road in the Yukon. Roads provide access and the potential for increased hunting and disturbance of wildlife, direct mortality from vehicle collisions, as well as a route for the introduction of invasive plant species (page 24).

The Dempster Highway is the only major habitat alteration within the range of the Porcupine Caribou Herd. It traverses the winter range of the herd, providing access to hunters from south of the ecozone+ as well as from the Mackenzie Delta communities. The highway has the potential to disrupt migration, which could restrict the caribou's access to much of their winter range east and south of the highway. Various methods are available to resource managers to address these potential conflicts including applying a no-hunting corridor along the highway and by completely closing the highway to hunting for one week during the peak of fall migration in the region.[11] The big game no-hunting corridor (500m) is currently (for the 2012-2013 season) not being applied to caribou hunting and the one-week closure in the fall may be announced if deemed appropriate.[78] Traffic on the Dempster Highway remained fairly constant over the period 1993 to 2005, increasing from 2005 to 2008 (Figure 19).

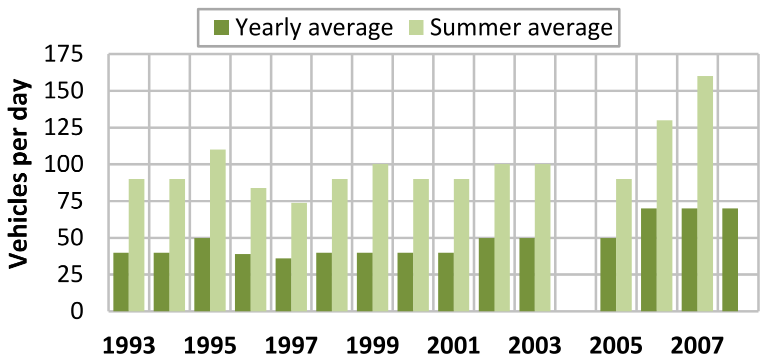


Figure 19. Traffic on the northern part of the Dempster Highway, 1993-2008.
Source: data from Department of Transportation, Government of Northwest Territories, compiled and provided by Arctic Borderlands Ecological Knowledge Co-op, 2009[41]

Key Finding 17 **Theme** Habitat, wildlife, and ecosystem processes

Species of special interest: economic, cultural, or ecological

National key finding
Many species of amphibians, fish, birds, and large mammals are of special economic, cultural, or ecological interest to Canadians. Some of these are declining in number and distribution, some are stable, and others are healthy or recovering.

Trends in northern mountain and boreal populations of woodland caribou are mainly declining or unknown. Some species of taiga-breeding landbirds are declining steeply. Peregrine falcons have recovered due to regulation of DDT globally and re-introduction of captive-bred birds to the ecozone⁺ (see page 26).

Caribou

As the main large herbivore over much of the ecozone⁺, caribou are ecologically important as well as being central to the economies, cultures and value systems of the First Nations and Inuvialuit of the Taiga Cordillera and neighbouring regions. There are three ecotypes of caribou in the ecozone⁺.

1. Porcupine caribou, though calving on the coastal plain to the north, are found in the Taiga Cordillera Ecozone⁺ through most of their annual cycle. This migratory caribou herd increased in numbers starting in 1970 to a peak in 1989, declined at a rate of 3.5% per year to 123,000 caribou in 2001 (Figure 20). Early movement of the herd away from the Alaskan coastal plain and bad weather during late June and early July prevented population estimates being made from 2003 through 2009. A successful 2010 survey resulted in a population estimate of 169,000, a return to a level close to that of the 1989 peak (see also box on Porcupine caribou and climate on page 28).

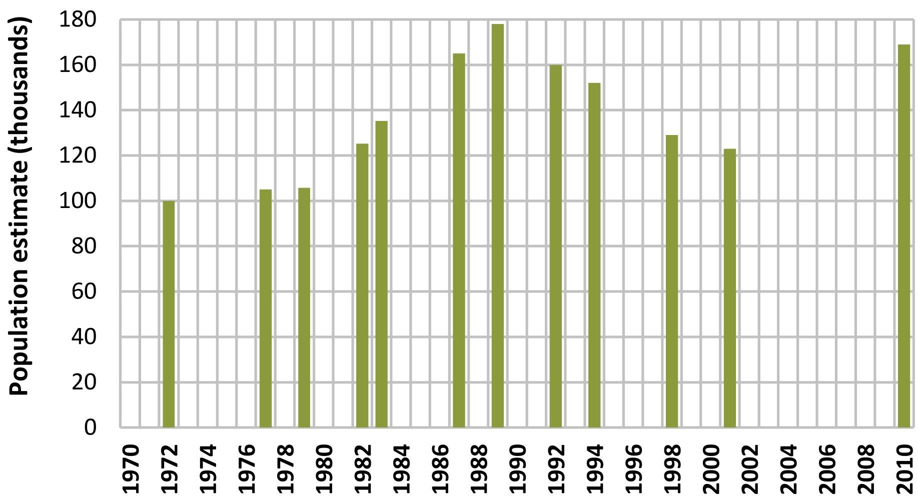


Figure 20. Porcupine Caribou Herd population estimates, 1972-2010.
Survey method is aerial photo-direct count extrapolation. Total count - no variance estimates calculated. Includes calves.
Source: based on data compiled for Gunn et al., 2011[11] – 1972-2001: Caikoski, 2009,[79] see also Joly et al., 2011;[80] 2010: Campbell, 2011[81]

2. Eight herds of the northern mountain population of woodland caribou have ranges in the ecozone+. The population is listed Special Concern under the federal *Species at Risk Act* and a management plan was released in 2012.[82] The Finlayson Herd is known to be decreasing and the Tay River Herd is considered stable – trends for the other six herds are not known (Figure 21 and Figure 22). Harvest is regulated for some herds to aid recovery.[82] Threats to the caribou herds include disturbance from human activities and from roads and other infrastructure. Habitat alteration from timber harvest, increases in forest fire suppression, and pine beetle outbreaks are major threats to northern mountain caribou herds further south but are not current threats in the Taiga Cordillera Ecozone+. Hunting and predation influence herd numbers, with implications both for wildlife management and management of habitat and access road development. Climate change may be affecting population status and trends through alteration of the caribou's forest habitat and/or through effects of increased snowfall and earlier springs – but there have been no specific studies completed on this.[82]

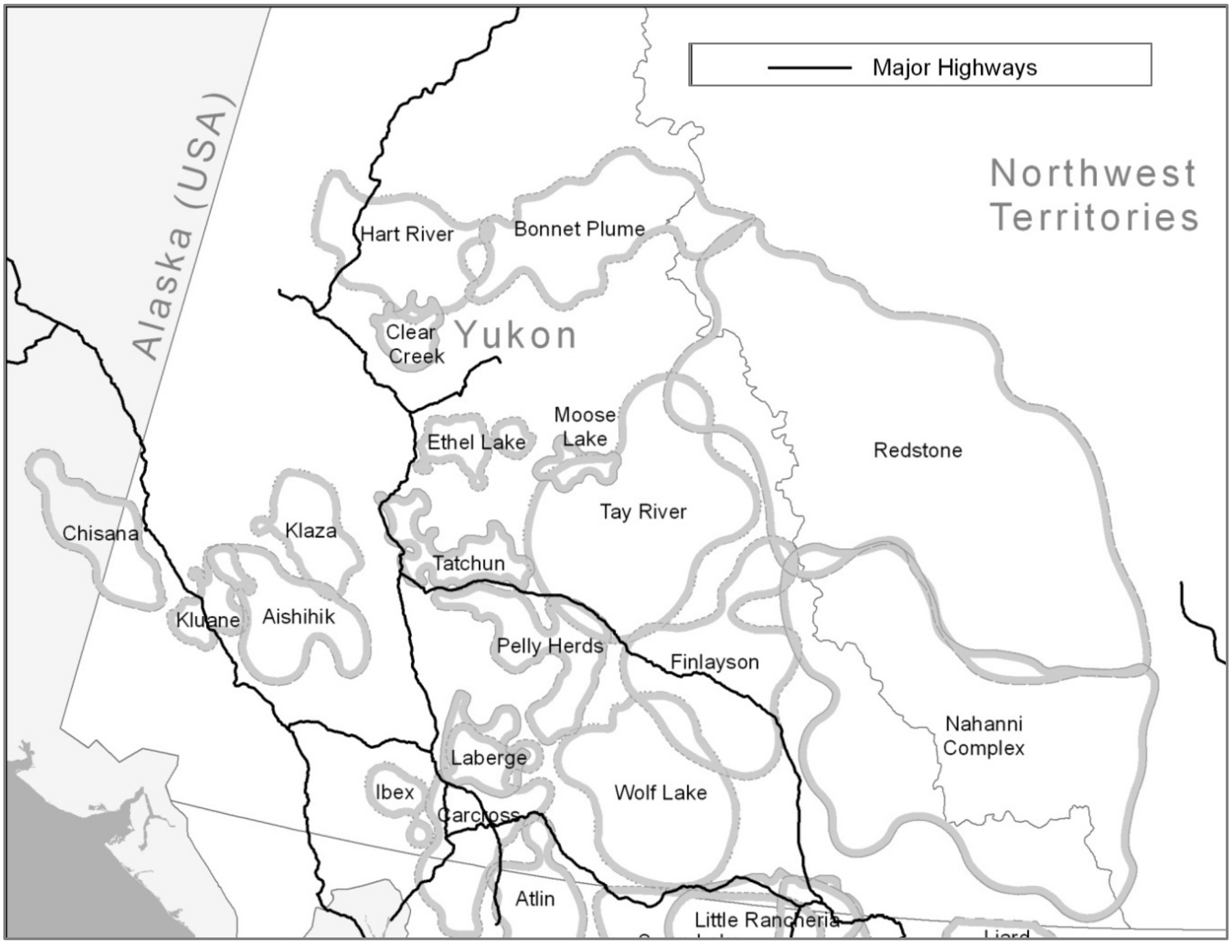
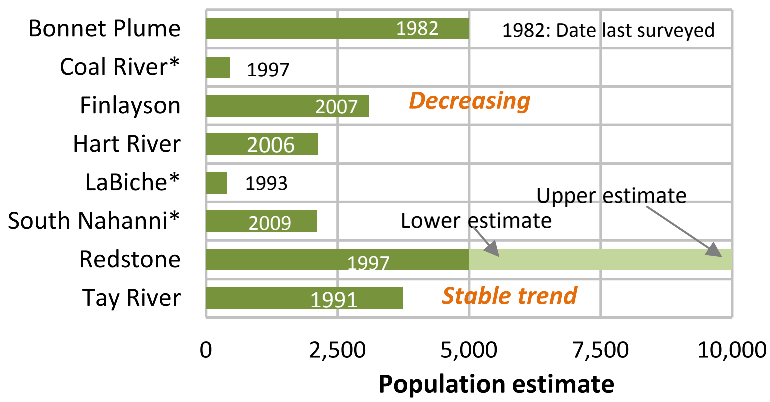


Figure 21. Annual ranges of northern mountain caribou herds in the Yukon and Northwest Territories.
Source: Environment Canada, 2012[82]



** Herds forming part of the Nahanni Complex*
Figure 22. Population estimates for northern mountain caribou herds,Taiga Cordillera Ecozone+. Unless otherwise noted, the overall population trends are not known. Results of the 2012 Redstone Herd population survey are not included.
Note: the herds forming the Nahanni Complex are now considered stable by Environment Yukon, Fish and Wildlife Branch[83]
Source: based on Appendix 2 of Environment Canada, 2012[82]

3. One local population of the boreal population of woodland caribou, listed as Threatened under the Species at Risk Act, ranges along the eastern boundary of the Taiga Cordillera Ecozone+, with the main parts of the range being in the Taiga Plains Ecozone+.[i] The population is estimated at 6,500 individuals.[84] While the trend for the entire population is unknown, increasing trends have been reported for some northern study areas where detailed demographic information has been collected over multiple years, and declining trends have been reported in more southerly study areas.[12, 84, 85]

Landbirds

Landbird information was reviewed for this report[13] considering all taiga ecozones+ as a group. Although there are very few data on landbirds breeding in the taiga, populations of some species are monitored in wintering ranges in the United States and southern Canada through the Christmas Bird Count. The results presented below are preliminary findings based on Christmas Bird Count data from Canada and the United States combined.[86]

Table 4 shows North American trends for six landbird species with breeding ranges that include portions of the three taiga ecozones+. Canada has a high stewardship responsibility for all these species because large portions of their western hemisphere breeding populations are in Canada.

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[i] The three local populations of boreal caribou said to occur in the Taiga Cordillera Ecozone+ in the related ESTR Technical thematic report (Callaghan et al., 2011[12]) are now all considered to be part of the one local population of boreal caribou occurring in the Northwest Territories.[84]

Table 4. Trends in annual abundance of selected landbirds from the three taiga ecozones[+], 1966-2005.

Species	Main breeding range	Population trend (%/yr)		Christmas Bird Count abundance index				
			P	1970s	1980s	1990s	2000s	Change
Rusty blackbird	Taiga and boreal	-5.46%	*	1.5	0.7	0.4	0.3	-78%
Boreal chickadee	Taiga and boreal	-1.73%	*	1.6	1.3	1.2	1.2	-29%
Northern shrike	Taiga	-0.79%	*	1.1	1.0	1.0	0.8	-29%
Pine grosbeak	Taiga and boreal	-0.78%		5.1	3.4	2.8	2.5	-52%
Smith's longspur	Taiga	-0.32%		0.05	0.06	0.07	0.08	57%
Lincoln's sparrow	Taiga and boreal	-0.08%		1.5	1.5	1.7	1.6	8%

Data show the annual rate of change and the average abundance index by decade.
Asterisks (*) indicate statistically significant trends (P<0.05). "Change" is percent change in average abundance between first decade (usually 1970s) for which there are results and 2000s decade (2000-06).
Source: based on data from the Christmas Bird Count (courtesy of D. Niven, Audubon) as reported in Downes et al., 2011[13]

Three of these species show consistent, statistically significant long-term declines in population. The rusty blackbird, a temperate migrant that winters in the United States, shows a dramatic 78% loss of population since the 1970s, by far the biggest decline of all species listed (Figure 23). The declines in rusty blackbirds, boreal chickadees and pine grosbeaks are supported by similar results from Breeding Bird Survey routes in other parts of their breeding ranges in Canada.

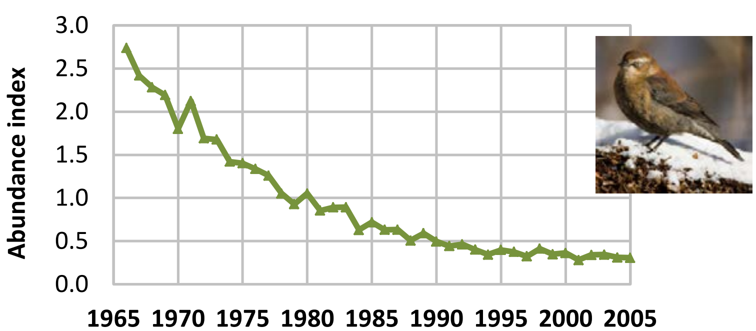

Figure 23. Trend in annual abundance index for the rusty blackbird, 1966-2005.
The decline is statistically significant (P<0.05).
Source: based on data from the Christmas Bird Count (courtesy of D. Niven, Audubon) as reported in Downes et al., 2011[13] Photo: Rusty blackbird © iStock.com

Chum salmon

Chum salmon *(Oncorhynchus keta*) in the Fishing Branch River (a tributary of the Porcupine River) have decreased from runs as high as 350,000 salmon in the 1970s to runs consistently below the lower bound of the escapement objective of 22,000 in the early 2000s, with some higher runs in recent years (Figure 24). Conservation concerns about the Porcupine River chum run resulted in the Vuntut Gwitchin First Nation adopting a voluntary fishery closure from 2002 to 2004. Fisheries biologists suspect that poor ocean conditions were responsible for low escapement levels between 1997 and 2003.[41] The salmon are part of an Aboriginal fishery and are a source of nutrients to land and river ecosystems, including an important seasonal food supply for grizzly bears (*Ursos arctos*).

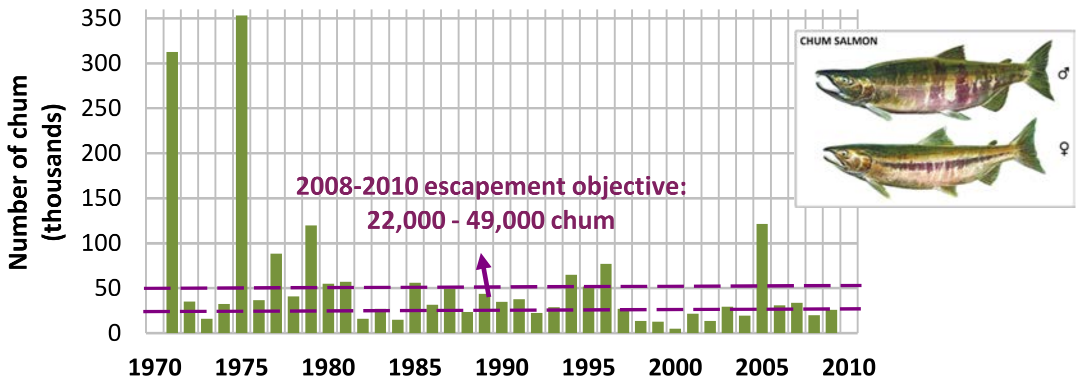

Figure 24. Chum salmon escapement, Fishing Branch River, 1971-2009.
The data for 1971, 1976-84, and 1990 are estimates based on aerial surveys. Remaining data are from fish weir counts. "Escapement" refers to the number of salmon that reach a specific location.
Source: data from Fisheries and Oceans Canada, compiled and provided by Arctic Borderlands Ecological Knowledge Co-op, 2009[41]

Key Finding 18 **Theme** Habitat, wildlife, and ecosystem processes

Primary productivity

National key finding
Primary productivity has increased on more than 20% of the vegetated land area of Canada over the past 20 years, as well as in some freshwater systems. The magnitude and timing of primary productivity are changing throughout the marine system.

Thirty-five percent of the land area of the Taiga Cordillera Ecozone+ showed a significant increase in the Normalized Difference Vegetation Index (NDVI) (a vegetation index related to primary productivity, derived from remote sensing) from 1986 to 2006.[15] Only 0.1% of land showed a decreasing trend. The increase in this ecozone+, one of the highest in Canada, is particularly evident in the extensive shrub and tundra vegetation communities south and west of the Mackenzie Mountains (Figure 25) – demonstrating that the trend reflects changes in growth characteristics not just of trees but of a range of plant types.

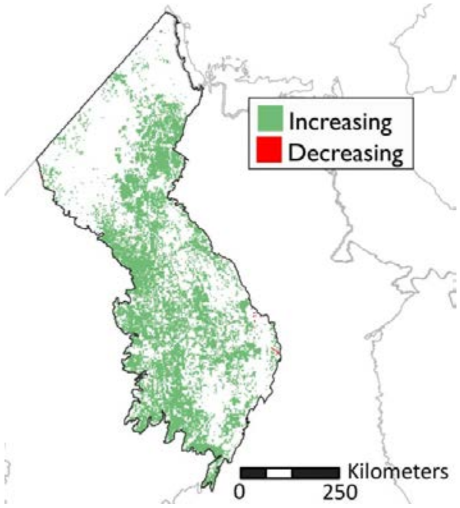

Figure 25. Trends in the Normalized Difference Vegetation Index for the Taiga Cordillera Ecozone⁺, 1985-2006.
Trends are in annual peak NDVI, measured as the average of the three highest values from 10-day composite images taken during July and August of each year. Spatial resolution is 1 km, averaged to 3 km for analysis. Only points with statistically significant changes ($p<0.05$) are shown.
Source: NDVI trend analysis by Pouliot et al., 2009[87]; ecozone⁺ analysis by Ahern et al., 2011[15]

Pouliot et al. (2009)[87] found that burns can have positive, negative, and zero NDVI trends, depending on the age of the burn. Some patches of increasing NDVI shown in Figure 25 are likely related to the dynamic process of wildfire and regeneration. There has been an increase in wildfire in the ecozone⁺ in recent decades (see section on natural disturbances on page 41). The trends in wildfire, however, cannot account for the scale and the distribution of the change in NDVI observed in the Taiga Cordillera Ecozone⁺ over the 22-year period.

Although warmer temperatures appear to be increasing primary productivity, studies show that tree growth can be negatively affected above a threshold. For example, annual growth of white spruce (measured from tree rings, 1901 to 1999) at an elevational treeline in the western part of the ecozone⁺ was strongly correlated with summer temperature for the first part of the time series. This temperature-growth relationship broke down and growth rates declined starting in the 1960s (Figure 26). This may have been related to increasing drought stress due to higher evapotranspiration in warmer summers. The authors conclude that if warming continues without significant gains in precipitation the increase in primary productivity (“greening”) of recent decades could be replaced by large-scale decreases (“browning”), which could slow or reverse carbon uptake by northern forests.[88]

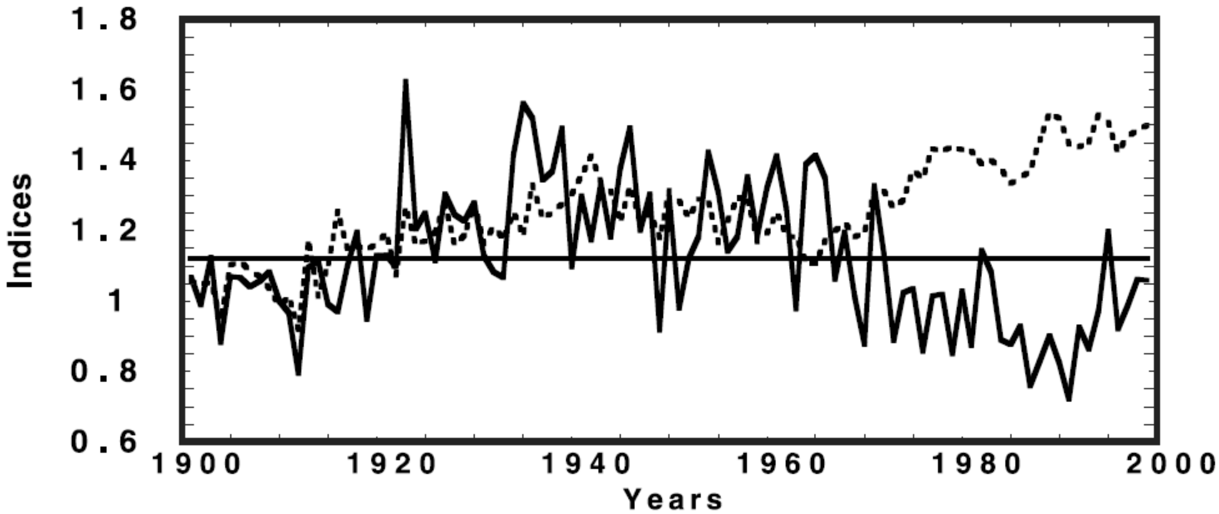

Figure 26. Relationship between temperature and growth of white spruce at treeline, 1901-1999. The solid line is an index of measured tree ring width for each year. The dashed line plots estimates of growth based on a linear relationship of growth with temperature. Temperatures from Dawson (south of the study area) were used in the model. The horizontal line is the tree ring mean, 1901-1999. Source: Figure 3 of D'Arrigo et al., 2004[88] © [2004] American Geophysical Union. Reproduced with permission of the American Geophysical Union.

Primary productivity, at the base of the food chain, has related impacts at higher trophic levels. Productivity of thinhorn sheep (*Ovis dalli*) populations across Yukon portions of the Taiga and Boreal Cordillera ecozones[+] is linked to climate conditions that affect spring productivity of forage plants. Annual horn growth, based on measurement of over 8,000 sheep horns submitted by hunters since 1972 was most strongly related to spring weather conditions (based on an index derived from local temperature, precipitation, and a measure related to large-scale, decadal climate oscillations in the Pacific Ocean).[89] Ten percent of growth in horn length and 7% of growth in horn volume could be predicted by this index of spring weather conditions – growth was greater in warmer springs. This is consistent with studies on Rocky Mountain bighorn sheep (*Ovis canadensis*) that show weather conditions in the spring have the greatest effect on sheep forage production (Stelfox 1975 cited in Loehr et al., 2010[89]). The effect is not just on the size of the horns – in years with warm spring conditions that favour horn growth, more lambs are counted in summer surveys (Figure 27). Annual horn growth has increased slightly over the time of measurement,[89] but fluctuates noticeably on a decadal cycle, as does lamb production (Figure 27).

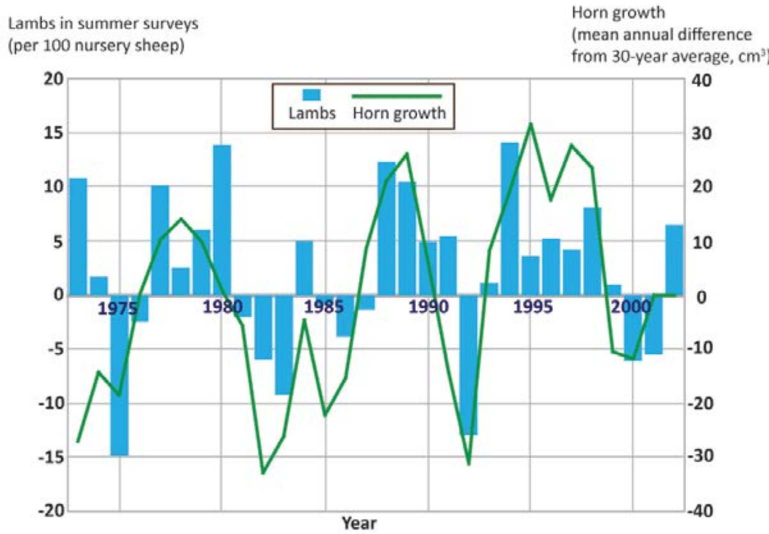

Figure 27. Congruence of lamb production and horn growth in thinhorn sheep, 1973-2002. Source: figure courtesy of J. Carey, Yukon Government, 2010[90]

Key finding 19 **Theme** Habitat, wildlife, and ecosystem processes

Natural disturbances

National key finding

The dynamics of natural disturbance regimes, such as fire and native insect outbreaks, are changing and this is reshaping the landscape. The direction and degree of change vary.

Fire has increased in the Taiga Cordillera Ecozone+, with the average annual area burned approximately doubling between the 1960s-1980s and the 1990s-2000s. The fire season has also extended longer in the fall. Insect outbreaks occur, but are not as significant a factor in forest disturbance.

Fire

On average, an area of 857 km^2 burns in large fires in the Taiga Cordillera Ecozone+ each year, a greater proportion of the forested area than in the Montane and Boreal Cordillera ecozones+.[8] This may be related to differences in suppression efforts[91] and/or to drier conditions.[92] There are no areas of intense fire suppression in the Taiga Cordillera.[91] At the decadal scale, there is no consistent pattern in area burned, (Figure 28) taking into consideration the improvement in monitoring of fires in northern Canada since the 1970s.[93] The most noticeable pattern is an increase in area burned in the most recent two decades over the 1980s, consistent with patterns in the Montane and Boreal cordilleras.[8] Fires usually occur in June and July, but there has been a significant, three-fold increase in the proportion of fires occurring in August from the 1960s to the 1990s, accompanied by an increase of 14 days in the duration of the active fire season in the 1990s (Figure 29). Most fires are caused by lightning.[8]

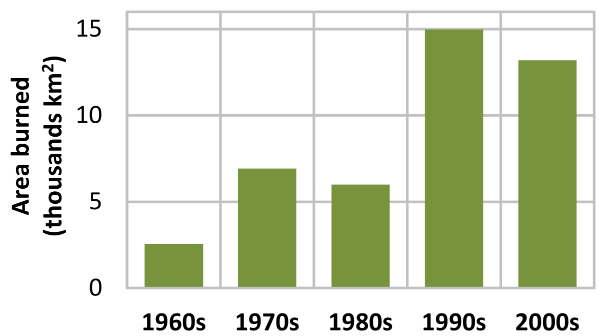

Figure 28. Trend in the total area burned per decade for the Taiga Cordillera Ecozone+, 1960s-2000s. The value for the 2000s decade was pro-rated over 10 years based on the average from 2000-2007. Source: Krezek-Hanes et al., 2011[8]

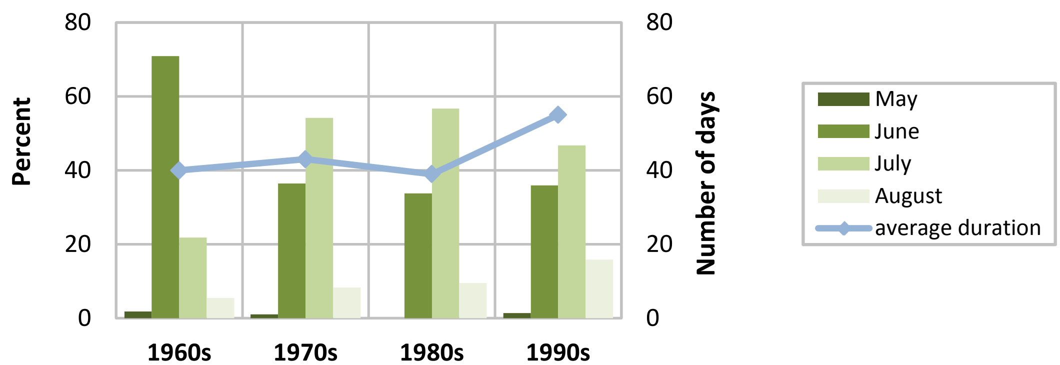

Figure 29. Proportion of large fires that occur each month and the average duration of the active fire season, 1960s-1990s.
Source: Krezek-Hanes et al., 2011[8]

Forest insect outbreaks

Forest insect infestation is assessed as a measure of forest ecological integrity for Nahanni National Park Reserve.[32] The two main defoliators in the area are aspen serpentine leafminer (*Phyllocnistis populiella*) and spruce budworm (*Choristoneura fumiferana).* The former, though widespread, has not had significant impact on the forest. Outbreaks of spruce budworm occurred in 1955-1969, 1982-1994, and 1998-2005, affecting large areas of forest in Nahanni but not resulting in significant tree mortality.[32]

In the Yukon, aspen serpentine leafminer is endemic in the southern half of the territory and is also present in the Old Crow region. Outbreaks of unprecedented scale and severity over the past two decades in parts of Alaska and Yukon, including in the Mayo region just to the south of the Taiga Cordillera, have resulted in extensive damage to stands of aspens and other deciduous trees, rarely killing trees but leaving them stunted and deformed. Warmer summer temperatures, resulting in reduced soil moisture and better overwinter survival of the insects, may be implicated in the outbreaks.[94]

Key finding 20 **Theme** Habitat, wildlife, and ecosystem processes

Food webs

National key finding

Fundamental changes in relationships among species have been observed in marine, freshwater, and terrestrial environments. The loss or reduction of important components of food webs has greatly altered some ecosystems.

Small mammal cycles are not monitored. Willow ptarmigan surveys conducted in the Ogilvie Mountains since 1971 indicate a change since about 2001, with a flattening out of the cyclic fluctuations.

Voles, lemmings, hares, and grouse populations are cyclic and in many ways drivers of the ecosystems in the Taiga Cordillera Ecozone+. Long-term data sets demonstrating these cycles exist for the Boreal Cordillera Ecozone+ in the Kluane region and in Taiga Plains Ecozone+ in the Northwest Territories.[95] For the Taiga Cordillera Ecozone+, population cycle information is limited to willow ptarmigan.

There are indications that ten-year population cycles of willow ptarmigan (*Lagopus lagopus*) may be breaking down, starting about 2000 – based on monitoring since 1971 in the Coast and Ogilvie Mountains.[96, 97] Mossop (2008)[97] reported that the previously stable cycles of ptarmigan abundance may have been disrupted and the changes could have strong influences on the ecosystem as ptarmigan is a keystone species for the tundra community (Figure 30). Keystone species play an important role in determining community structure.[98] There are indications of disruption at the top of the food chain: gyrfalcon in the Coast Mountains (Boreal Cordillera Ecozone+) may be breeding later,[99] producing fewer young, and declining in abundance.[100]

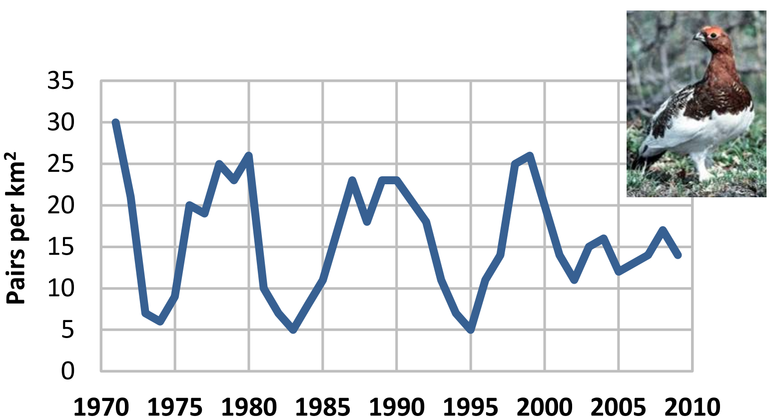

Figure 30. Willow ptarmigan population trends, Ogilvie Mountains, 1971-2009.
Based on surveys along the Dempster Highway.
Source: data from Mossop, 2006[101] and updated by the author. Photo: © Parks Canada/W. Lynch/1984

THEME: SCIENCE/POLICY INTERFACE

Key finding 21 **Theme** Science/policy interface

Biodiversity monitoring, research, information management, and reporting

National key finding
Long-term, standardized, spatially complete, and readily accessible monitoring information, complemented by ecosystem research, provides the most useful findings for policy-relevant assessments of status and trends. The lack of this type of information in many areas has hindered development of this assessment.

Overall, there is little long-term ecological monitoring in the ecozone+ and little integration of data into accessible, synthesized formats. Few conclusions can be drawn about ecosystem status and trends. Baseline, descriptive information has been compiled for several regions, especially in relation to the formation of protected areas and for land use planning. There are some important long-term datasets and bodies of information and expertise that are valuable for this and future ecosystem assessments if they are maintained and further developed.

Strengths

- Good body of traditional knowledge and research in progress (especially through International Polar Year) on the use of Aboriginal Traditional Knowledge (ATK) and science in monitoring and assessing ecological change.
- Knowledge (science and ATK) of the Porcupine Caribou Herd, including habitat use and relationship of climate variables with population parameters.
- Monitoring of ptarmigan in the Ogilvie Mountains, one of the longest records of cyclic populations in the Canadian north.
- Landscape-level analysis of Old Crow Flats wetlands that demonstrates the complex effects of climate and structural change and provides a good baseline for future trend analysis.
- Research and long-term monitoring on waterfowl in the Old Crow Flats.
- Twenty-year monitoring records on changes in palsas and peat plateaus and in permafrost temperatures in the Mackenzie Mountains.
- Developing set of ecological integrity measures and state of the park reporting for Nahanni National Park Reserve.
- The Harvest Management Plan for the Porcupine Caribou Herd in Canada (2009)[102] and the Implementation Plan (2010)[103] confirmed commitments from all users groups to collect and report their harvest information.

- The CircumArctic Rangifer Monitoring and Assessment (CARMA) Network's climate database is available for climate-based research.

Gaps identified

- Only one climate station on which to base long-term trend analysis and little ongoing monitoring of ecosystem processes with major ecological impacts – for example, stream flow, glaciers, permafrost, and forest insects.
- Many of the ecological consequences of accelerated climate change are not known specifically from research in this ecozone+. Some, such as changes in shrub growth, can be inferred from research in other parts of sub-arctic, but research and monitoring would be needed to confirm the trends and to understand the ecological consequences of these changes.
- Limited information is readily available on extent of human activities related to resource development and on changes in activity levels over time. Because information has not been compiled and georeferenced, identification of potential issues and tracking of cumulative impacts are difficult.
- Little information on status and trends of grizzly bears, important ecologically and as a species of conservation concern.
- Varied population and trend data for northern mountain woodland caribou herds within the ecozone and lack of understanding of factors influencing the trends.
- Poor and out-of-date estimates of total harvest for the Porcupine Caribou Herd, needed for effective management. The Harvest Management Plan for the Porcupine Caribou Herd in Canada (2009)[102] and the Implementation Plan (2010)[103] confirmed commitments from all users groups to collect and report their harvest information and should help address this issue.
- Little information on distribution, status, and trends for landbirds, shorebirds and other waterbirds.

Key finding 22 **Theme** Science/policy interface

Rapid changes and thresholds

National key finding
Growing understanding of rapid and unexpected changes, interactions, and thresholds, especially in relation to climate change, points to a need for policy that responds and adapts quickly to signals of environmental change in order to avert major and irreversible biodiversity losses.

There are at least three signals that may indicate abrupt ecological change in the Taiga Cordillera Ecozone+: (1) at some point around 1972 the influence of warmer temperatures on evapotranspiration moved the Old Crow Flats into a negative water balance (see page 11), (2) in the 1960s a summer temperature threshold was exceeded for white spruce growth at a treeline site in the Ogilvies (see page 40); and (3) the ten-year population cycle of willow ptarmigan evident in monitoring since 1971 has flattened since 2001 (see page 43). An example of an early warning signal of potential abrupt change is the presence of several invasive plant species that could spread rapidly.

CONCLUSION: HUMAN WELL-BEING AND BIODIVERSITY

The Taiga Cordillera Ecozone+, in comparison with most ecological regions in Canada and around the world, has relatively intact ecosystems with high wilderness values and with lands and waters that support harvesting of traditional/country foods. In the national and global contexts, the large, productive wetland complexes and the far northern mountain ecosystems of the Taiga Cordillera are rare and are of high ecological and cultural significance.

The Taiga Cordillera Ecozone+ is also significant in the diversity of its peoples and heritage. Although there are only two small communities, traditional territories of the Aklavik Inuvialuit and of several Yukon and Northwest Territories First Nations include substantive portions of the Taiga Cordillera Ecozone+ – speaking to the long history of the wealth of the land and the importance of the plants, fish, and wildlife as traditional/country foods. The ecozone+ is also of growing importance for tourism, including wildlife viewing, hunting, fishing, and river expeditions.

The ecozone+ contains oil, gas, and mineral resources that have been explored and exploited only to a limited degree. Due to the remoteness of the region, costs are high and resource activity is very dependent on commodity prices. There are few studies to help predict what level of human activity would lead to disruption of current ecosystem services and naturally functioning processes and little monitoring to detect early warning signals of disruption.

Climate change is occurring most rapidly in the northern and western parts of Canada, and this is currently of concern for the long-term maintenance of biodiversity and ecosystem health in the Taiga Cordillera Ecozone+. With little ongoing ecological monitoring, including little monitoring of the climate itself, there are few clear trends that can be identified. There are, however, many changes that fall within the 'early warning' category, providing indications of climate change impacts similar to those observed in neighbouring regions and to those that are projected in climate change impact assessments for Arctic and subarctic ecosystems.

Trends in permafrost reported here (increased temperatures and collapse of the widespread permafrost landforms) are expected to continue and to increase in scope. These changes, as well as affecting infrastructure such as the Dempster Highway, will likely alter habitats, affecting distribution and abundance of animals and access routes for hunters and fishers. Wetland changes are also likely to continue, though the direction of change is difficult to predict.

Changes in vegetation are expected to result from the observed increasing trend in primary productivity, combined with collapse of permafrost landforms, increased wildfire, and perhaps increased moisture stress. Local observations record greater shrub growth in some areas and studies show increased tree density in other areas. Treeline advance in the region has been shown to have occurred slowly in the past in response to warmer temperatures and it may take some time for major changes to become apparent. Analyses of current conditions and climate model projections for the ecozone+ predict large increases in fire and expansion of shrubs and trees to higher elevations. These emerging trends will likely lead to shifts, expansions and reductions in habitat for many animals, as well as to shifts in potential human land uses – with implications for protected area management and for land use planning.

Of immediate concern for the Taiga Cordillera Ecozone+ is the long-term health of caribou populations. The decline of the Porcupine Caribou Herd from 1989 to at least 2001 could have been part of a natural cycle, as numbers have since increased. Future cyclical declines, however, may be compounded by, among other things, climate change impacts and harvest in the Taiga Cordillera Ecozone+. Both the importance of the herd to human well-being and the impact on the herd of harvest in the ecozone+ are disproportionate to the number of residents because the Dempster Highway provides road access to the herd's winter range. Further south, the ecozone+'s herds of northern mountain caribou are an important resource for communities in the neighbouring Taiga Plains and Boreal Cordillera ecozones+. Measures to monitor and to conserve these herds have recently been recommended in a management plan for this caribou population of Special Concern, completed in 2012.[82] Recommendations in the management plan build on many conservation and management activities already underway.

Another prized resource in the Taiga Cordillera Ecozone+ is the half-million waterfowl and waterbirds that converge on Old Crow Flats each year. Surveys conducted since 1955 show mainly stable or increasing species trends. Dabbling ducks in particular have increased substantially.

Two aspects of this ecozone+ stand out. First, of Canada's ecozones+, it contains some of the largest areas of intact ecosystems. Secondly, current research and monitoring are not sufficient to identify and track threats, problem areas, and management options for conserving these ecosystems and the services they provide.

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