



# Hudson Plains Ecozone<sup>+</sup>

## Evidence for key findings summary

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## PREFACE

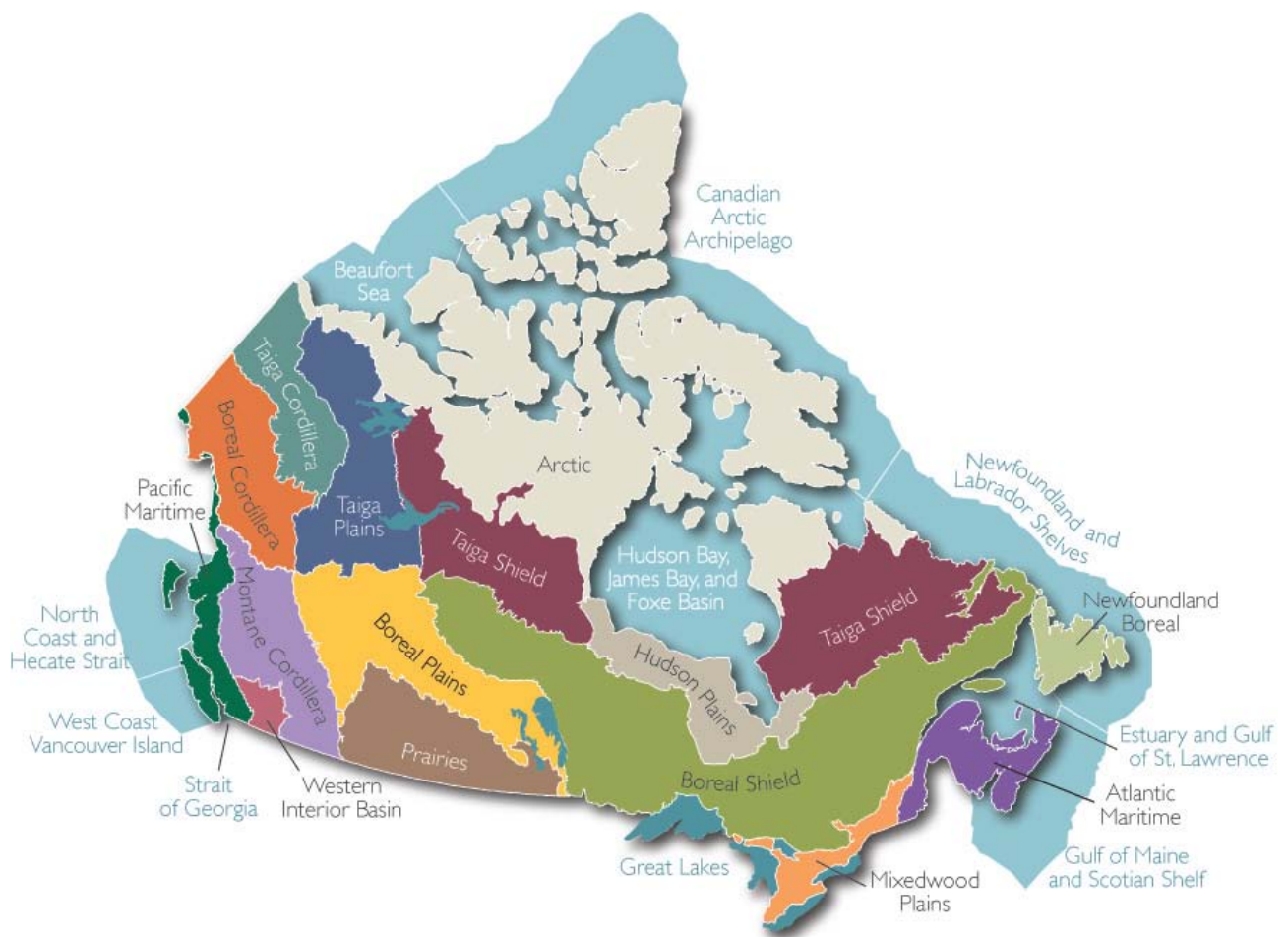
The Canadian Councils of Resource Ministers developed a Biodiversity Outcomes Framework<sup>1</sup> in 2006 to focus conservation and restoration actions under the *Canadian Biodiversity Strategy*.<sup>2</sup> *Canadian Biodiversity: Ecosystem Status and Trends 2010*<sup>3</sup> was the first report 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<sup>+</sup> of Canada (the Technical Ecozone<sup>+</sup> 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<sup>+</sup> to present the ecozone<sup>+</sup>-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, *Hudson Plains Ecozone<sup>+</sup> Evidence for Key Findings Summary*, presents evidence from the Hudson Plains Ecozone<sup>+</sup> related to the 22 national key findings. The report is not a comprehensive assessment of all ecosystem-related information. The level of detail presented on each key finding varies, and issues or datasets may have been missed. Some emphasis is also placed on information from the national Technical Thematic Report Series. 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 on the full Technical Ecozone<sup>+</sup> Report for this ecozone<sup>+</sup>, *Hudson Plains Ecozone<sup>+</sup> Status and Trends Assessment*,<sup>4</sup> which was prepared for this project and also incorporates information from many of the Technical Thematic Reports. Many experts from a broad range of disciplines and organizations contributed to the full Hudson Plains status and trends assessment as authors and reviewers (see acknowledgements section on page iii). Additional reviews of this summary report were provided by scientists and resource managers from relevant provincial, territorial, and federal government agencies.

## Ecological classification system – ecozones<sup>+</sup>

A slightly modified version of the Terrestrial Ecozones of Canada, described in the *National Ecological Framework for Canada*,<sup>5</sup> 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.<sup>6</sup> For the Hudson Plains, modifications were made to the southern boundary of the ecozone within Ontario to reflect the actual contact between the Precambrian and Paleozoic bedrock.



## Acknowledgements

This summary report is based on the technical report, *Hudson Plains Ecozone+ Status and Trends Assessment* (see credit box below),<sup>4</sup> and has been prepared in partnership by the lead authors of the full technical report and the ESTR Secretariat. Additional reviews of this summary report were provided by scientists and resource managers from relevant provincial, territorial, and federal government agencies through a review process administered by the ESTR Steering Committee. Direction and report production were provided by the ESTR Secretariat.

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Figure 1. Overview map of the Hudson Plains Ecozone<sup>+</sup>.  
 Gillam lies outside of ecozone<sup>+</sup> boundaries, but is shown for geographic context.

## ECOZONE<sup>+</sup> BASICS

The Hudson Plains Ecozone<sup>+</sup> (Figure 1) is a low-lying northern region that has been little altered by human activities; however, it is increasingly under threat from climate change and pressure for new development. Its extensive wetlands provide critical habitat for a variety of birds and its peatlands also play an important global role in carbon storage. Species of national conservation concern such as polar bear, woodland caribou, wolverine, and lake sturgeon find an important refuge there. This ecozone<sup>+</sup> has many critical information gaps. Table 1 provides an overview of the main features of the ecozone<sup>+</sup>.

*Table 1. Hudson Plains Ecozone<sup>+</sup> overview.*

<b>Area</b>	352,980 km <sup>2</sup>
<b>Topography</b>	Very low grade 0.5 m/km rise from the ocean, with little relief; maximum elevations 130 m near the Nelson River in Manitoba and 240 m east of James Bay Broad, poorly drained plains, interrupted by incised valleys along major rivers, a low bedrock ridge at Churchill, Manitoba and the Sutton Ridges (a 50 km long, 120 m high cuesta) southwest of Cape Henrietta Maria, Ontario Extensive wetlands and numerous small lakes and ponds
<b>Climate</b>	Maritime boreal climate, influenced significantly by Hudson and James bays, especially seasonal sea ice cover Mean annual air temperatures vary from -7°C at Churchill, Manitoba to -1°C at Moosonee, Ontario; precipitation varies from 430 mm to 680 mm correspondingly
<b>River basins</b>	Churchill, Nelson, Hayes, Severn, and Winisk rivers flowing into Hudson Bay Attawapiskat, Albany, Moose, Harricana, Nottaway, Rupert, and Eastmain rivers flowing into James Bay
<b>Geology</b>	Former Tyrell Sea bottom, formed by retreat of Laurentide Ice Sheet; land is still rebounding at one of the highest rates in North America Bedrock mostly Paleozoic limestone and dolomite; glacial and postglacial deposits up to 80 m thick Surface sediments largely fine-grained calcareous deposits overlain by thin blankets of marine sand or thicker sandy deposits forming beach ridges
<b>Permafrost</b>	Sea ice in Hudson and James bays cools the climate and contributes to the occurrence of the most southern continuous permafrost in North America Permafrost grades from continuous along the Hudson Bay coast; to discontinuous towards the south and inland; to isolated patches around James Bay in the south Permafrost is absent in the most southern reaches of the ecozone <sup>+</sup> away from the coast
<b>Settlement</b>	Moosonee and Moose Factory, both in Ontario, were the largest communities in 2006 (last census year), with estimated populations of 2,006 and 2,700, respectively
<b>Economy</b>	Mixed traditional (especially hunting and fishing) and wage-based economies, with high unemployment rates in the wage economy Transportation, government services, hydroelectricity, and tourism (the latter principally at Churchill, Manitoba and Moosonee-Moose Factory, Ontario), with mining increasing in importance Economic development is being increasingly explored and promoted

<b>Development</b>	<p>Access into the ecozone<sup>+</sup> is limited to sea, air, two railway lines, and one all-season road that connects Eastmain and Waskaganish in Quebec with the highway system in the south; communities within the ecozone<sup>+</sup> are seasonally connected by winter roads</p> <p>Resource developments mostly in the hydroelectric sector but a diamond mine was established near Attawapiskat, Ontario in 2006 (opened 2008) and recent discovery of world-class chromite deposits further inland portends major mining-related infrastructure</p> <p>Very little forestry or agriculture; limited subsoil asset extraction (except the one mine)</p>
<b>National/global significance</b>	<p>Largest wetland complex in Canada and third largest in the world, making this ecozone<sup>+</sup> of hemispheric importance to migratory birds</p> <p>Largest peat basin in Canada and the second largest in northern latitudes (&gt;40-50°), making this ecozone<sup>+</sup> globally important for carbon storage</p> <p>Contains two designated Wetlands of International Importance: Polar Bear Provincial Park and Southern James Bay Migratory Bird Sanctuaries (Moose River and Hannah Bay)</p> <p>Part of one of the largest intact tracts of forest remaining in Canada and the world</p>

**Jurisdictions:** Most of the Hudson Plains Ecozone<sup>+</sup> lies in northern Ontario (Figure 1). From its core in Ontario, the ecozone<sup>+</sup> extends west along the Hudson Bay coast to the Churchill area in northern Manitoba and east into the western part of coastal Quebec. The few islands in James Bay that are part of this terrestrial ecozone<sup>+</sup> are jurisdictionally part of Nunavut. Akimiski Island is the largest of these islands and it is located just off the western coast of James Bay.

**Population:** The Hudson Plains Ecozone<sup>+</sup> is home to an estimated 14,000 residents, concentrated in 11 communities at a density of about one person per 24 km<sup>2</sup>.<sup>12, 13</sup> Most of these communities are coastal villages located near the mouths of major rivers (estuaries) (Figure 1) and residents are primarily of Aboriginal descent, principally Cree and Metis.<sup>14</sup>

## KEY FINDINGS AT A GLANCE: NATIONAL AND ECOZONE<sup>+</sup> LEVEL

Table 2 presents the national key findings from *Canadian Biodiversity: Ecosystem Status and Trends 2010*<sup>3</sup> together with a summary of the corresponding trends in the Hudson Plains Ecozone<sup>+</sup>. Topic numbers in this section correspond to the national key findings as described in *Canadian Biodiversity: Ecosystem Status and Trends 2010*.<sup>3</sup> Topics in grey text were identified as key findings at a national level but were either not relevant or not assessed for this ecozone<sup>+</sup>. Key findings that are not relevant to the Hudson Plains Ecozone<sup>+</sup> do not appear in the body of this document. Evidence for the statements that appear here are found in the subsequent text organized by key finding and further elaborated on in the full Technical Ecozone<sup>+</sup> Report, *Hudson Plains Ecozone<sup>+</sup> Status and Trends Assessment*.<sup>4</sup>

Table 2. Key findings overview.

Themes and topics	Key findings: NATIONAL	Key findings: HUDSON PLAINS ECOZONE <sup>+</sup>
<b>THEME: BIOMES</b>		
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.	No trends are apparent in the extent of forest cover. Information is insufficient to assess for potential changes in forest structure, including species composition, age class (or time-since-fire), and intactness. No such changes are expected based on minimal anthropogenic disturbance, including harvest, and an effectively natural and apparently unchanged disturbance regime.
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.	Information is currently insufficient for analysis of trends in the distribution, extent, or condition of inland wetlands. These wetlands are assumed healthy, with extensive peatlands largely intact, except in limited areas affected by hydroelectric and mining developments.

Themes and topics	Key findings: <b>NATIONAL</b>	Key findings: <b>HUDSON PLAINS ECOZONE<sup>+</sup></b>
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.	The streamflow network is deficient but a reduced total annual volume of freshwater naturally discharged from several rivers is evident over the last four decades, associated with a four day advance in annual peak discharge rate and a decline in peak intensity. Lakes and rivers are relatively undisturbed and assumed to be mostly in good condition overall. However, hydroelectric developments in and around the ecozone <sup>+</sup> have affected flow rates and other physical parameters of some rivers and created a large reservoir in the ecozone <sup>+</sup> , with impacts on biota. Cumulative effects from these and possible future hydroelectric developments in the watershed is a concern.
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.	Intense foraging principally by a greatly increased Mid-Continent population of lesser snow goose has resulted in an apparent trophic cascade in this biome, with an associated loss of ~30% of coastal salt marsh vegetation since the 1970s, from Manitoba to James Bay. Additional area is still being damaged. Hydroelectric development that has reduced the discharge of freshwater from some rivers has caused more saltwater intrusion into estuaries with associated impacts on fish communities. Deterioration of eelgrass beds along the eastern James Bay coast is a concern.
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.	The marine biome is not directly part of the Hudson Plains Ecozone <sup>+</sup> , but Ice across biomes and Species of special interest: economic, cultural, or ecological illustrate links between sea ice and the ecozone <sup>+</sup> 's climate and polar bears. Other information about the marine ecosystem adjacent to Hudson Plains Ecozone <sup>+</sup> can be found in the Arctic-marine Ecozone <sup>+</sup> technical and summary reports of the ESTR. <sup>15, 16</sup>

Themes and topics	Key findings: <b>NATIONAL</b>	Key findings: <b>HUDSON PLAINS ECOZONE<sup>+</sup></b>
Tundra <sup>*</sup>	Ecozone <sup>+</sup> -specific key finding	Information is insufficient for analysis of trends in the extent or condition of the tundra (including potential treeline shifts) but some damage is occurring to tundra freshwater marshes as an effect of excessive feeding by a greatly expanded lesser snow goose population (see Coastal biome section above). Some damage is also being caused by operation of wheeled vehicles (tundra buggies/ATVs). The tundra, which reaches its most southerly extent in this ecozone <sup>+</sup> , is especially vulnerable to climate change and associated permafrost thaw.
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.	Sea ice extent in the broader Hudson Bay marine ecosystem has declined 5.3% per decade over the period 1979 to 2006, with decreases evident in all seasons except winter. The annual period of sea ice cover in western Hudson Bay, southern Hudson Bay, and James Bay (areas adjacent to the ecozone <sup>+</sup> ) has decreased an average of about three weeks since the mid-1970s. These changes in sea ice are correlated with deteriorations in the polar bear subpopulations that use the ecozone <sup>+</sup> . Monitoring data are currently insufficient to assess trends in permafrost but some permafrost degradation is suspected from casual observations, as well as permafrost loss occurring just outside western and eastern ecozone <sup>+</sup> borders. Data are insufficient for analysis of trends in lake and river ice.
<b>THEME: HUMAN/ECOSYSTEM INTERACTIONS</b>		
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.	The amount of protected area has grown from 1939 to the present, most substantially with the addition of Polar Bear Provincial Park in 1970 and Wapusk National Park in 1996. Protected areas now cover 12.8% of the land base, and include two designated Wetlands of International Importance and two new protected areas announced December 2009. Some representation and connectivity gaps remain, particularly in the interior versus the coast.

<sup>\*</sup> This key finding is not numbered because it does not correspond to a key finding in the national report.<sup>3</sup>

Themes and topics	Key findings: <b>NATIONAL</b>	Key findings: <b>HUDSON PLAINS ECOZONE<sup>+</sup></b>
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.	Co-management agreements among First Nations and other levels of government are a particularly important type of stewardship initiative in this ecozone <sup>+</sup> . Some important new initiatives were recently introduced, including Ontario's <i>Far North Land Use Planning Initiative</i> and the <i>Eeyou Marine Region Land Claims Agreement</i> . Such initiatives have the capability to have a direct influence at a broad level on conservation of biodiversity values.
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.	A number of species both non-native and native to Canada have been introduced into the ecozone <sup>+</sup> from outside their normal range but their impacts on the ecology of the ecozone <sup>+</sup> are not well studied or monitored. Most introduced species are vascular plants (at least 98 species), generally found near villages. A few introduced species of smaller mammals, birds, and fish are also known to be present, with smallmouth bass (a species native to Canada that was introduced outside its normal range) most recently discovered (2008-09). The potential spread of this warm water predatory species as the climate warms is a concern for fish community composition and dynamics.
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.	Trends in persistent organic pollutants (POPs) in polar bears are variable with some legacy contaminants declining and some newer (emerging) contaminants increasing. Dietary changes linked to a shortening sea-ice season may be affecting the rates at which POPs change in these bears. In contrast, levels of metals in polar bears, including mercury, have not changed since the 1980s. Mercury monitoring in fish has been limited but significant increases were observed following inundation of the Opinaca reservoir in 1980. Methylmercury levels in water declined to pre-impoundment values in ~8-10 years while mercury levels in fish have declined more gradually and are forecast to increase again due to receipt of mercury exported from a recently impounded reservoir upstream, just outside the ecozone <sup>+</sup> . Environmental contaminants at former Mid-Canada Line radar sites are a concern but remediation is now in progress for Ontario sites.

Themes and topics	Key findings: <b>NATIONAL</b>	Key findings: <b>HUDSON PLAINS ECOZONE<sup>+</sup></b>
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 <sup>+</sup> . Minimal nutrient inputs and no known algal blooms or related concerns.
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 <sup>+</sup> . No significant concerns with acid deposition at present, although the ecozone <sup>+</sup> has some acid-sensitive terrain.
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.	The few climate stations in the ecozone <sup>+</sup> with long-term data show significant trends over the period 1950-2007 for increased mean annual and/or mean seasonal temperatures (winter and/or summer), increased effective growing degree days, decreased total spring precipitation, decreased seasonal days with precipitation (spring or winter), and a decreased proportion of precipitation falling as snow, depending on location. Main impacts associated with the changing climate include: a significantly shorter sea-ice season in Hudson and James bays; deterioration in the polar bear subpopulations that use the ecozone <sup>+</sup> ; advancing wildlife phenology; and changing predator-prey interactions involving polar bear. Other early impacts might also be present but are not detectable given a paucity of monitoring. Climate projections forecast a substantial or complete loss of seasonal sea ice in areas adjacent to the ecozone <sup>+</sup> and a ~50% or more reduction in continuous permafrost (and complete loss of permafrost that is currently discontinuous or in isolated patches) in the ecozone <sup>+</sup> by 2100. Cascading effects on the ecozone <sup>+</sup> 's ecosystems and biota are expected as the ecozone <sup>+</sup> 's defining climatic and edaphic conditions are lost.



Themes and topics	Key findings: <b>NATIONAL</b>	Key findings: <b>HUDSON PLAINS ECOZONE<sup>†</sup></b>
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.	There is no compelling evidence that the capacity of the ecozone <sup>†</sup> to supply ecosystem services has deteriorated, based on limited information available for a select set of services examined for the ESTR. Fur harvests continue to decline but this is probably related to market conditions and changes in Aboriginal lifestyle. The ecozone <sup>†</sup> 's climate-regulating services are of notable concern – the ecozone <sup>†</sup> is Canada's largest peatland complex and climate change impacts on carbon storage and cycling there (currently not monitored) may be globally significant.
<b>THEME: HABITAT, WILDLIFE, AND ECOSYSTEM PROCESSES</b>		
Intact landscapes and waterscapes <sup>†</sup>	Intact landscapes and waterscapes was initially identified as a nationally recurring key finding and information was subsequently compiled and assessed for the Hudson Plains Ecozone <sup>†</sup> . In the final version of the national report, <sup>3</sup> information related to intact landscapes and waterscapes was incorporated into other key findings. This information is maintained as a separate key finding for the Hudson Plains Ecozone <sup>†</sup> .	This ecozone <sup>†</sup> has the most intact (97% intact, based on a 2006 analysis) or least anthropogenically fragmented landscape of the forested ecozones <sup>†</sup> in Canada, with very few linear disturbances (hydroelectricity transmission corridors, winter roads, and two railway lines and one all-season road that connect the ecozone <sup>†</sup> to the south). As such, the ecozone <sup>†</sup> still provides quality habitat for top predator species such as grey wolf, as well as species of national conservation concern such as polar bear, woodland caribou, and wolverine that require large tracts of unfragmented and/or unroaded landscape and are especially vulnerable to human disturbance. Waterscapes (rivers) have experienced some fragmentation by hydroelectric developments but again much less than many other ecozones <sup>†</sup> . As such, this ecozone <sup>†</sup> still provides much quality, unfragmented habitat important for anadromous fish species and the migratory lake sturgeon (a species of national conservation concern), which tends to be more deeply in decline or extirpated in more developed locales. Development pressure is, however, mounting and cumulative impacts from roads and hydroelectric developments are concerns.

<sup>†</sup> This key finding is not numbered because it does not correspond to a key finding in the national report.<sup>3</sup>

Themes and topics	Key findings: <b>NATIONAL</b>	Key findings: <b>HUDSON PLAINS ECOZONE<sup>+</sup></b>
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 for this ecozone <sup>+</sup>
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.	Polar bear has declined in body condition (both Southern and Western Hudson Bay subpopulations) and number (Western Hudson Bay subpopulation only). The forest-dwelling ecotype of woodland caribou shows no evidence of range recession or population decline but the migratory forest-tundra ecotype of woodland caribou, and more specifically the Pen Islands (aka Hudson Bay Coastal Lowland) herd, shows eastward range-shift and possible decline. Some migratory bird populations that use the ecozone <sup>+</sup> show strong changes in local, seasonal abundance or distribution (for example, semipalmated sandpiper and brant), or otherwise declining populations of continental concern. The increased number and size of discrete lesser snow goose colonies nesting in the ecozone <sup>+</sup> is notable. Lake sturgeon is declining in some rivers affected by hydroelectric development.
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.	Increases in primary productivity in this ecozone <sup>+</sup> appear much less than for some other areas of Canada. From 1985 to 2006, Normalized-Difference Vegetation Index (NDVI, a measure of gross primary photosynthesis and a proxy for green leaf area based on remote sensing), significantly increased over 4.9% of the land surface and decreased over 0.1% of the land surface. Some increase in primary productivity may also be suggested by observations of increased tree and shrub cover above the treeline near Churchill, Manitoba.

Themes and topics	Key findings: <b>NATIONAL</b>	Key findings: <b>HUDSON PLAINS ECOZONE<sup>+</sup></b>
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.	There is little evidence to suggest that the natural disturbance regime has changed. The large fire ( $\geq 2 \text{ km}^2$ ) regime is essentially natural and no trends are apparent since 1980 in its analyzed elements (annual area burned, causes of fire, seasonality and duration of the active fire season, and fire severity index). Information is insufficient to examine trends in native insect outbreaks. Trends in extreme weather events have not been directly examined but rather indirectly using indicators or indices of extreme weather derived from daily temperature and precipitation data. These indices suggest only limited potential change in extreme weather, including increased diurnal temperature range and variability, more warm days (days with daily maximum temperature $> 90^{\text{th}}$ percentile), and more summer days (days with daily maximum temperature $> 25 \text{ }^\circ\text{C}$ ), depending on location.
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.	Predator-prey cycles are not being monitored and food web structures are otherwise largely unstudied but some changes in food webs are apparent. Loss or serious reduction of important components of the coastal salt marsh food web are evident, reflecting the severe damage that has occurred to these salt marshes since the 1970s. As well, some changes in predator-prey relationships involving polar bear are apparent that are implicated with climate change and associated changes in wildlife phenology.

THEME: SCIENCE/POLICY INTERFACE		
<p>21. Biodiversity monitoring, research, information management, and reporting</p>	<p>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.</p>	<p>With certain exceptions such as climate station monitoring and some studies of waterfowl, polar bear (and sea ice in the broader geography), and fish mercury levels in areas affected by hydroelectric development, inventory, monitoring, and research have been episodic and without continuity over the long term. A geographical bias to the available information is also evident, with most information pertaining to coastal versus inland areas. Much of the available information, including Aboriginal traditional knowledge, is also contained in disparate sources of variable accessibility. Enhanced interests in climate change and economic development are currently driving the collection of much new information that will help inform future assessments. Permafrost, hydrology, and carbon flux are particularly notable and important among knowledge gaps but better information is needed on most fronts, including cumulative impacts and climate modelling.</p>
<p>22. Rapid changes and thresholds</p>	<p>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.</p>	<p>Thresholds and natural ranges of variability are poorly understood. A somewhat anomalous finding for a relatively remote and undisturbed ecozone<sup>+</sup> such as this is a substantially damaged coastal biome (see the Coastal biome section above). As well, sea ice is changing more rapidly than expected, ahead of modelled climate change projections and these changes are correlated with deteriorating polar bear subpopulations. As the sea-ice season shortens, trophic interactions are changing between polar bears and species such as seals and geese. Unexpected interactions are sometimes observed, such as dietary shifts in polar bears amplifying their contaminant levels. These early effects of climate change are a prelude to the major changes expected in this ecozone<sup>+</sup> as extent and duration of seasonal sea ice is reduced.</p>

# 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.

The boreal forests of the Hudson Plains Ecozone<sup>+</sup> form an important part of the largest intact tract of forest in Canada, which is also considered one of the largest intact forests remaining in the world.<sup>17</sup> However, the Hudson Plains Ecozone<sup>+</sup> has a lower proportion and density of forest than many other forested ecozones<sup>+</sup> in Canada.<sup>9, 18</sup> Owing to widespread wet edaphic conditions, forests there are primarily open and often poorly delineated from the many small bodies of water and non-forested wetlands on the landscape. Truly closed forest stands more typically associated with boreal forests are generally confined to better-drained embankments, slopes, flats, and riverbank levees.<sup>19, 20</sup> As such, forest productivity in this ecozone<sup>+</sup>, as reflected in volume per hectare, is low (42 m<sup>3</sup>/ha) compared to that of the adjacent Boreal Shield and Taiga Shield ecozones<sup>+</sup>.<sup>21</sup> Overall, forest density decreases from south to north (Figure 2).<sup>9, 22</sup> On an area basis, coniferous forest types (conifers  $\geq 75\%$  of total) dominate (54.9%) over mixedwood (34.6%), broadleaved (1.1%), and unclassified (9.5%) ones.<sup>21</sup> Spruce is the leading genus in 88% of all forest stands.

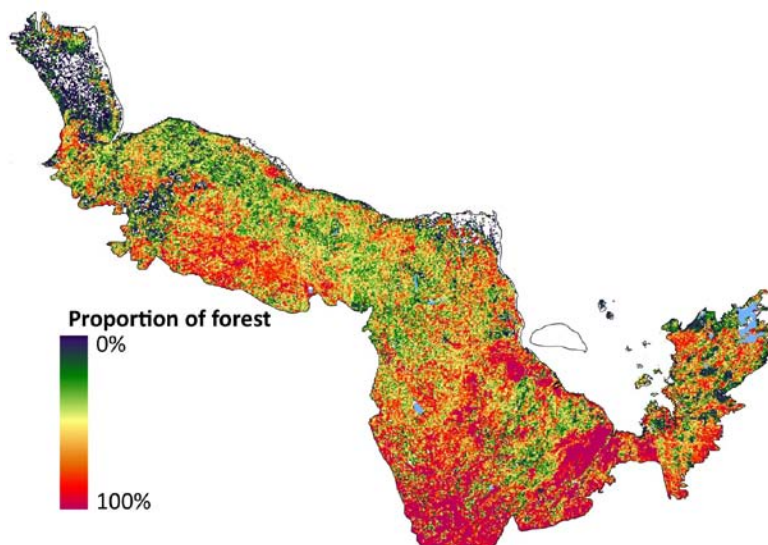


Figure 2. Forest density in the Hudson Plains Ecozone<sup>+</sup> circa 2000, calculated as the percent of forested 30 m<sup>2</sup> Landsat pixels in each 1 km<sup>2</sup> analysis unit.

No data are available for Akimiski Island. Forested areas are areas with >10% tree crown cover.

Source: Ahern et al., 2011<sup>9</sup>

Inventory and monitoring information is very limited for forests in this ecozone<sup>+</sup>, inhibiting the ability to track changes and report on trends.<sup>4</sup> A coarse-scale satellite remote sensing analysis of land cover classes from 1985 to 2005, however, suggests no significant changes are occurring in the extent of forest cover.<sup>9</sup> Overall reductions in forest cover from 1985 to 2005 were small (0.25%) and primarily due to fire, i.e., burned areas that have not yet revegetated<sup>9</sup> (see also Natural disturbances on page 63). Given the coarse scale of the analysis, the errors in mapping may, however, be greater than the small amount of change detected. There is also currently little evidence to suggest that the treeline may be moving (see Tundra biome on page 24).

Data are also insufficient to assess trends in forest structure, including: species composition; age class or time-since-fire; and relative intactness. The ecozone<sup>+</sup>'s forests are, however, also assumed stable in these respects, given an effectively natural and apparently unchanged disturbance regime (see Natural disturbances on page 63) with only minimal anthropogenic disturbance (see Intact landscapes and waterscapes on page 51), including forest harvest. Although commercial forestry is an important industry elsewhere in Canada's boreal forest (see for example Anielski and Wilson, 2009<sup>23</sup>), it has not been important in this ecozone<sup>+</sup>, presumably because of the low productivity of its forests, limited existing access to them, and insufficient markets. Currently, only a very small portion at the southern end of the ecozone<sup>+</sup> forms part of a forest management unit in Ontario where commercial harvesting may be permitted,<sup>24</sup> and planning for potential commercial forestry has been undertaken in the Moose Factory area by the Moose Cree First Nation.<sup>25, 26</sup> Anthropogenic fragmentation is also very minor, rendering the ecozone<sup>+</sup>'s forests particularly important for species such as woodland caribou and wolverine that tend to thrive in large tracts of intact and/or unroaded landscape (see Intact landscapes and waterscapes on page 51).

### **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.

The Hudson Plains Ecozone<sup>+</sup> is considered Canada's largest wetland complex, and the third largest in the world.<sup>27</sup> These extensive wetlands provide critical habitat for many breeding bird populations.<sup>28</sup> Two sites, Southern James Bay Migratory Bird Sanctuaries (comprised of Moose River Bird Sanctuary and Hannah Bay Bird Sanctuary) and Polar Bear Provincial Park (see also Protected areas on page 30), have been designated Wetlands of International Importance<sup>29</sup> because of the staging and breeding habitat these ecosystems respectively provide for geese, dabbling ducks, and tundra swans.<sup>28</sup> Several species of national conservation concern (such as short-eared owl and yellow rail) also use the ecozone<sup>+</sup>'s inland (freshwater) wetlands.<sup>14, 30</sup> Also notable is that a large proportion of wetlands in the Hudson Plains Ecozone<sup>+</sup> are peat-forming wetlands (bogs and fens), making this ecozone<sup>+</sup> Canada's largest peatland complex and the

second largest at northern latitudes (>40-50°).<sup>31</sup> As such, the ecozone's peatlands contribute significantly to global carbon-cycling and climate regulation (see Climate regulation, a regulating ecosystem service on page 49).

Although there has been high loss of wetlands in southern Canada, there are few documented changes or trends in the distribution, extent (expansions or contractions), or condition of wetlands in the Hudson Plains Ecozone+, albeit these wetlands are for the most part not being monitored. The ecozone's wetlands are assumed healthy with extensive peatlands largely intact, with a few notable exceptions where changes have occurred.

The most important documented change in the ecozone's wetlands is in the coastal biome, where about one-third of the coastal salt marsh vegetation from Manitoba to James Bay has been destroyed, and additional areas damaged, as a result of overuse by overabundant lesser snow geese (see Coastal biome on page 20). However, the phenomenon is also occurring to some extent in the freshwater marshes and fens of the adjacent tundra biome, as a decrease of preferred salt marsh forage forces the geese to move inland to nest and feed (see Tundra biome on page 24).

Other known stressors of wetlands in the ecozone+ include hydroelectric and mining developments, both of which may cause loss of wetlands or alter wetland classes. Where river flows in the ecozone+ have been reduced by hydroelectric development (for example, Eastmain and Opinaca rivers, see Lakes and rivers on page 16), some desiccation has occurred downstream with, for example, shrubby species expanding at the expense of pioneer wetland species.<sup>32</sup> Conversely, some wetlands in the ecozone+ were affected by flooding in 1980<sup>32</sup> when waters diverted from the Eastmain and Opinaca rivers flooded 740 km<sup>2</sup> of land at the northeast edge of the ecozone+ to create the 1,040 km<sup>2</sup> Opinaca reservoir that is part of the La Grande hydroelectric complex that continues to the north (see Taiga Shield Evidence for Key Findings Summary<sup>33</sup> for further discussion).<sup>34</sup> Diversion in 2009 of 72% of the mean annual flow of the Rupert River north to the La Grande complex is further changing wetland hydrology in the Quebec portion of the ecozone+.<sup>35</sup>

The ecozone's only active mine, the Victor open-pit diamond mine (90 km west of the mouth of the Attawapiskat River) was constructed beginning in 2006, opened in 2008,<sup>36</sup> and is expected to operate for at least 12 years.<sup>37</sup> Although the mine occupies a relatively small area of the ecozone+ (~28.8 km<sup>2</sup> in direct project-related developments<sup>37</sup>), the potential area affected by it, like other mining operations, is considerably larger than the mine itself. As well, although a reclamation plan is in place for the mine,<sup>38</sup> some activities associated with the mine can adversely affect the ecozone's wetlands to the extent that areas will not be restorable.<sup>37</sup> Wetlands are being impacted by dewatering (potentially affecting an area up to ~500 km<sup>2</sup><sup>39</sup>), as well as infilling during development of mine infrastructure; replacement with mineral stockpiles; and drainage interruption around stockpiles.<sup>37</sup> Some wetlands have also been altered through construction of winter roads and transmission lines from Attawapiskat.

Additional resource developments (see Intact landscapes and waterscapes on page 51) and especially climate change (see Climate change on page 42) are notable future concerns for the ecozone's wetlands. Although climate-related changes in the extent of inland (freshwater)

wetlands are generally not apparent in this ecozone<sup>+</sup>, a long-term change or trend involving partial degradation and conversion of frozen peat plateau bogs to fens is suggested in an area from the Nelson River north to Churchill.<sup>40</sup>

#### **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.

No clear trends in overall river-flow and lake-level regimes (for example, magnitude, frequency, timing, duration, and flashiness of low and high flow events) are evident for undeveloped waters in the Hudson Plains Ecozone<sup>+</sup>, albeit this result is based on data from only two reference hydrometric stations with data judged useful for this analysis.<sup>10</sup> Indeed, the Hudson Bay basin has one of the most deficient streamflow networks in Canada.<sup>41</sup> Reduced total annual volume of freshwater naturally discharged from several of the ecozone<sup>+</sup>'s rivers is, however, indicated in studies of the broader Hudson Bay region.<sup>42-44</sup> These trends for reduced total volume of freshwater discharged (1964 to 2000 or 2003), disregarding rivers with hydroelectric development or correcting for them, are correlated with large-scale climate oscillations<sup>42</sup> and associated with a four day advance in annual peak discharge rate and a decline in peak intensity.<sup>43</sup>

Lakes and rivers in the ecozone<sup>+</sup> are relatively undisturbed and generally assumed to be in good condition overall. However, hydroelectric developments have affected flow rates and other physical parameters of some rivers and created a large reservoir (Opinaca) in the ecozone<sup>+</sup>, along with associated impacts on biota (see below). Monitoring is mostly limited to these hydroelectric developments, while the remoteness of most of the area's hundreds of rivers/streams and tens of thousands of small lakes and ponds precludes a comprehensive survey of their component fish communities.<sup>14, 45</sup> Portions of the Hudson Plains Ecozone<sup>+</sup> are, however, recognized as supporting among the highest diversity of freshwater fish species in Canada.<sup>46, 47</sup>

### **Rivers**

Rivers in the Hudson Plains Ecozone<sup>+</sup> are typically shallow, slow moving, and have cut deeply into the clay and alluvial sediments.<sup>48</sup> The ecozone<sup>+</sup> is drained by twelve major rivers: the Churchill, Nelson, and Hayes rivers in Manitoba; the Moose, Albany, Attawapiskat, Winisk, and Severn rivers in Ontario; and the Harricana, Rupert, Eastmain, and Nottaway rivers in Quebec. The large quantities of nutrients and organic material carried by these rivers make the coastal zone (see Coastal biome on page 20), and especially the river deltas, very productive for fish and wildlife.<sup>37</sup> As well, the large volume of freshwater they discharge dilutes the saltwater



in Hudson and James bays to a salinity one-third that of normal oceanic water,<sup>49</sup> which in turn allows this inland sea to freeze over completely each year (see Sea ice on page 26).

Hydroelectric developments are currently the principal direct human influence on rivers in this ecozone<sup>+</sup> (but mining near Attawapiskat is having smaller-scale effects<sup>37</sup>). The few hydroelectric developments located within the ecozone<sup>+</sup> are near the southern boundaries, concentrating downstream effects within the lowlands (Figure 3). Two hydroelectric generating complexes (Long Spruce, established 1976-77; and Limestone Rapids, established 1989) are located along the Nelson River and one generating station (Otter Rapids, established 1961) is located on the Abitibi River (a tributary of the Moose River). Development in the eastern portion of the ecozone<sup>+</sup> includes a complex of eight sites associated with the Eastmain River and Opinaca reservoir (established 1979-80), as part of the La Grande hydroelectric complex. After waters from the Eastmain River and its tributary, the Opinaca River, were diverted to the more northerly La Grande River, flows of the Eastmain River (at its mouth into James Bay) and the confluent Opinaca River were reduced by 90% and 87%, respectively.<sup>32, 34</sup>

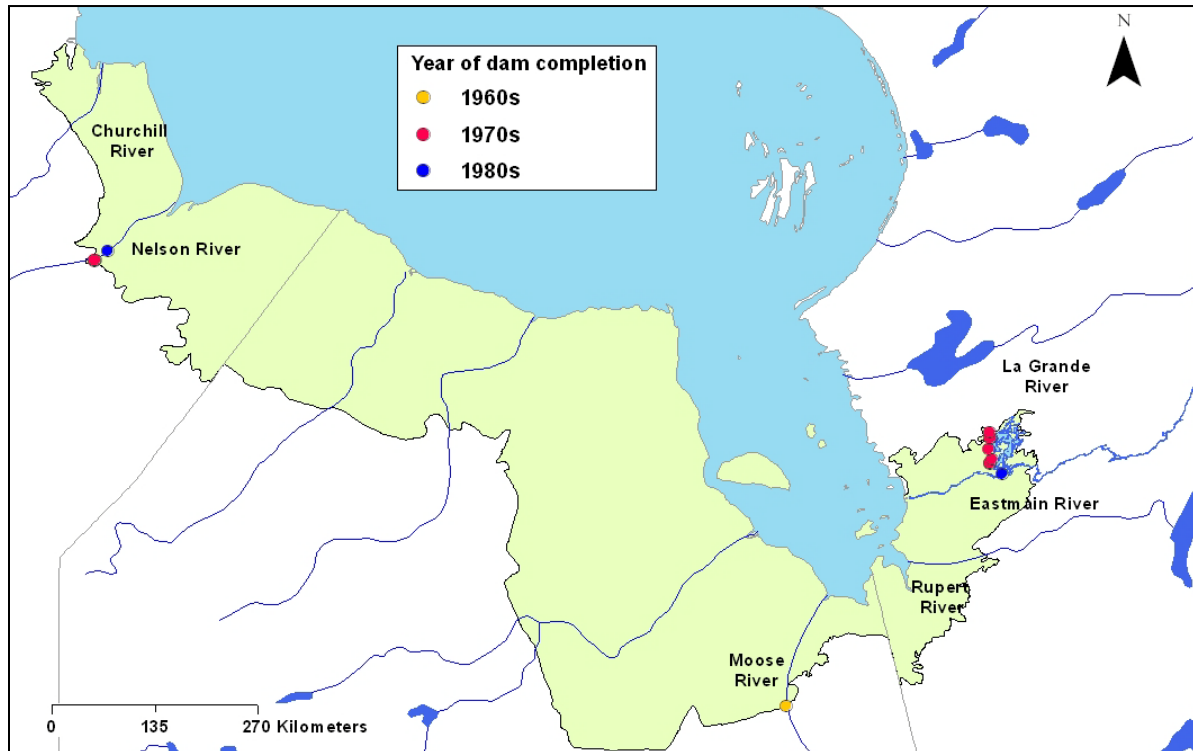


Figure 3. Spatial distribution of dams (>10 m height) in the Hudson Plains Ecozone<sup>+</sup> as of 2005, grouped by decade of completion.

Source: adapted from Monk and Baird, 2011<sup>10</sup> using data from the Canadian Dam Association, 2003<sup>50</sup> updated to 2005

In addition to altering river flow rates, hydroelectric developments have altered the magnitude and timing of fluctuations in river flows. For example, post-development studies ~50 km downstream of the Otter Rapids generating station (Abitibi River) reported diurnal water level fluctuations of 0.7-0.9 m in summer and dewatering of one-third to one-half of the river channel

during low flows.<sup>51</sup> The effects of water level fluctuations at this station are still apparent at least 75 km downstream.<sup>52</sup>

Rivers in the Hudson Plains Ecozone<sup>+</sup> are also influenced by hydroelectric developments upstream, within adjacent ecozones<sup>+</sup>. Diversion of water from the Churchill River to the Nelson River is noteworthy, as it reduced the flow of the Churchill River into Hudson Bay by about 40%.<sup>53</sup> The recent (2009) diversion of 72% of the mean annual flow of the Rupert River north to the La Grande hydroelectric complex<sup>35</sup> is likewise noteworthy (though lateral flow from tributaries increases the flow at the river mouth to ~48%). Overall, river channel fragmentation and/or flow regulation have strongly affected the Churchill and Nelson river systems in Manitoba, the Moose River system in Ontario, and the Eastmain and Rupert river systems in Quebec.<sup>35, 54</sup> The Albany River in Ontario and Nottaway River in Quebec are systems that are considered moderately affected.<sup>54</sup>

The hydroelectric developments in and around the ecozone<sup>+</sup> (described above) are associated with changes in river biota. Lake sturgeon in the northwestern part of the ecozone<sup>+</sup> is assigned an elevated “at risk” status category by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) due in part to hydroelectric development (see Lake sturgeon on page 61). Changes in fish habitat and community composition, including a loss in dominance of lake sturgeon, have also occurred in the reduced flow portions of the Eastmain and Opinaca rivers<sup>34</sup> (see also the estuary and near-shore impacts in the Coastal biome on page 20). Fish species composition also did not fully recover following impoundment of the Opinaca reservoir in 1980, even though total fishing yield stabilized by 1996 to levels near baseline.<sup>34</sup> An additional concern with this reservoir has been the mobilization of mercury and its subsequent bioaccumulation and contamination of fish (see Contaminants on page 38). Impacts on benthic macroinvertebrate communities are also evident, as in the Abitibi River downstream of the Otter Rapids generating station.<sup>52</sup>

Although construction of hydroelectric facilities appears to have peaked in the ecozone<sup>+</sup> in the late 1970s to early 1980s,<sup>10</sup> a high potential exists for more. At least one additional development is proposed for the Nelson River.<sup>55, 56</sup> In Ontario, seven of the 15 new hydroelectric developments included in the Ontario Power Authority’s supply mix plan for development by 2025 are in the ecozone<sup>+</sup>, along Abitibi (4), Albany (2), and Moose (1) rivers.<sup>57</sup> Additional hydroelectric developments are also either in progress or being considered in Quebec.<sup>35, 58</sup> Cumulative impacts from multiple hydroelectric developments in the Hudson Bay watershed is an ongoing concern.<sup>59-63</sup>

## **Lakes**

The Hudson Plains Ecozone<sup>+</sup> contains a multitude of mostly shallow bog lakes and ponds that freeze to the bottom in winter, but some larger lakes are deep enough that they do not freeze to the bottom and can, therefore, support fish communities.<sup>40, 64-66</sup> Owing to remoteness and limited harvest, fish populations in these lakes are assumed to be generally healthy overall, despite insufficient monitoring.<sup>45</sup>

Information on trends in water levels, water temperature, and water quality is not available for most natural lakes in this ecozone<sup>+</sup>. However, observations from thermal monitoring of Hawley Lake are notable from the perspective of unusual warming and fish kills (Hawley Lake is one of four lake trout lakes located near the Sutton Ridges). During the unusually warm summer of 2001, Hawley Lake showed strong and unusual thermal stratification, with temperatures exceeding 20 °C in the surface layer<sup>67, 68</sup> (Figure 4). Lake trout in the lake were not affected because ample coldwater habitat remained below the epilimnion.<sup>67</sup> Warm air temperatures (daily maximums >30°C) combined with the unusual thermal stratification in this headwater lake, however, contributed to a major die-off of anadromous brook trout, as well as white sucker, downstream in the lower reaches of the Sutton River (which drains Hawley Lake) close to its intersection with the Hudson Bay coast.<sup>68</sup> Anadromous brook trout summer in the cold ocean but return to spawn and overwinter in cool freshwater rivers and lakes.

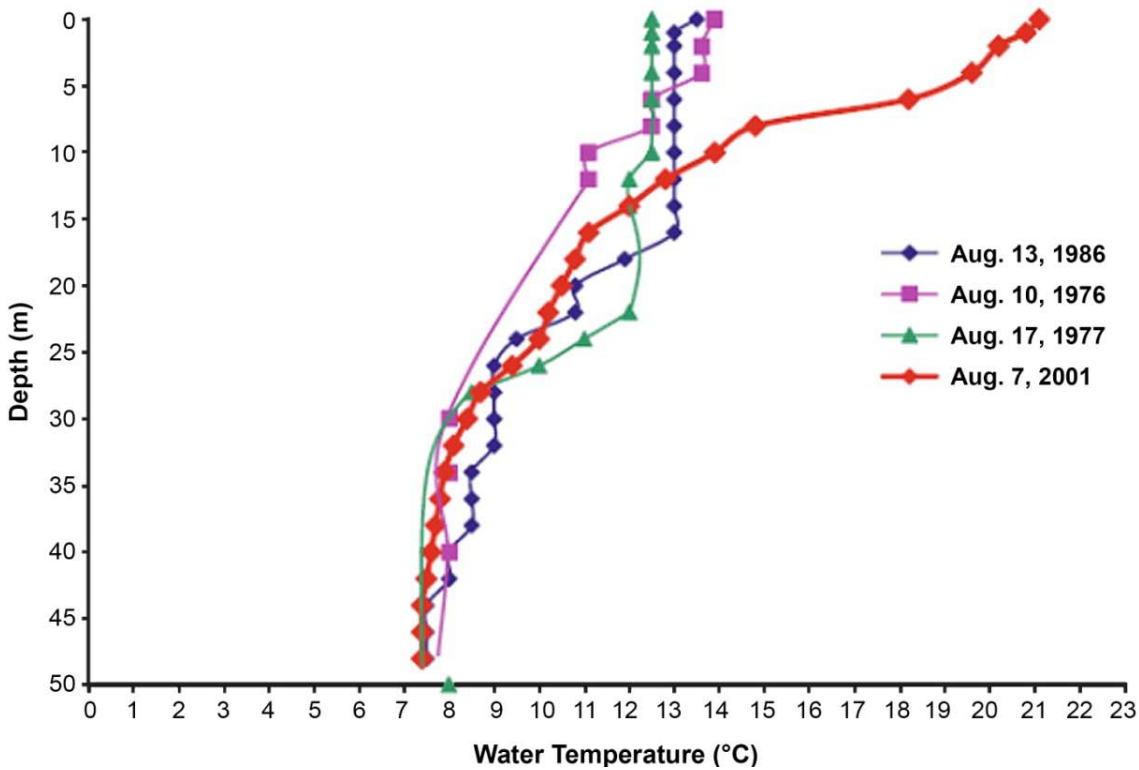


Figure 4. Temperature-depth profiles for Hawley Lake in the Hudson Plains Ecozone<sup>+</sup>, 1976-2001. In 2001 Hawley Lake showed strong thermal stratification for one of the first times on record, with water temperatures exceeding 20 °C in the surface (discharge) layer.

Source: reprinted from Gunn and Snucins, 2010<sup>68</sup> (p 82, fig 2) with permission from Springer Science+Business Media

Such die-offs of fish during warming events have rarely been recorded within arctic or subarctic watersheds (but see also Hori (2010)<sup>69</sup> regarding Aboriginal knowledge of lake whitefish and sucker die-offs in the lower Albany River during a heat wave and period of reduced precipitation in 2005) and it was suggested that this may be among the first of an increasing number of die-offs of vulnerable anadromous stocks that will occur as climate change proceeds<sup>68</sup> (Climate change is discussed on page 42). The seasonal sea ice cover in Hudson and James bays moderates the continental climate, but the sea ice season has been shortening (see Sea ice on page 26) and rivers may consequently be warming. Reduced river flows in the region (see earlier) may also contribute to warming.

## **Key finding 5**

## **Theme Biomes**

### **Coastal**

#### **National key finding**

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.

New land emerges and vegetation develops continuously along the coastline of Hudson and James bays, as a result of one of the highest rates of isostatic rebound in North America.<sup>70</sup> The coastal biome of the Hudson Plains Ecozone<sup>+</sup> is dominated by extensive tidal flats, salt marshes, and shallow waters,<sup>5</sup> including some of the largest and best-developed polar salt marshes in the world (i.e., those characterized by the presence of permafrost).<sup>71</sup> These salt marsh ecosystems provide important breeding grounds and staging areas for a large number of migratory waterfowl and shorebirds.<sup>72-76</sup> Subtidal eelgrass beds are also an important component of the coastal ecosystem along the Quebec coast in eastern James Bay and in isolated portions of the Ontario James Bay coast.<sup>77-79</sup> Eelgrass beds provide feeding grounds and nurseries for coastal fish species and invertebrates, and forage for brant, Canada geese, and ducks.

The Hudson Plains Ecozone<sup>+</sup> is an exception to the national key finding that coastal ecosystems tend to be healthy in areas with little development. The coastal-intertidal zone, and in particular its extensive salt marshes, has been under considerable stress over the past four decades, predominantly due to a continuous increase in foraging (grazing and grubbing) by lesser snow goose, but also by increasing Canada goose breeding and moulting populations in this area.

The Mid-Continent population of lesser snow goose, to which individuals migrating through and nesting in both Manitoba and Ontario belong, has greatly increased over the past four decades, by as much as 7% per year,<sup>80</sup> with the adult portion of the population reaching as

many as 7 million<sup>81</sup> or more<sup>‡</sup>. The goose population increase is thought to be principally a result of human influences outside the Hudson Plains Ecozone<sup>+</sup>, including increased supply of agricultural food on wintering grounds (mostly in the southern United States) and along migration routes, declining harvest rate, and the development of refugia.<sup>80, 83</sup> In many years, especially those with late snow melt and thaw, millions of geese are held up in the Hudson Plains Ecozone<sup>+</sup> on their northward journey, exacerbating the impact of their foraging.

Within these grass- and sedge-dominated coastal salt marshes, intensive foraging by the geese has led to vegetation loss, shifts in plant community composition, and exposure and sometimes erosion of sediment.<sup>81, 83, 84</sup> As snow geese forage with increasing intensity, an apparent trophic cascade occurs wherein swards of their preferred forage species (*Puccinellia phryganodes* and *Carex subspathacea*) are replaced by mudflats often devoid of vegetation.<sup>85, 86</sup> The trophic cascade is sustained by positive feedbacks. One such feedback involves grubbing in spring, whereby geese uproot large areas of *P. phryganodes* and *C. subspathacea* and other species in the salt marshes, fragmenting swards and exposing the edges to secondary effects such as erosion, drying, and hypersalinity. The combined effect of the grubbing and the secondary processes is a reduction in the amount of above-ground vegetative matter. The second feedback involves grazing during the nesting season and following hatch. The remaining sward area, both intact and fragmented, is grazed more intensively by ever larger numbers of geese, allowing for less compensatory growth, and eventual exhaustion of the plants. The end result is an alternate stable state, wherein large areas of exposed sediments are resistant to re-colonization (Figure 5) because few plants can germinate or establish in the saline sediments. The effects are long-lasting when foraging pressure continues and recovery can take decades.<sup>81</sup> In some cases, the geese have been forced to move inland to freshwater marshes and fens in the adjacent tundra biome to nest and feed due to the scarcity of preferred salt marsh forage (see Tundra biome on page 24).<sup>83, 87</sup>

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<sup>‡</sup> This population estimate is higher than estimates derived from mid-winter population surveys reported in other references (for example Canadian Wildlife Service Waterfowl Committee 2009,<sup>82</sup> referenced in *Canadian Biodiversity, Ecosystem Status and Trends 2010*). Mid-winter survey estimates are known to largely underestimate total population levels<sup>83</sup> and are most useful for examining trends in relative population size over time.



*Figure 5. An example of the severe damage caused to coastal salt marsh ecosystems of the Hudson Plains Ecozone<sup>+</sup> due to over-feeding by the greatly increased Mid-Continent population of lesser snow goose.*

*Geese were excluded from the area inside the fence, La Pérouse Bay, Manitoba.*

*Photo© Hudson Bay Project (<http://research.amnh.org/~rfr/hbp/>)*

Trends showing increasing area damaged over time are evident from remote-sensing analyses, whereby successive waves of plant community destruction are seen to transform the entire intertidal ecosystem (Figure 6). Similar processes, feeding pressure, and damage to coastal vegetation have been described from Manitoba to James Bay, including Akimiski Island, Nunavut. Approximately one third of the coastal salt marsh vegetation in the ecozone<sup>+</sup> has been destroyed by geese since the 1970s and a far greater area will be severely damaged if this intense foraging pressure continues.<sup>88</sup> Not only does the destruction of salt marshes remove important food resources for species that feed directly on the vegetation, it also reduces suitability of the zone for other bird species dependent on these habitats for nesting and food<sup>89, 90</sup> (see also Food webs on page 66).

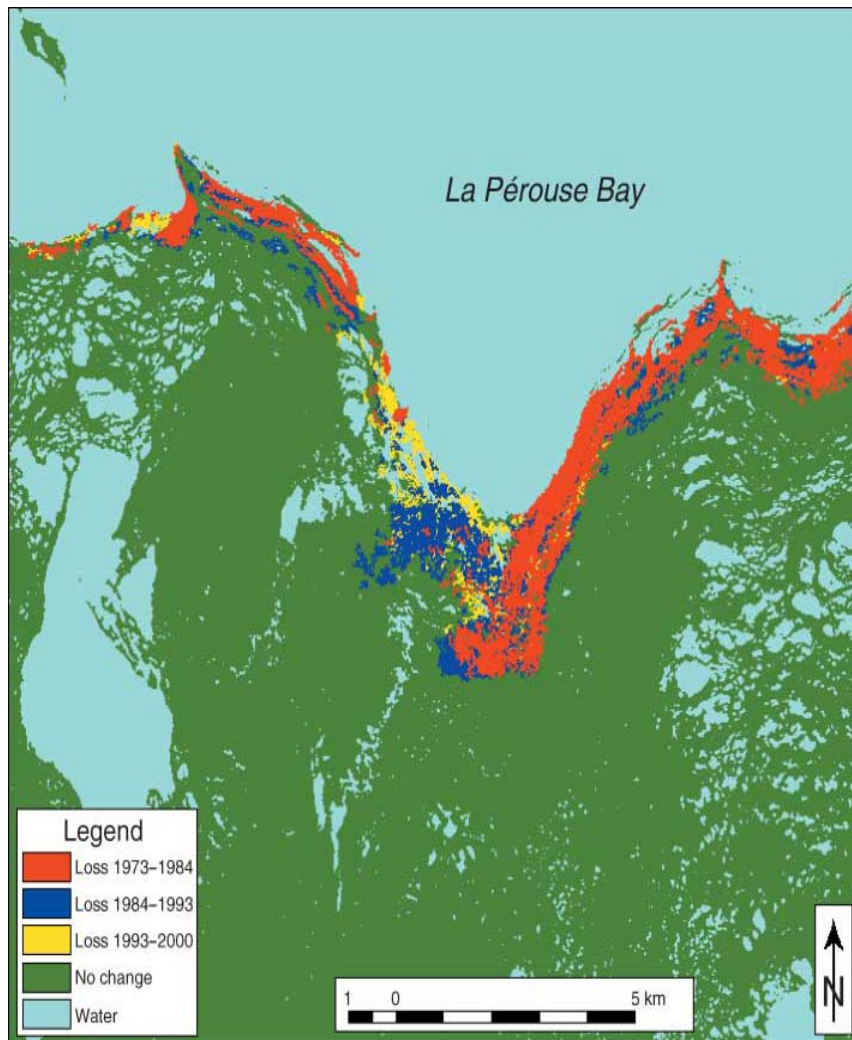


Figure 6. Normalized-difference vegetation index (NDVI) analysis of Landsat imagery showing areas with vegetation loss from goose foraging at La Pérouse Bay, Manitoba, for three successive periods between 1973 and 2000.

Source: reprinted from Jefferies et al., 2006<sup>81</sup> (p 238, fig 3) with permission from Blackwell Publishing Ltd.

Changes in overland river flow and associated nutrient and sediment loads that result from hydroelectric developments in and around the Hudson Plains Ecozone<sup>+</sup> (see Lakes and rivers on page 16) have impacted salinity and other aspects of habitat quality in the interfacing estuarine and marine environments of Hudson and James bays. For example, the 90% reduction in flow at the mouth of the Eastmain River associated with its diversion north to the La Grande River has led to a greater intrusion of saltwater into the Eastmain River estuary with associated impacts on the fish community.<sup>34</sup> Marine species (sculpin, Greenland cod, sand lance) now inhabit the saltwater portion of the estuary; although anadromous lake whitefish and cisco still migrate up the estuary in fall to spawn, their overwintering area is smaller due to the saltwater intrusion; and feeding grounds for walleye are now 5 to 10 km further upstream.

In the near-shore environment, hydroelectric development in the broader James Bay region, and particularly the increased flow output from the La Grande River (to which flows from the Eastmain and Opinaca rivers were diverted), has been implicated<sup>91</sup> in a steep decline in subtidal eelgrass beds along the eastern James Bay coast.<sup>92, 93</sup> Reduced salinity during the major growing period (June and July) and increased duration of ice cover related to reduced salinity were suggested as the major causes of a sudden and precipitous decline in eelgrass health near the La Grande River, while wasting disease, climate change, and isostatic rebound were rejected as major causes.<sup>93</sup>

Climate change is an important future threat to the ecozone<sup>+</sup>'s coastal biome (see Climate change on page 42) but sea-level rise is less of a concern for this ecozone<sup>+</sup> than for some other coastal areas (for example, Tsuji et al., 2009<sup>94</sup>) due to an especially high rate of isostatic rebound.<sup>70</sup> Still, the combined effect of isostatic rebound and sea-level rise could reduce the rate of successional development of coastal systems.

## Theme Biomes

### Tundra

#### Ecozone<sup>+</sup>-specific key finding

The tundra in the Hudson Plains Ecozone<sup>+</sup> represents the southernmost zone of continuous tundra vegetation and continuous permafrost in North America.<sup>14, 76, 95, 96</sup> It occurs as a series of beach ridges and inter-ridge areas (extensive sedge meadows and fens and shrub-dominated fens), in a band of land contiguous with the inland side of the coastal-intertidal zone, from Churchill, Manitoba to near the Lakitusaki River, Ontario, in the area of continuous permafrost<sup>97, 98</sup> (see Figure 9 in Ice across biomes). The most inland tundra sites comprise a forest-tundra landscape. The defining tree "line" itself has been described as erratic, extending farthest north on river levees and beach ridges where drainage is better and the active layer deeper.<sup>99</sup>

Information is insufficient for analysis of trends in extent or condition of the tundra in the Hudson Plains Ecozone<sup>+</sup> as a whole. However, a portion of the ecozone<sup>+</sup>'s tundra, and in



particular its freshwater marshes, is being damaged from excessive feeding by a greatly expanded lesser snow goose population (see the Coastal biome on page 20 for further discussion of snow goose damage). That is, in some cases the geese have so drastically depleted their preferred food sources (*P. phyganodes* and *C. subspathacea*) in the coastal salt marshes that they have moved to forage in less desirable areas within tundra freshwater marshes with similarly devastating effects.<sup>100, 101</sup> In response to development of hypersaline soils in grubbed areas, *Salix* sp. shrubs have been reduced as much as 65%,<sup>102, 103</sup> resulting, in turn, in declines of tundra-nesting bird populations located close to snow goose colonies.<sup>83, 89</sup> Sammler et al., 2008<sup>101</sup> have shown that localized nesting populations of semipalmated sandpipers, dunlins, savannah sparrows, Lapland longspurs, and other tundra-nesting passerines were more frequent in intact sedge meadow habitats than those altered by goose activity. Although no area-wide population effects were reported, it is likely that as degraded areas expand with continued goose foraging, area-wide effects will occur.<sup>101</sup>

Damage to plant communities on both the drier beach ridges and wetter inter-ridge areas of the tundra is also being caused by the operation of wheeled vehicles (tundra buggies/ATVs) in Manitoba<sup>97</sup> and in Ontario<sup>104</sup> (Figure 7).



Figure 7. An example of ATV damage to wet tundra, near Fort Severn, Ontario (July 2008).  
Photo © Queen's Printer for Ontario/K.F. Abraham, Ontario Ministry of Natural Resources

The tundra, which reaches its most southerly Canadian extent in the Hudson Plains Ecozone<sup>+</sup>, is especially vulnerable to climate change and associated permafrost thaw (see Climate change on page 42). Currently, there is no strong evidence that the ecozone<sup>+</sup>'s treeline is moving north (for example, Scott et al., 1987<sup>105</sup>), as is occurring in some other northerly locations in Canada and the world (for example, Harsch et al., 2009<sup>106</sup>). The treeline in this ecozone<sup>+</sup> has, however, received relatively little direct study. Ballantyne (2009)<sup>107</sup> recently documented increases of 12.6% and 6.9% of shrub and tree cover, respectively, in a 2.55 km<sup>2</sup> study area just north of the functional treeline at Churchill. Climate-driven change to the ecozone<sup>+</sup>'s tundra may also be suggested by a long-term (non-successional) change or trend involving partial degradation and conversion of frozen peat plateau bogs to fens in an area from the Nelson River north to Churchill.<sup>40</sup>

## 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.

The sea ice in Hudson and James bays is significantly changing. Loss of sea ice is correlated with deteriorations in the polar bear subpopulations that use sea ice as habitat in winter and the terrestrial environment of the Hudson Plains Ecozone<sup>+</sup> in summer. On the terrestrial landscape, permafrost degradation is suspected, but cannot currently be confirmed due to insufficient monitoring data. Data are also insufficient for analysis of trends in lake and river ice.

### *Sea ice*

Hudson Bay, along with James Bay to the south and Foxe Basin to the north, is the largest inland sea in the world and the only sea at this latitude that goes through a complete cryogenic (ice) cycle each year.<sup>108, 109</sup> This factor has been primary in shaping the ecosystem around it by creating much cooler temperatures than what is typical of this latitude.<sup>110</sup> These cooler temperatures provide the conditions necessary to maintain the southernmost continuous permafrost in North America<sup>95, 96</sup> and support species of arctic affinity, such as polar bear, arctic fox, and some plants, at their southernmost occurrence (see also Polar bear on page 54).<sup>99, 111, 112</sup>

The winter maximum extent of sea ice has not changed, and Hudson and James bays continue to completely freeze over each year. However, sea ice extent in the broader Hudson Bay marine ecosystem declined significantly over the period 1979 to 2006, on the order of  $-5.3 \pm 1.1\%$  per decade, with decreases evident in all seasons except winter.<sup>108</sup> As well, significant trends for longer ice-free periods each year have been detected in areas of Hudson and James bays adjacent to the Hudson Plains Ecozone<sup>+</sup>, associated with later freeze-up dates, earlier break-up dates, or both, depending on location (see inset).<sup>109, 113-115</sup> On average, the annual ice-free period in western Hudson Bay, southern Hudson Bay, and James Bay has increased by ~3 weeks since the mid-1970s.<sup>109</sup> These trends in sea ice are correlated with significant negative impacts on polar bear, which is dependent on sea ice as habitat and a platform for hunting and feeding on seals (see Polar bear on page 54 for further discussion). These trends in sea ice are projected to continue, such that James Bay and the southern portion of Hudson Bay (i.e., marine areas adjacent to the ecozone<sup>+</sup>) may become substantially to completely ice-free by 2100 (see Climate change on page 42).

## Sea Ice is Changing

Analysis of historical sea ice data for Hudson and James bays reveals that this inland sea is becoming increasingly ice-free. Gough et al., (2004)<sup>115</sup> found significant trends for earlier dates of sea ice break-up in southwestern Hudson Bay over the period 1971 to 2003. Although they did not find a trend in later freeze-up dates, the trend for earlier break-up alone resulted in an approximate increase in ice-free conditions by approximately 0.49 days per year (Figure 8). Subsequent work that expanded the study area to include the entire Hudson Bay region found a significant trend for earlier break-up in James Bay, southern Hudson Bay, and western Hudson Bay with magnitudes ranging from 0.49 to 1.25 days earlier per year, coincident with temperature trends in these areas.<sup>109</sup>

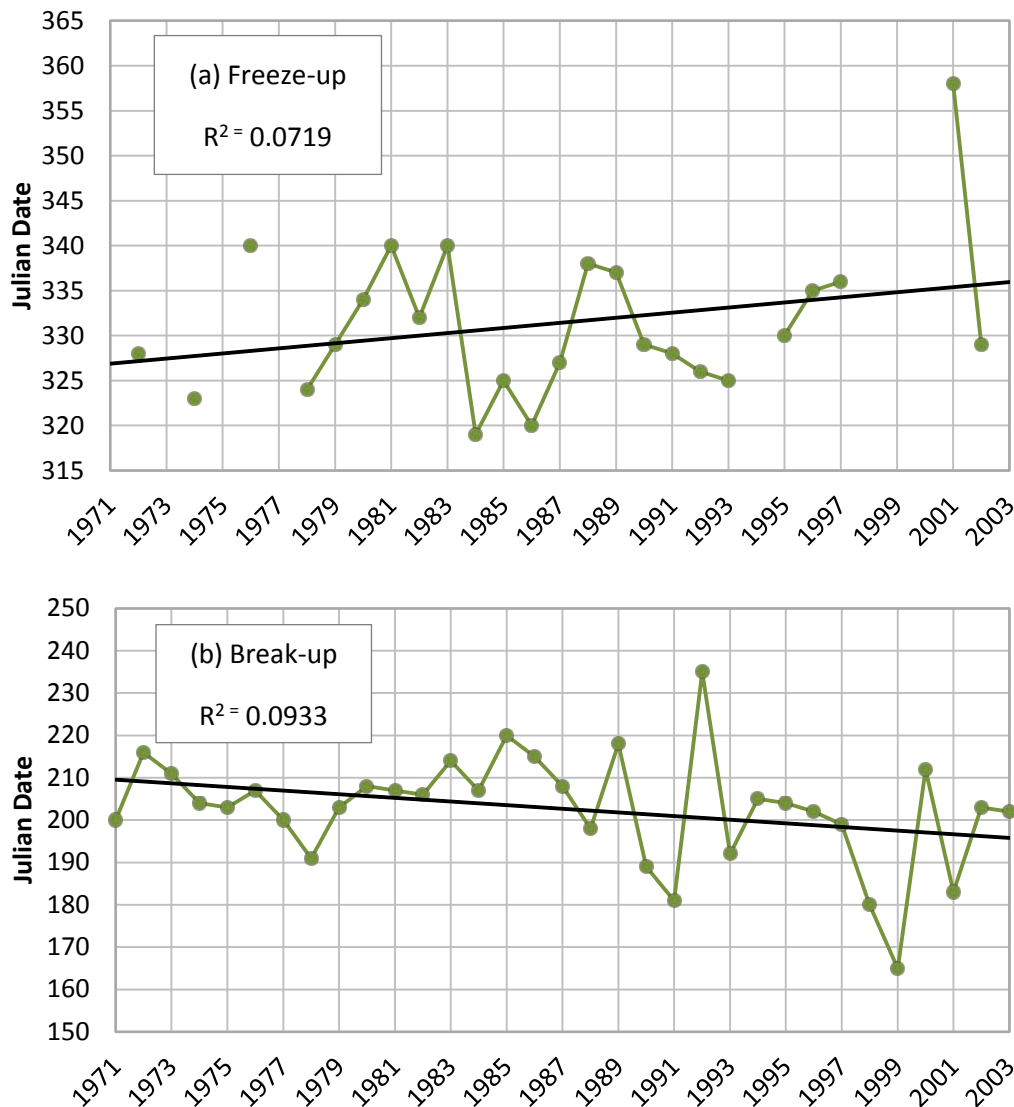


Figure 8. Trends in a) date of freeze-up and b) date of break-up of sea ice in southwestern Hudson Bay.

Source: redrawn from Gough et al., 2004<sup>115</sup> (p 303, fig 2) with permission from Arctic Institute of North America. Data from the Canadian Ice Service archives

## Permafrost

The Hudson Plains Ecozone<sup>+</sup> supports the most southern continuous permafrost in North America<sup>95, 96</sup> and includes a full range of permafrost types across its geography (Figure 9). At the northern extent of the ecozone<sup>+</sup>, continuous permafrost can be found beneath the coastal ridges and wetlands. As little as 20 km inland from the coast in some areas (as near York Factory), the terrain changes to palsas, localized geomorphic mounds indicative of a transition from continuous to discontinuous permafrost. Sporadic discontinuous and isolated patches of permafrost are found further south, while permafrost is absent at the most southerly extent of the ecozone<sup>+</sup> in areas away from the coast. The presence of permafrost, and its effective retention of surface water, contributes greatly to the unique nature of this ecozone<sup>+</sup> as Canada's largest wetland complex.

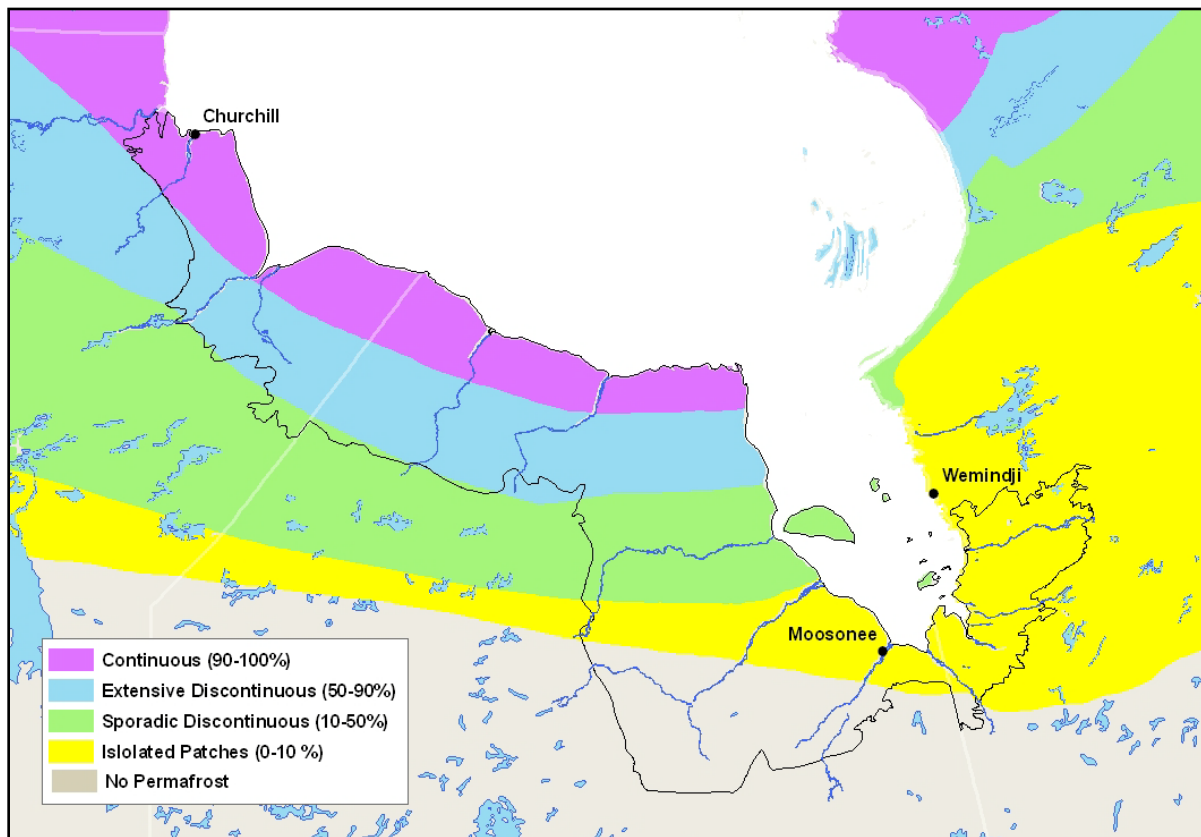


Figure 9. Permafrost zones in and around the Hudson Plains Ecozone<sup>+</sup>.

Source: adapted from Heginbottom et al., 1995<sup>116</sup>

Sufficient data are not currently available with which to evaluate trends in the extent and condition of permafrost, or associated shifts in permafrost boundaries, in the Hudson Plains Ecozone<sup>+</sup>. Until relatively recently, no permafrost thermal monitoring sites were located and maintained there to help track changes as is being done elsewhere in Canada's north.<sup>117, 118</sup>

Ten year data are now available for a permafrost site at Churchill, Manitoba,<sup>119</sup> a new permafrost monitoring site was established in 2007 at York Factory, Manitoba,<sup>120</sup> and two more

sites have recently been added in northern and southern areas of Wapusk National Park, Manitoba.<sup>121</sup> In Ontario, annual summer monitoring of permafrost began in 2007 and a permanent monitoring site (Brant River) is now in place.<sup>122</sup>

Changes in permafrost, however, are suspected in the Hudson Plains Ecozone<sup>+</sup>. Both collapse and erosion features and aggrading features are visible in the ecozone's permafrost tension zone and collapse features appear to have become more widespread over time, as in the Ekwan to Lake River areas of the northern James Bay coast.<sup>99</sup> In recent decades, casual observations have also been made of slumping and collapse of river banks along the Hayes and Nelson rivers in the vicinity of York Factory, Manitoba, close to the boundary between discontinuous and continuous permafrost. Partial degradation and conversion of frozen peat plateaus to fens, as well as the enlargement of some associated lakes from eroding shorelines, is also suggested in the area from the Nelson River north to Churchill.<sup>40</sup> Moreover, although the relatively short 10 year permafrost record from Churchill shows no significant trend to date, comparison of this data with the much longer climate record at Churchill suggests that the air temperature warming there might have resulted in permafrost warming of ~0.5 °C since the mid-1970s.<sup>119</sup> Permafrost loss is known to be occurring just outside both western and eastern ecozone<sup>+</sup> boundaries in areas where permafrost is discontinuous and in isolated patches respectively.<sup>123, 124</sup>

Modeling for the Hudson Bay region forecasts a loss of ~50% or more of the continuous permafrost and a virtual elimination of a climate that supports permafrost by 2100,<sup>95, 125</sup> which would have significant impacts on ecozone<sup>+</sup> integrity (see Climate change on page 42).

### ***Lake and river ice***

Data are insufficient for analysis of long-term trends in river and lake ice in the Hudson Plains Ecozone<sup>+</sup>.<sup>7</sup> For example, trends in break-up dates for the lower Attawapiskat, Albany, and Moose rivers (near the James Bay coast) were inconclusive when examined from disparate community-based data sources.<sup>126</sup> It is, therefore, not known from monitoring if trends being observed elsewhere in northern Canada for earlier break-up and in some cases also later freeze-up of freshwater ice<sup>127-129</sup> are occurring in this ecozone<sup>+</sup>. Changes in freshwater ice are, however, suspected. Aboriginal peoples in western James Bay have noted changes in the break-up and/or freeze-up of rivers,<sup>126</sup> as well as a reduction in ice thickness both in naturally flowing rivers and rivers with flows modified by hydroelectric developments and longer ice-free periods for some inland lakes.<sup>61</sup>

## 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.

The global and national significance of the Hudson Plains Ecozone<sup>+</sup>, which rests in its extensive wetlands, peatland carbon, intact forests, and habitats for species of national conservation concern, is recognized by a protected area system. The ecozone<sup>+</sup> contains two designated Wetlands of International Importance (Ramsar convention sites): Polar Bear Provincial Park (Ontario) and Southern James Bay Migratory Bird Sanctuaries, the latter comprised of Hannah Bay Bird Sanctuary (Ontario and Nunavut) and Moose River Bird Sanctuary (Ontario).<sup>29</sup> The ecozone<sup>+</sup> also includes one large national park, Wapusk, in Manitoba, and one large wilderness park, Polar Bear Provincial Park, in Ontario, both also with areas of coastline. A number of other, smaller protected areas occur throughout, in all four component jurisdictions.<sup>130</sup> Smaller protected areas include some narrow linear corridors along segments of some of the major rivers.

The protected area system in the Hudson Plains Ecozone<sup>+</sup> is currently comprised of 31 federal, provincial, and territorial protected areas that together account for 12.8% of the land base. All of these protected lands are in IUCN (World Conservation Union – previously known as International Union for Conservation of Nature) categories I to III.<sup>131</sup> Categories I to III include nature reserves, wilderness areas, and other parks and reserves managed for conservation of ecosystems and natural and cultural features. Figure 10 shows the distribution of the ecozone<sup>+</sup>'s protected areas as of May 2009, when they accounted for 11.7% of the land base.<sup>130</sup> Recent additions not represented in Figure 10 are the Kaskatamagan Wildlife Management Area (portion in IUCN category II, 2,595 km<sup>2</sup>) and the Kaskatamagan Sipi Wildlife Management Area (IUCN category Ib, 1,338 km<sup>2</sup>) (Figure 11), both announced in December 2009.<sup>132</sup>

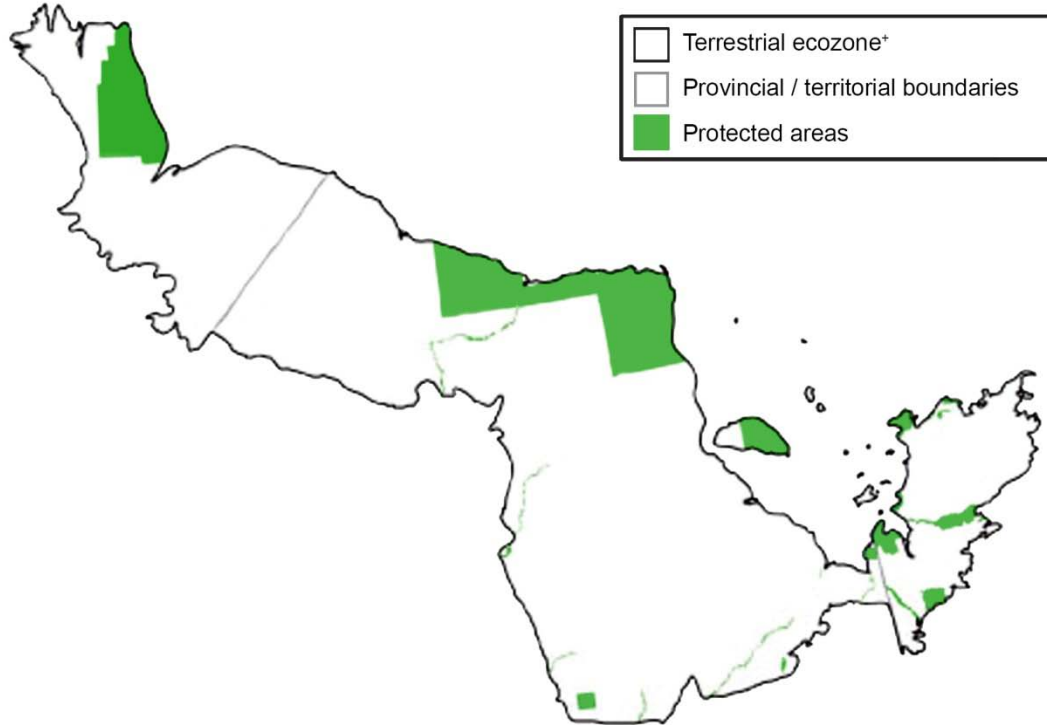


Figure 10. Map of protected areas (legally protected areas and, for Quebec, also proposed and soon to be legally protected areas) in the Hudson Plains Ecozone<sup>+</sup>, as of May 2009. Not shown are the Kaskatamagan Sipi Wildlife Management Area and a portion of Kaskatamagan Wildlife Management Area that were announced in December 2009 (see Figure 11). Source: Environment Canada, 2009,<sup>133</sup> using Conservation Areas Reporting and Tracking System (CARTS) v.2009.05<sup>130</sup> data provided by federal, provincial, and territorial jurisdictions

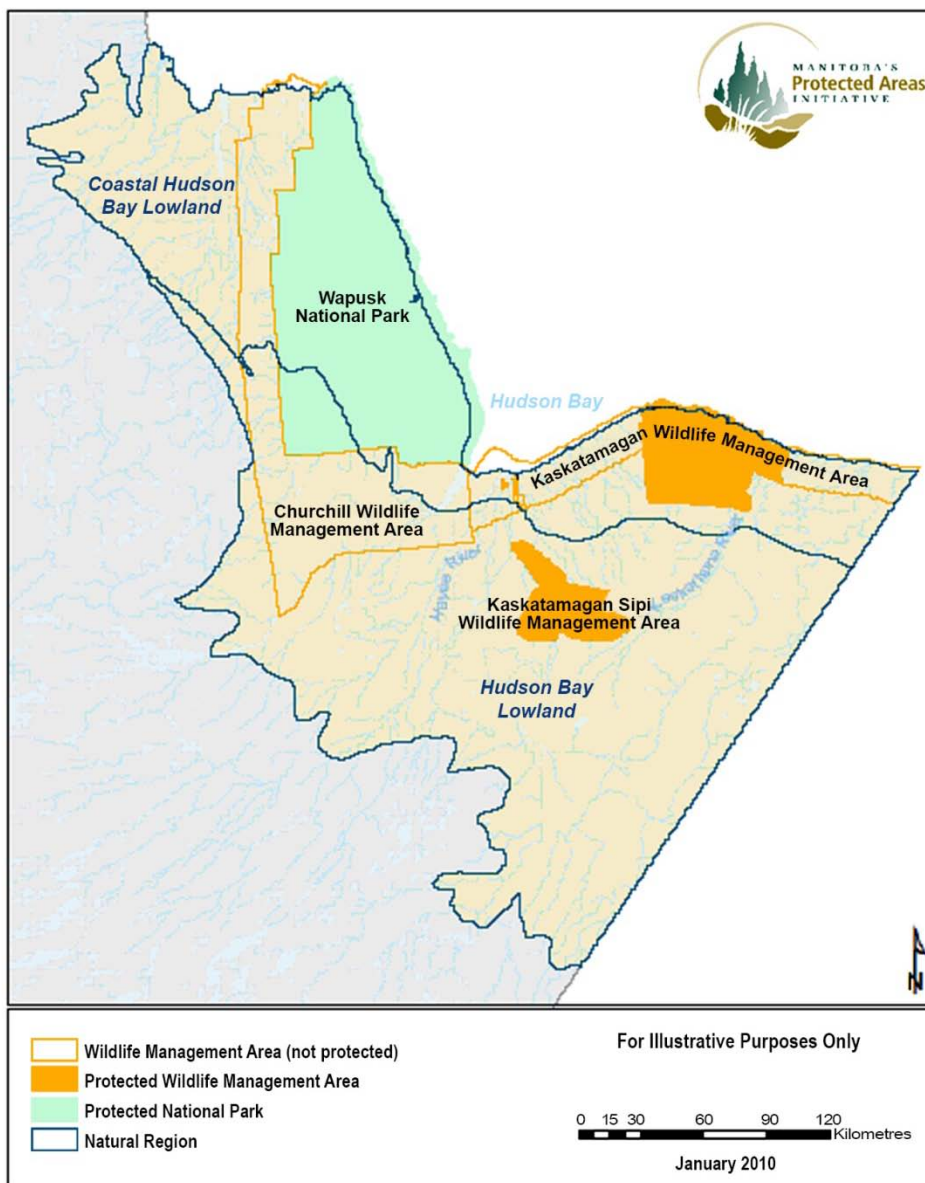


Figure 11. Map of legally protected areas, as well as designated but not legally protected Wildlife Management Areas, in the Manitoba portion of the ecozone<sup>+</sup>. The Kaskatamagan Sipi Wildlife Management Area and a portion of the Kaskatamagan Wildlife Management Area are new legally protected areas, announced in December 2009. Source: Manitoba Conservation, Protected Areas Initiative, 2010<sup>134</sup>

Figure 12 illustrates how the amount of land protected in the ecozone<sup>+</sup> has increased over time, since 1939 when the first protected area, Hannah Bay Migratory Bird Sanctuary, was established, to May 2009. Over time, the largest area gains were made with the addition of Polar Bear Provincial Park in 1970 and Wapusk National Park in 1996, which currently account for 75% of the total area protected. Several small biodiversity reserves and other protected areas have been established since 2003, as well as the new Kaskatamagan Wildlife Management Area and the Kaskatamagan Sipi Wildlife Management Area that are not represented in Figure 12.



A number of designated but not protected areas also occur throughout the ecozone<sup>+</sup>, including wildlife management areas in Manitoba (see Figure 11) and an extensive network of Important Bird Areas along the coast in all three provinces and on Nunavut's islands (not shown).<sup>135</sup>

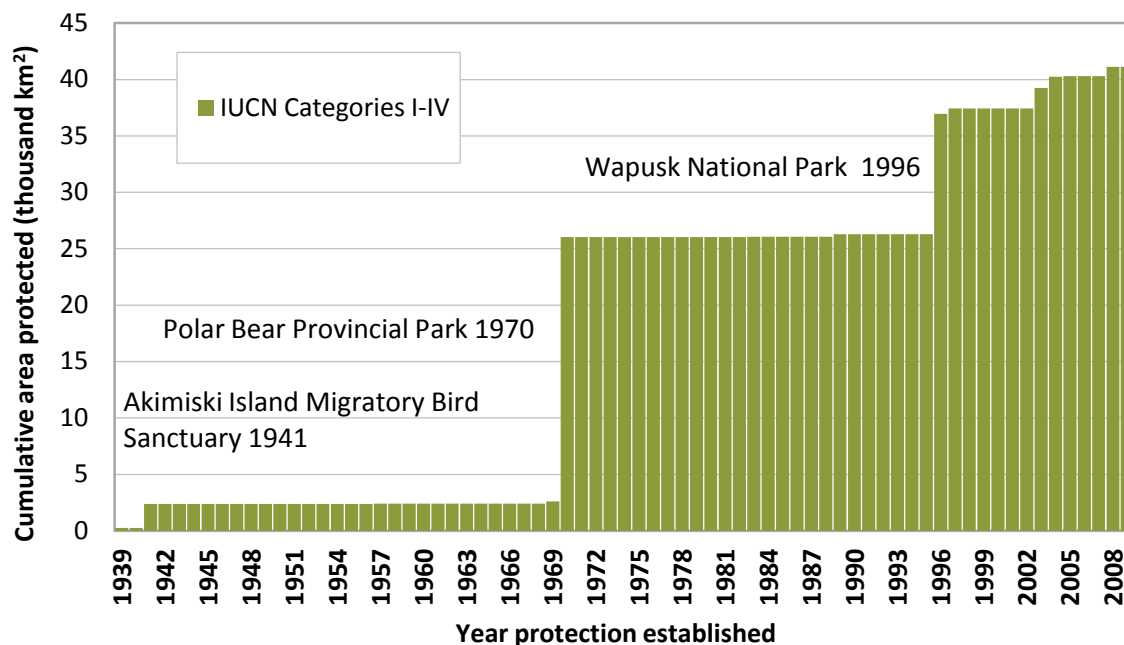


Figure 12. Growth of protected areas (IUCN categories I-IV) in the Hudson Plains Ecozone<sup>+</sup>, 1939-May 2009.

Data correspond with Figure 10 and include legally protected areas as well as some proposed and soon to be legally protected areas in Quebec. The three largest protected areas are noted, along with their dates of establishment. As the year 2009 only represents the period up to and including May, it does not include the two newest protected areas announced in Manitoba in December 2009. The Kaskatamagan Wildlife Management Area (protected portion) and Kaskatamagan Sipi Wildlife Management Area contribute an additional 2,595 km<sup>2</sup> and 1,338 km<sup>2</sup> of legally protected area to the ecozone<sup>+</sup>, respectively. All protected areas shown are in IUCN categories I-III; no protected areas are category IV.

Source: Environment Canada, 2009;<sup>133</sup> using Conservation Areas Reporting and Tracking System (CARTS) v.2009.05<sup>130</sup> data provided by federal, provincial, and territorial jurisdictions

Although the protected area system in the Hudson Plains Ecozone<sup>+</sup> is relatively well developed and extensive, representation gaps remain, particularly in inland portions of the ecozone<sup>+</sup>.<sup>4</sup> The degree of connectivity is also low in some areas, including parts of the Hudson Bay coast. A large coastal gap of about 150 km exists between Polar Bear Provincial Park in Ontario and the Kaskatamagan Wildlife Management Area in Manitoba. Portions of this unprotected coast have been identified as Important Bird Areas, but these are not regulated and have no legal standing. Additional protected areas may be established in the Ontario portion of the Hudson Plains Ecozone<sup>+</sup> through its new Far North Land Use Planning Initiative that is supported by legislation in the form of a Far North Act.<sup>136</sup> Manitoba<sup>137</sup> and Quebec<sup>138</sup> also identified new initiatives that include the potential for new protected areas in their portions of the broader boreal forest, and may include additional areas in this ecozone<sup>+</sup>.

Wapusk National Park (established 1996) is mandated to report on its ecological integrity. The park submitted its first five year ecological integrity monitoring plan in 2008<sup>139</sup> (no results yet available). Ecological integrity is also the guiding principle in Ontario's Provincial Parks and Conservation Reserves Act.<sup>140</sup> Although individual park reporting is not required, a system-wide State of the Protected Areas Report is required every 5 years. Ontario's first report will be published in 2011. There is no periodic re-assessment of the ecological integrity of the other protected areas in the ecozone<sup>+</sup> at the present time. Climate change<sup>141</sup> (on page 42) and development in adjacent lands (see Intact landscapes and waterscapes on page 51) are emerging threats to the ecozone's protected areas.

### 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.

Co-management agreements among First Nations and other levels of government are a notably important type of stewardship initiative in the Hudson Plains Ecozone<sup>+</sup>, with some important new initiatives introduced in recent years. Such initiatives have the capability to directly influence broad-level conservation of biodiversity values although their effectiveness has not generally been assessed.

Some co-management agreements involve federal as well as provincial or territorial and First Nations governments, such as the James Bay and Northern Quebec Agreement (JBNQA), the Eeyou Marine Region Land Claims Agreement, and the Wapusk Management Board. The JBNQA was signed in 1975<sup>142</sup> after plans were announced to build a system of hydroelectric dams in northern Quebec in areas used by Aboriginal peoples.<sup>142, 143</sup> The JBNQA mandates that consideration be given to such aspects as the protection of hunting, fishing, and trapping rights, protection of wildlife resources, physical and biotic environments and ecological systems, and minimizing negative environmental and social impacts, all with respect to development activities. Under this agreement protection bodies, including Aboriginal, federal, and Quebec provincial government representatives, are appointed for the review and formulation of laws and regulations for environmental protection, to set guidelines for environmental and social impact assessment, and to evaluate and review impact assessments.<sup>142, 143</sup> Although the JBNQA does affect coastal development it does not, however, address land use planning or include offshore waters.

The Eeyou Marine Region Land Claims Agreement (EMRLCA)<sup>144</sup> was recently concluded for some islands offshore of Quebec in Hudson and James bays (Nunavut) that are not covered by the JBNQA (Figure 13). Issues to be addressed under this federal-territorial (Nunavut)-Aboriginal agreement relate to contaminated sites and protected areas, as well as wildlife

harvesting and management. The Government of Canada and the Eeyou Istchee Cree agreed to base the new EMRLCA on the Nunavik Inuit Land Claims Agreement, which received Royal Assent in 2008. The EMRLCA was approved by referendum of the Eeyou Istchee Cree in March 2010<sup>145</sup> and signed by all parties in July 2010.<sup>144</sup> It has a unique jurisdictional aspect: its beneficiaries are in Quebec while the claim is located in Nunavut.

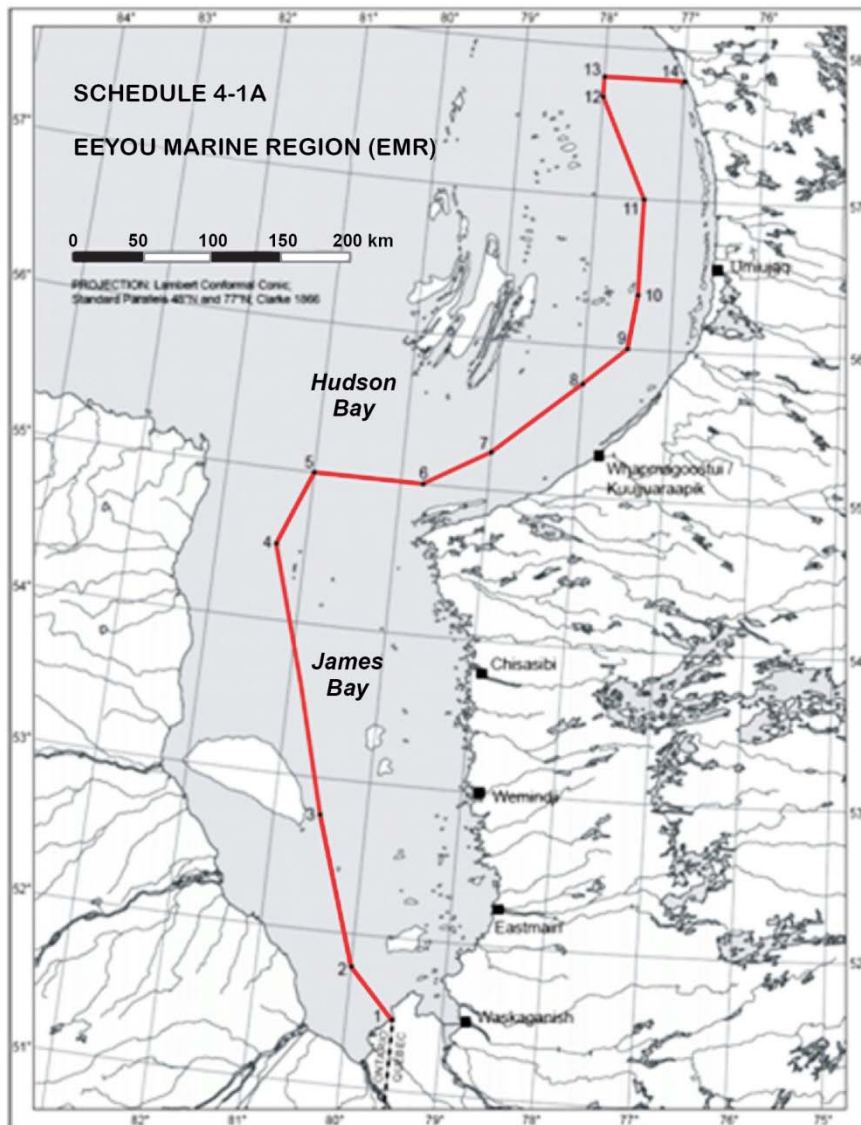


Figure 13. Map showing the area of offshore islands in Hudson and James bays that is covered by the Eeyou Marine Region Land Claims Agreement.

The agreement applies to islands offshore of Quebec's portion of the Hudson Plains Ecozone<sup>+</sup>, as well some islands offshore of the more northerly Taiga Shield Ecozone<sup>+</sup>.

Source: Government of Canada, Government of Nunavut, and Grand Council of the Crees, 2010<sup>144</sup>

In Manitoba, the Wapusk Management Board was formed to co-manage Wapusk National Park (Manitoba) after its creation from part of the Cape Churchill Wildlife Management Area in 1996. This co-management arrangement was articulated in the Federal-Provincial Memorandum of

Agreement for the Park through two major intents: 1) the park is to be managed in the context of its adjoining lands; and 2) the residents of the area are to continue to have access to the park lands.<sup>146</sup> The Wapusk Management Board consists of ten members appointed by associated Aboriginal groups, federal, provincial, and municipal governments.<sup>146, 147</sup> The board makes recommendations to the federal Minister of Environment on matters related to planning, management, and development of the park, while Parks Canada administers day-to-day operations.<sup>147</sup>

In addition to initiatives with federal involvement (as above), a variety of provincial and territorial initiatives are in place that demonstrate various targeted management levels (i.e., landscape-level or ecosystem-level), and are inconsistent among jurisdictions. Perhaps most notable is Ontario's new comprehensive Far North Land Use Planning Initiative.<sup>136</sup> Objectives, which apply to public land in the "Far North" geography of Ontario (including the Ontario portion of the Hudson Plains Ecozone<sup>+</sup>), are to: 1) set-out a process for community-based land use planning that includes a significant role for First Nations in the planning (community-based land use plans are to be developed by First Nations in advance of major developments); 2) support protection for at least half of the Far North area of Ontario in an interconnected network of protected areas designated in community-based land use plans; 3) maintain biological diversity and ecological processes/functions, including carbon storage and sequestration; and 4) enable sustainable economic development of natural resources that benefits the First Nations, while recognizing the environmental, social, and economic interests of all Ontarians. This land use planning initiative has substantial potential for protection of biodiversity and ecosystem integrity for the bulk of the Hudson Plains Ecozone<sup>+</sup> that lies in Ontario, particularly in the face of increasing pressure there for further resource developments (see Intact landscapes and waterscapes on page 51). The initiative was further supported by a Far North Science Advisory Panel<sup>148</sup> to the Ontario Ministry of Natural Resources. This advisory panel recommended a regional-scale "conservation-matrix" model for the aforementioned land use planning, supported by adaptive management and an associated, sustained commitment to the collection and sharing of both scientific and Aboriginal information.

This type of comprehensive land use planning has not yet been developed in either Manitoba or Quebec to similarly help guide development in the Hudson Plains Ecozone<sup>+</sup>. That said, both jurisdictions recently put forth intents for further stewardship of their respective far north lands (including the Hudson Plains Ecozone<sup>+</sup>). Specifically, the Government of Manitoba<sup>132</sup> committed to developing a boreal peatlands stewardship strategy in co-operation with stakeholders and leading climate change non-governmental agencies and the Government of Quebec (2009)<sup>138</sup> committed to protect from industrial development at least 50% of the area covered by its Plan Nord, i.e., lands north of the 49<sup>th</sup> parallel.

## 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.

*\*Note: In contrast to the scope in the national key finding statement above (limited to non-native invasive species), the discussion of invasive species in this section includes reference to species both native and non-native to Canada that have been introduced outside their natural ranges.*

The Hudson Plains Ecozone<sup>+</sup> has relatively few introduced and potentially invasive species compared to most other ecozones<sup>+</sup> in Canada (for example, CFIA 2010<sup>149</sup>). A number of species native and non-native to Canada have been introduced into the ecozone<sup>+</sup> from outside their normal ranges, but their impacts on the ecology of the ecozone<sup>+</sup> are not well studied or monitored, and therefore their degree of invasiveness there is unknown. Most introduced species present in the ecozone<sup>+</sup> are vascular plants (at least 98 species), most of which remain localized around the few villages and other areas with most human activity.<sup>99</sup> Introduced mammals include the house mouse<sup>150</sup> and introduced birds include rock pigeon, European starling and house sparrow,<sup>90, 151</sup> all also found around villages in small numbers.

Introduced fish species include common carp,<sup>152</sup> rainbow smelt,<sup>153-156</sup> and smallmouth bass.<sup>157, 158</sup>

Common carp (non-native) is a destructive bottom feeder present in the Nelson River that damages habitat for native fish by feeding heavily on vegetation and uprooting substrate.<sup>152</sup>

Rainbow smelt, a small anadromous and predatory non-native species, was reported in the Nelson River in 1998 and the Churchill River in 2002,<sup>154, 155</sup> but has not been observed in the Churchill River since then, despite several attempts to capture more.<sup>159</sup> The spread of rainbow smelt is a concern, because this species is a voracious predator of invertebrates.<sup>153, 156</sup>

Rainbow smelt competes directly for food with many native fish, especially lake whitefish and cisco, and preys upon their eggs and larvae. Smallmouth bass is native to Canada but was introduced outside its natural range, including in Ontario.<sup>160</sup> This predatory warmwater species has recently been found in the Hudson Plains Ecozone<sup>+</sup> in the Moose River (2008),<sup>157</sup> and the lower Albany River (2009),<sup>158</sup> for the first time. Smallmouth bass is a strong competitor with typically negative impacts on species such as brook trout, lake trout, and walleye.<sup>160-162</sup> Although its expansion in the Hudson Plains Ecozone<sup>+</sup> is currently limited by harsh climatic and physical conditions,<sup>163</sup> the species is expected to become more competitive there as a result of climate change (Climate change is discussed on page 42).

The introduction of additional species into the Hudson Plains Ecozone<sup>+</sup> may be facilitated through hydrological connectivity with adjacent ecozones<sup>+</sup> to the south (in this area of Canada rivers and wetlands drain north) as, for example, for the fish species above, but also by other transportation routes. Transportation routes into the ecozone<sup>+</sup> are, however, still fairly limited,

being comprised of a deepwater shipping port at Churchill (one of only three deepwater ports in the marine arctic), a non-deepwater port at Moosonee, air, and two railway lines (Manitoba and Ontario) and one all-season road (Quebec) that connect the ecozone<sup>+</sup> to land-based transportation systems in the south<sup>14, 76, 164-166</sup> (but see discussion of development pressure in Intact landscapes and waterscapes on page 51).

## 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.

Very little pollution originates within the Hudson Plains Ecozone<sup>+</sup> but long-range transport contributes to contaminants found in some species there.<sup>4</sup> Monitoring of contaminant levels in the ecozone<sup>+</sup>'s biota is very limited, with a few exceptions such as persistent organic pollutants and metals in polar bears (top predator) and mercury in some fish populations affected by hydroelectric developments.

Many persistent organic pollutants (POPs) have been detected in the tissues of polar bears throughout their global range, including individuals of both the Western Hudson Bay (WHB) and Southern Hudson Bay (SHB) subpopulations that summer on land in the Hudson Plains Ecozone<sup>+</sup>.<sup>167-170</sup> Among global populations, polar bears from the SHB subpopulation have shown particularly high concentrations of chlordane-related compounds and metabolites ( $\Sigma$ CHL); 4,48-DDE, and dieldrin.<sup>167, 168</sup> Overall trends in POP levels in WHB and SHB subpopulations are variable,<sup>170, 171</sup> with levels of some contaminants declining including legacy contaminants such as the pesticide DDT (Figure 14). However, concentrations of emerging POPs such as the brominated flame retardants and perfluoroalkyl contaminants are rapidly increasing in arctic and subarctic regions,<sup>170-174</sup> and polar bears from the SHB subpopulation show greater contamination than those from other areas.<sup>172, 173, 175, 176</sup> It is not clear what impacts the measured levels of contaminants may have on wild polar bears, but impaired endocrine and immune function and reproductive effects have been suggested.<sup>177-180</sup>

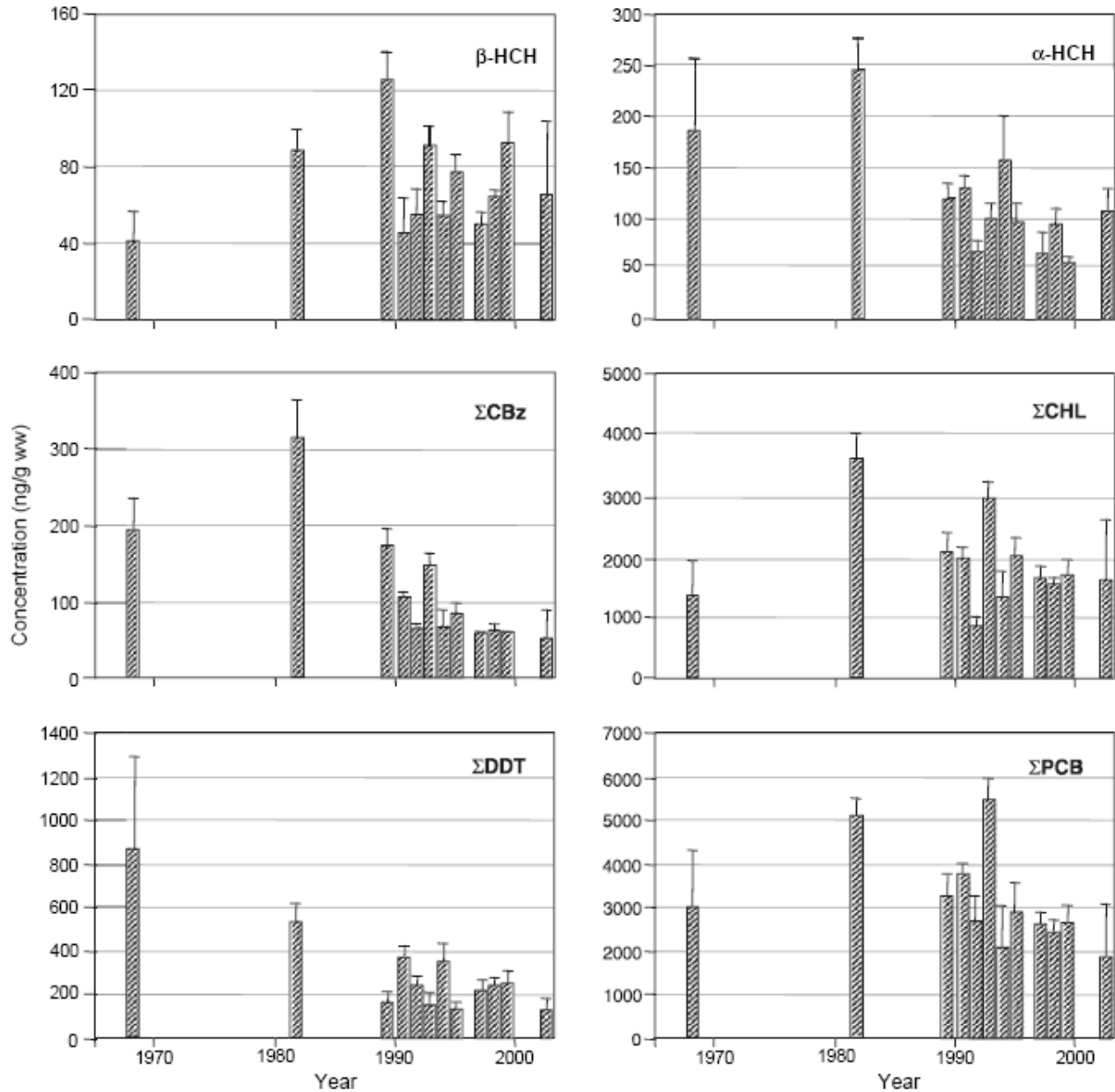


Figure 14. Temporal trends of major organochlorines in the adipose tissue of polar bears from the Western Hudson Bay subpopulation.

Samples are from the Churchill area of western Hudson Bay from 1968 to 2002. Samples from 1991 to 2002 are fat biopsies but earlier samples are adipose tissue. Abbreviations:  $\beta$ -HCH, beta-hexachlorocyclohexane;  $\alpha$ -HCH, alpha-hexachlorocyclohexane;  $\Sigma$ CBz, chlorobenzenes;  $\Sigma$ CHL, chlordanes;  $\Sigma$ DDT, dichlorodiphenyltrichloroethane and its metabolites;  $\Sigma$ PCB, polychlorinated biphenyl congeners. Source: reprinted from Braune et al., 2005<sup>171</sup> (p 42, fig 21) with permission from Elsevier. Data from Norstrom, 2001<sup>181</sup> and Letcher et al., 2003<sup>182</sup>

As a result of changing sea-ice conditions (see Sea ice on page 26), WHB polar bears are feeding less on ice-associated bearded seals (which eat invertebrates) and more on open-water harbour and/or harp seals (which eat fish).<sup>170</sup> Because fish-eating seals have higher levels of

contaminants, some legacy contaminants in polar bear tissues may not be declining as much as would be expected if the polar bear's diet had not changed and the levels of newer (emerging) contaminants may be increasing at a faster rate.<sup>170</sup> Concentrations of brominated flame retardants (PBDEs) in the bears are estimated to have increased 28% faster from 1991 to 2007 than would have occurred if the bears had not changed their diet. Based on limited data (2001-2003), it is not clear if similar trends in diet may be occurring in SHB polar bears.<sup>183</sup>

In contrast to POPs, concentrations of 21 elements (i.e., mercury, lead, cadmium) have not changed significantly in Canadian polar bears since the 1980s, including the SHB subpopulation of bears; all measured elements, including mercury, are below levels associated with toxic effects.<sup>184, 185</sup> Relatively few industrial emissions of mercury occur in northerly areas although some mercury is deposited there as a result of long-distance transport.<sup>186</sup> Atmospheric acid deposition, which could increase methylation of mercury to its more bioavailable form, is not currently an issue in this geography but the ecozone<sup>+</sup> does have some acid-sensitive terrain.<sup>187, 188</sup>

Mercury levels are relatively high in natural aquatic environments in the Hudson Plains Ecozone<sup>+</sup> and proximal northerly areas, especially in areas where organic content is high (organic matter binds mercury effectively).<sup>65</sup> Thus, the prospect of increased methylmercury uptake within the aquatic food chain is a concern when inundating new reservoirs, particularly over organic soils (flooding can promote bacterial conversion of inorganic mercury to methylmercury, a more bioavailable form).<sup>189</sup> Significant increases in mercury levels were observed in the Hudson Plains Ecozone<sup>+</sup> following inundation of the Opinaca reservoir in 1980<sup>65, 190, 191</sup> (for more information on the reservoir, see Wetlands on page 14 and Lakes and rivers on page 16). Methylmercury levels in water increased and then declined to pre-impoundment values in about 8 to 10 years, while mercury levels in fish (bioaccumulated) have declined more gradually (Figure 15). Following reservoir creation, mercury levels were also elevated in fish in the associated diversion, but not in the reduced-flow segments of the lower Eastmain and Opinaca rivers. Any impacts of elevated mercury levels on these fish are not clear but safe human consumption recommendations from public health institutions have been as low as two fish meals per month for piscivorous species<sup>191</sup> and four meals per month (occasional consumption) more recently.<sup>190</sup> Fish mercury levels are projected to increase again in the Opinaca reservoir due to receipt of mercury exported from the recently impounded Eastmain-1 reservoir upstream, just outside ecozone<sup>+</sup> boundaries.<sup>190</sup>



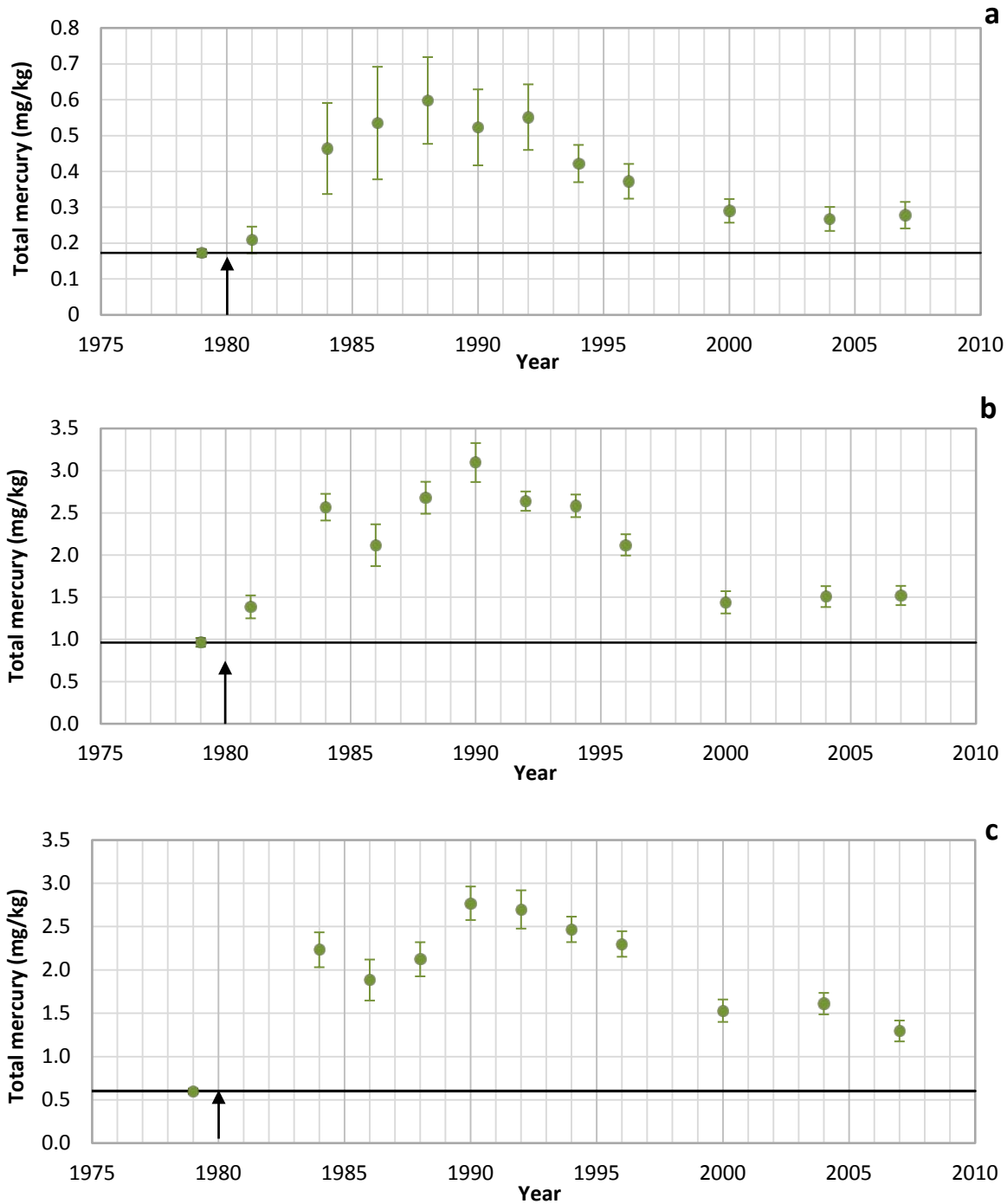


Figure 15. Changes in mercury levels (mg/kg) in the flesh of a) lake whitefish (non-piscivorous), b) walleye (piscivorous), and c) northern pike (piscivorous) in the Opinaca reservoir, 1981-2007. Pre-inundation levels of mercury, shown as the data point for 1979 (and as the reference line), represent the natural levels of mercury in these fish species in lakes in the area prior to reservoir creation in 1980 (arrow). All data points represent fish of standardized lengths, which are 500 mm for lake whitefish and walleye and 700 mm for northern pike. Note the differences in y-axis scales. Source: Abraham et al., 2011<sup>4</sup> using data from Therrien and Schetagne, 2008<sup>190</sup>

Environmental contaminants confirmed at some former Mid-Canada Line radar (doppler detection) sites in the ecozone+ include petroleum hydrocarbons, asbestos, heavy metals, pesticides, and polychlorinated biphenyls (PCBs).<sup>192-204</sup> Limited evaluation of hare tissue samples at a radar line site just south of the ecozone+ (site 060, Relay/Foxville) resulted in a health advisory at that site for country foods, due to PCB levels that exceeded Health Canada guidelines for safe food consumption.<sup>205</sup> Concern from local Aboriginal peoples about the potential impacts of these former radar line sites on local ecosystems and human health are based on the Health Canada advisory as well as local Aboriginal perspectives and knowledge about impacts in the area.<sup>206, 207</sup> The Mid-Canada Line, which included 21 sites in the Manitoba and Ontario portions of the Hudson Plains Ecozone+, became fully operational in 1958 and closed in 1965. Remediation is now in progress for Ontario sites. Leeches (*Haemopsis* spp.) were used to monitor PCB levels in the Albany River following remediation of the first site (Site 050, Anderson Island) located adjacent to Fort Albany (completed 2001). Results suggested that, although PCB levels were still elevated 4 years after remediation, PCB levels were declining and, thus, removal of the terrestrial source of PCBs at Site 050 appears to have removed the main source of PCBs in the river.<sup>208</sup>

#### **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.

Climatic trends are evident in the Hudson Plains Ecozone+ and the broader Hudson Bay region. Modelling projects that this ecozone+ will experience amplified climatic warming in the future, likely with major consequences for the ecology of the area.

#### **Observed changes**

Over the period 1950 to 2007, the few climate stations located in the Hudson Plains Ecozone+ that have long-term data (Figure 16) showed significant trends for increased mean annual and/or mean seasonal temperature (winter and/or summer), increased effective growing degree days, decreased total spring precipitation, decreased seasonal days with precipitation (spring or winter), and a decreased proportion of precipitation falling as snow, depending on location (Table 3).<sup>7</sup> Significant changes in both temperature and precipitation are also evident in the broader Hudson Bay region.<sup>7, 209</sup>



*Figure 16. Locations of climate stations in the Hudson Plains Ecozone<sup>†</sup> that have long-term data sufficient for trend analysis.*

*Note that all three stations represent coastal conditions and that long-term temperature data exist for only two of these stations, Churchill and Moosonee; the Eastmain station is used only in precipitation analyses.*

*Source: site locations from Zhang et al., 2011<sup>7</sup>*

Table 3. Overview of climate trends from stations in the Hudson Plains Ecozone<sup>+</sup>, 1950-2007.

Climate variable	Significant (p<0.05) trends, total change 1950-2007
Mean annual temperature	<ul style="list-style-type: none"> <li>Churchill: ↑ 1.3 °C</li> <li>Moosonee: no significant trends</li> <li>Eastmain: not analyzed</li> </ul>
Mean seasonal temperature	<ul style="list-style-type: none"> <li>Churchill: summer mean temperature ↑ 1.9 °C winter mean temperature ↑ 2.2 °C</li> <li>Moosonee: summer mean temperature ↑ 1.6 °C</li> <li>Eastmain: not analyzed</li> </ul>
Effective growing degree days	<ul style="list-style-type: none"> <li>Moosonee: ↑ 220.4 °C over the growing season</li> <li>Churchill and Eastmain not analyzed</li> </ul>
Total annual precipitation	<ul style="list-style-type: none"> <li>No significant trends (all 3 stations)</li> </ul>
Total seasonal precipitation	<ul style="list-style-type: none"> <li>Churchill: no significant trends</li> <li>Moosonee: spring precipitation ↓ by 28.1% of 1961-1990 mean</li> <li>Eastmain: no significant trends</li> </ul>
Mean annual # of days with precipitation	<ul style="list-style-type: none"> <li>No significant trends (2 stations, Eastmain not analyzed)</li> </ul>
Mean seasonal # of days with precipitation	<ul style="list-style-type: none"> <li>Churchill: ↓ of 14.4 spring days with precipitation</li> <li>Eastmain: ↓ of 33.1 winter days with precipitation</li> <li>Moosonee: no significant trends</li> </ul>
Snow to total precipitation ratio	<ul style="list-style-type: none"> <li>Moosonee: 7.0% unit ↓ in proportion of precipitation falling as snow</li> <li>Churchill: no significant trends</li> <li>Moosonee: not analyzed</li> </ul>

For this analysis, temperature and precipitation variables were expressed as anomalies with respect to a 1961-1990 reference period. Seasonal analyses were based on four seasons defined as: spring, March-May; summer, June-August; fall, September-November; and winter, December-February.

Source: data for ecozone<sup>+</sup> provided by authors of Zhang et al., 2011<sup>7</sup>

Impacts of the changing climate are apparent. The extent of sea ice has significantly declined and the sea-ice season has become significantly shorter (see Sea ice on page 26). The shorter sea-ice season is, in turn, correlated with declines in the body condition, survival, and abundance of the polar bear subpopulations that use the Hudson Plains Ecozone<sup>+</sup> (see Polar bear on page 54). The changes in sea ice are also implicated in some changes in wildlife phenology and predator-prey interactions, including interactions between polar bear and lesser snow goose, whose mean hatching date in the ecozone<sup>+</sup> is advancing as the climate changes (see Food webs on page 66). Canada goose hatching date is also advancing.<sup>210</sup> Other potentially early effects of climate change may be present, but not detectable given the general paucity of monitoring in this ecozone<sup>+</sup>. For example, it is not known from monitoring if permafrost is thawing or if the freshwater ice season for lakes and rivers is shortening, but such changes are suspected (see Ice across biomes on page 26).

## **Projected changes**

Most studies of climatic projections are at larger spatial scales than the Hudson Plains Ecozone<sup>+</sup> and for long temporal periods. A high degree of uncertainty therefore prevails as to the changes that will occur in this ecozone<sup>+</sup> in the future. Nevertheless, it is possible to comment on trajectories of climatic and ecological change based on a growing number of studies.

Climate scenarios developed for the Hudson Bay region using various general circulation models (GCMs) and regional climate models (RCMs) project warmer temperatures over both sea and land in all seasons, with peak temperature differences generally occurring in winter.<sup>69, 125, 141, 211-214</sup> Precipitation results are more equivocal than those for temperature but precipitation is also often forecast to increase, with some exceptions depending on model, season, and/or location. Where precipitation is projected to increase over land in summer, the increase will tend to be more than offset by higher evaporation due to the warmer temperatures (i.e., conditions will be drier overall). As the cover of sea ice disappears, an amplified warming of up to ~10 °C in winter (or 8 °C annual average) is projected through ice-albedo feedback effects,<sup>125</sup> threatening permafrost throughout the ecozone<sup>+</sup>.<sup>95, 125, 211</sup>

The more specific implications<sup>95, 125, 211</sup> of this modeling are that warming will likely lead to:

- 1) a substantial reduction or complete loss of seasonal sea ice from James Bay and the southern portion of Hudson Bay (i.e., areas adjacent to the Hudson Plains Ecozone<sup>+</sup>) by 2100 (see also Joly et al. (2010)<sup>212</sup> for higher-resolution regional modeling to 2070);
- 2) a virtual elimination of a climate that supports permafrost, by 2100; and
- 3) an associated loss of at least 50% of the continuous permafrost (and complete loss of permafrost that is currently discontinuous or in isolated patches).

Because the ecozone<sup>+</sup>'s defining climatic and edaphic conditions are a result of sea ice and permafrost, cascading effects on the ecology of the ecozone<sup>+</sup> are anticipated. Sea ice-dependent species are at most immediate risk, with current trends for deterioration in polar bear subpopulations expected to continue or accelerate<sup>215-217</sup> (see also Polar bear on page 54). The presence of more open sea water increases the likelihood of increased wave action (coastal erosion) and storm surges that could result in more frequent inundation events inland.<sup>71</sup> Peatland sensitivity mapping suggests that much of the ecozone<sup>+</sup>'s peatlands will likely be severely or extremely severely impacted as permafrost thaws and other changes in hydrology occur<sup>218</sup> (Figure 17). In more northerly areas, thawing of permafrost is initially expected to collapse the peat, raise the water table, and form ponds.<sup>219</sup> Conversely, more southerly areas where permafrost is limited may become more xeric,<sup>219</sup> potentially resulting in fragmentation of wetlands<sup>220</sup> and shifts to shrub and tree-dominated communities.<sup>221, 222</sup> Prime denning habitat for polar bears will be affected as geomorphic features such as palsas degrade and eventually disappear<sup>223-225</sup> and important habitat for wetland-dependent species, including much of the breeding bird population, will also be altered or lost. Like elsewhere, other changes in species' ranges and assemblages are expected in both freshwater and terrestrial environments (for example, Minns and Moore (1995);<sup>226</sup> McKenney et al., (2007)<sup>227</sup>).

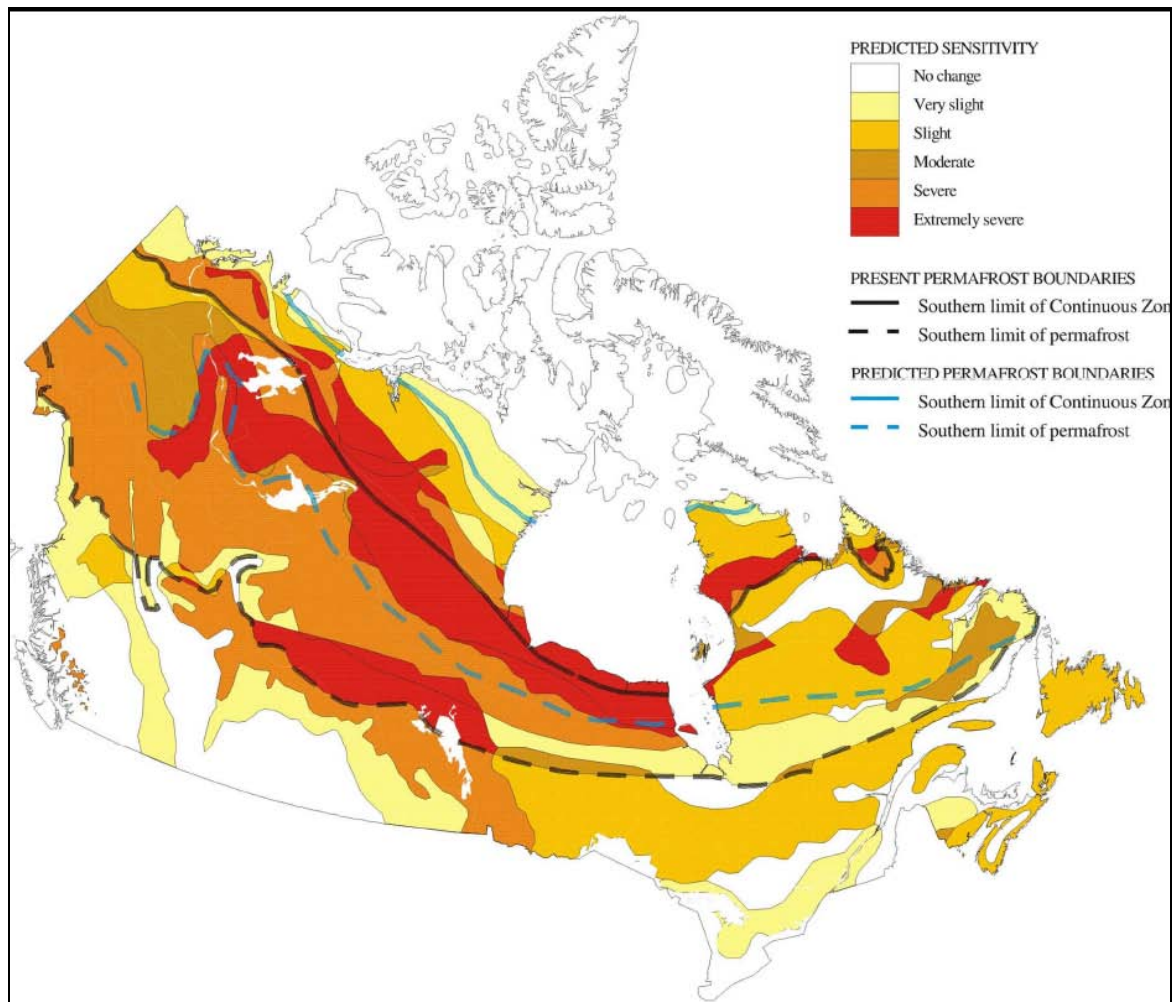


Figure 17. Peatland sensitivity map of Canada.

Much of the Hudson Plains Ecozone<sup>+</sup> is expected to be severely or extremely severely impacted by climate warming.

Source: reprinted from Tarnocai, 2006<sup>218</sup> (p 224, fig 2; adapted from Kettles and Tarnocai, 1999<sup>228</sup>) with permission Elsevier and Copibec

It is not clear how well the ecozone's extensive peatlands will be able to continue storing and accumulating carbon<sup>229</sup> but potential changes in the carbon balance of these peatlands are of global concern for biodiversity and human well-being. If carbon stored in the ecozone's peatlands is released to the atmosphere,<sup>218, 230</sup> the release may lead to a positive feedback to atmospheric greenhouse gases<sup>230</sup> that could be further exacerbated if large areas of dry peatlands burn as projected.<sup>214, 231-233</sup> Increased fire activity could in turn lead to increased mercury emissions, which in boreal areas can be more than 10-fold greater from burning peatlands than from fires in non-peatland forests.<sup>234</sup> Increased temperature-dependent methylation of mercury in aquatic environments is also a concern.<sup>235</sup>

## 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.

There is no compelling evidence to suggest that the capacity of the Hudson Plains Ecozone<sup>+</sup> to supply ecosystem services has deteriorated, based on limited information available for a select set of services examined for the ESTR.<sup>4</sup> The ecozone<sup>+</sup>'s ecosystem services are also assumed for the most part stable, given a high degree of intactness and minimal levels of development (see Intact landscapes and waterscapes on page 51). The effects of climate change and further development on the resilience or capacity of this ecozone<sup>+</sup> to continue supplying ecosystem services are, however, uncertain.

One provisioning service (wildlife harvest), one cultural service (traditional land use), and one regulating service (climate regulation) are profiled below. Although both climate regulation and the flood control (disturbance moderation) and water filtration (water quality regulation) services afforded by freshwater (including wetlands) are sometimes considered the most important ecosystem services provided by Canada's boreal ecozones<sup>+</sup>,<sup>23, 236, 237</sup> only climate regulation is profiled here in relation to its global significance.

### ***Wildlife harvest, a provisioning ecosystem service***

The provisioning services of the Hudson Plains Ecozone<sup>+</sup> (i.e., goods derived from the living portion of the ecosystem, such as food, furs, and plant fibre) are still very important for the majority of the principally Aboriginal peoples that live there.<sup>238, 239</sup>

Current, standardized, and complete data on provisioning services are lacking for the ecozone<sup>+</sup> as a whole and the information examined (harvests of caribou, moose, and waterfowl for food and harvests of furbearing mammals for fur) had significant spatial and/or temporal gaps in representation, particularly in recent years.<sup>4</sup> The strongest evidence of a trend in recent years is for fur harvest, for which comparable data are available across most of the ecozone<sup>+</sup>'s geography. However most, if not all, records of fur harvest come from official sealing records and Manitoba mandatory dealer reports and, therefore, the absolute total harvest (i.e., including animals retained by Aboriginal peoples for personal use) is unknown. Still, revenue generated by the sale of pelts is important to many communities where other sources of income may be few.

The available data show that the trend for declining fur harvest is continuing in present times (Figure 18), largely as a result of trends in American beaver and muskrat harvest (not shown). This trend, however, is probably not strongly related to decreasing furbearer populations, i.e., a reduced capacity of the ecozone<sup>+</sup> to supply furs. Declines in trapping effort in the ecozone<sup>+</sup> (and

resultant harvest) often coincide with changes in market conditions and the trapping effort there has also depended on local economic conditions and the desire of Aboriginal trappers to maintain traditional trapping lifestyle<sup>64</sup> (see also Traditional land use, a cultural ecosystem service below). Indeed, there is no indication that the actual population sizes of furbearing mammals are decreasing across the ecozone<sup>†,4</sup>

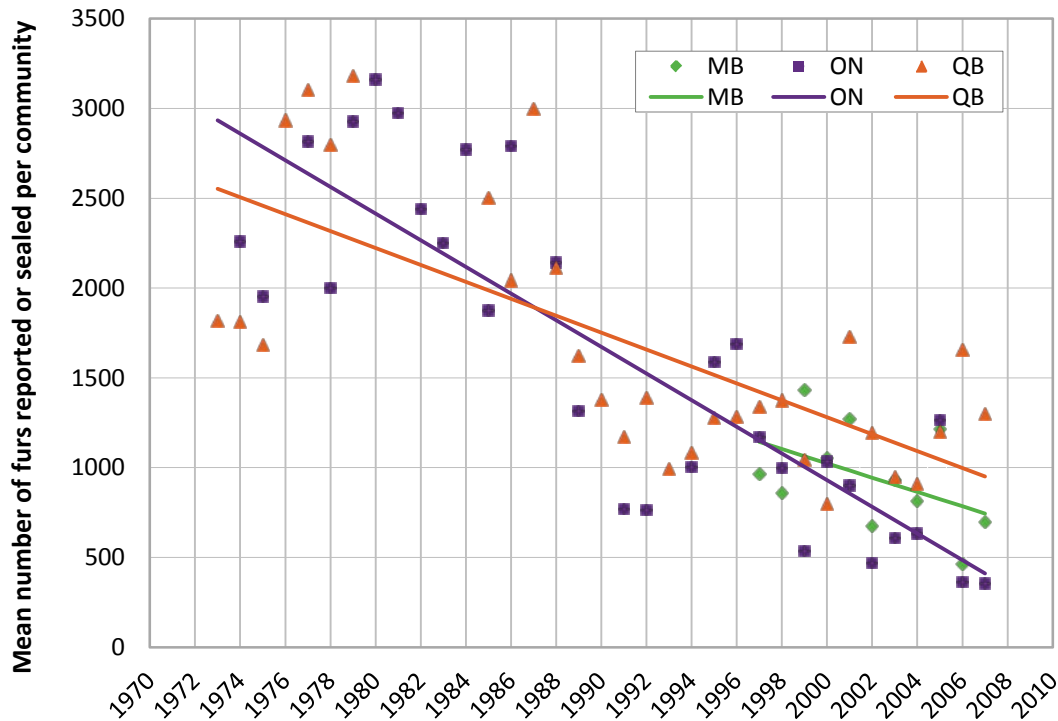


Figure 18. Harvest trends of furbearing mammals as measured by mean number reported or sealed per community for Manitoba (1996-1997 to 2006-2007), Ontario (1973-1974 to 2006-2007), and Quebec (1983-1984 to 2006-2007) portions of the Hudson Plains Ecozone<sup>†</sup>.

For Manitoba, the average is based on mandatory fur dealer reports for traplines entirely or partially in the Hudson Plains Ecozone<sup>†</sup>, i.e., those in the Churchill, Limestone, Shamattawa, Gods Lake, and Split Lake Registered Trapline Sections. For Ontario, the number of communities participating varied from year to year; therefore, the average is based on seven main communities in the ecozone<sup>†</sup>. For Quebec, the average is based on sealing records from Eastmain and Waskaganish.

Source: Abraham et al., 2011<sup>4</sup> using unpublished data from Manitoba Conservation, 2010;<sup>240</sup> Ontario Ministry of Natural Resources, 2010;<sup>241</sup> and Ministère des Ressources Naturelles et de la Faune, 2010<sup>242</sup>

### Traditional land use, a cultural ecosystem service

Historically, Lowland Cree livelihoods were based mostly on hunting, trapping, fishing, gathering, and the trading of products from these pursuits.<sup>61, 165</sup> Such activities provided a strong connection to the land and environment, which was important for survival and for maintaining social relationships and cultural identity.<sup>61, 243</sup> One proxy for the trend in traditional land use (cultural continuity) is the level of participation in the Income Security Program (ISP) under the James Bay and Northern Quebec Agreement.<sup>142</sup> Families who spend more than four months of the year on the land come under the ISP. Since the late 1970s, the percentage of



families under ISP has declined, including in Eastmain and Waskaganish (Figure 19). Similarly, studies in the Ontario portion of the ecozone<sup>+</sup> show that the activity patterns of Cree harvesters have shifted from long trips to numerous short trips of a few days in duration.<sup>239</sup> The fact that the majority of families no longer spend a substantial part of the year on the land is consistent with the observation of many elders that the younger generations are not as well connected to the land as in the past,<sup>244</sup> and is probably not related to deterioration in the supporting environment itself.

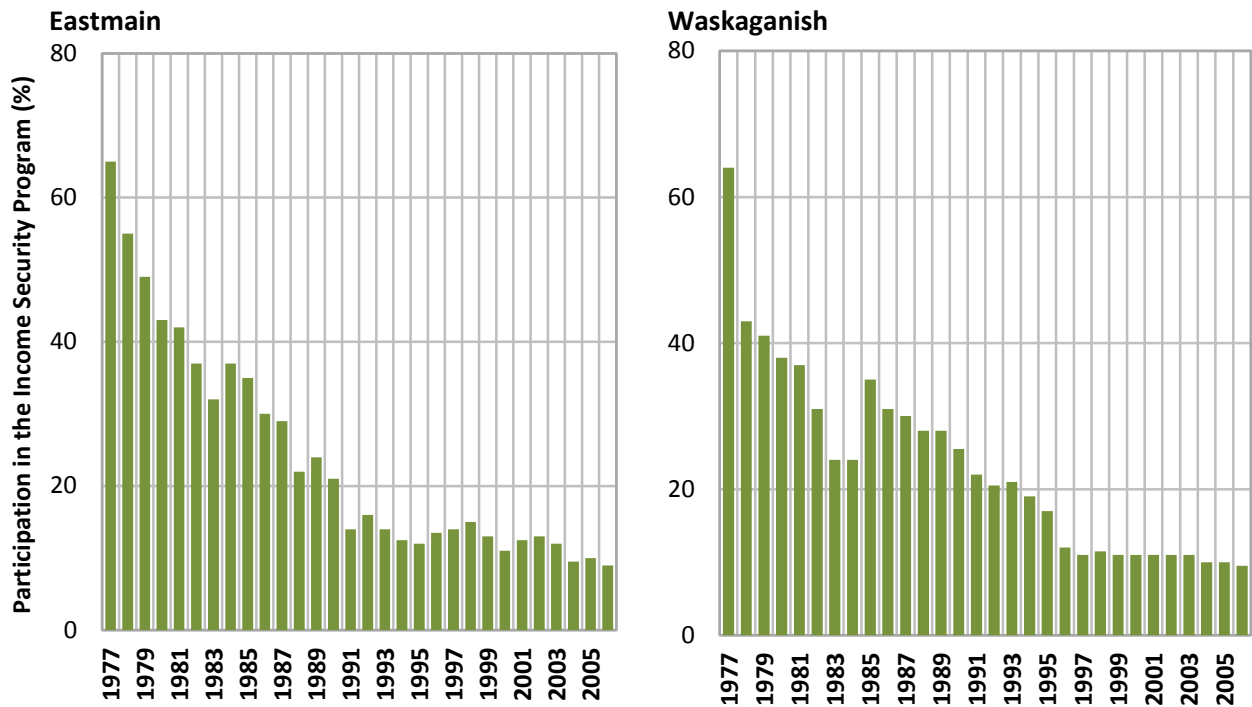


Figure 19. Percentage of the Cree member's population in Eastmain and Waskaganish participating in the Cree Hunter and Trappers Income Security Program, 1977-2006. Source: Cree Hunter and Trappers Income Security Program, 2009<sup>245</sup>

### **Climate regulation, a regulating ecosystem service**

Ecosystems regulate climate through carbon storage and release, by either sequestering (as a sink) or emitting (as a source) greenhouse gases.<sup>246</sup> Canada accounts for 87% of the peatland area in North America, and the Hudson Plains Ecozone<sup>+</sup> is its largest peatland complex.<sup>31</sup> As such, this ecozone<sup>+</sup> stores an exceptionally high amount of carbon, on both a national and global basis.<sup>247</sup>

The carbon stored in the ecozone<sup>+</sup>'s peatlands is estimated at 6.483 trillion tonnes, which accounts for 33% of total peatland carbon in Canada's boreal region even though the Hudson Plains Ecozone<sup>+</sup> covers only 6% of this land area (Table 4). From the same analysis, another approximately 945 billion tonnes of carbon is stored in this ecozone<sup>+</sup>'s forests.<sup>23, 236</sup> In other assessments, the Hudson Plains Ecozone<sup>+</sup> is estimated to contain approximately 33 Gt of soil carbon or 12% of the organic carbon stored in Canadian soils.<sup>248</sup> More recently, Tarnocai et al.,

(2009)<sup>249</sup> discovered that permafrost-affected soils contain more carbon than previously thought, the implication being that absolute values of carbon storage may have been strongly underestimated in permafrost areas across the globe. Updated regional estimates of carbon storage are not fully available at this time, in part because the Tarnocai et al., (2009)<sup>249</sup> study did not differentiate among various types of permafrost sites (see Schindler and Lee 2010).<sup>237</sup> Nonetheless, on a relative basis the Hudson Plains Ecozone<sup>+</sup> still has some of the highest carbon densities globally.<sup>249</sup>

*Table 4. Carbon storage in peatlands in Canada’s boreal ecozones. The Hudson Plains Ecozone accounts for ~6% of the area of Canada’s boreal region but ~33% of the carbon stored in its boreal peatlands.*

Ecozone <sup>a</sup>	Total ecozone area (ha) <sup>b</sup>	Peatlands		Carbon storage in peatlands (millions of tonnes)
		Area (ha)	Percent of ecozone area (%)	
<b>Taiga Cordillera</b>	26,366,000	6,700	0.03	<b>1.1</b>
<b>Taiga Plains</b>	63,722,000	14,110,000	22.1	<b>2,372</b>
<b>Taiga Shield</b>	135,431,000	9,705,400	7.2	<b>1,632</b>
<b>Hudson Plains</b>	<b>36,734,000</b>	<b>24,868,600</b>	<b>67.7</b>	<b>6,483</b>
<b>Boreal Shield</b>	199,642,000	24,515,400	12.3	<b>6,391</b>
<b>Boreal Plains</b>	74,412,000	9,816,100	13.2	<b>2,559</b>
<b>Boreal Cordillera</b>	47,772,000	177,500	0.37	<b>84</b>
<b>TOTAL, Canada’s Boreal Region</b>	<b>584,079,000</b>	<b>83,199,800</b>	<b>14.2</b>	<b>19,522</b>

a. These are the Ecological Stratification Working Group (2005)<sup>5</sup> ecozone boundaries, which differ slightly from the ecozone<sup>+</sup> boundaries used in the ESTR.<sup>6</sup>

b. Areas are for ecozones, not ecozones<sup>+</sup>.

Source: adapted from Anielski and Wilson, 2005.<sup>236</sup> See also Anielski and Wilson, 2009<sup>23</sup>

The comparatively large carbon store in the Hudson Plains Ecozone<sup>+</sup> has high value to society. In their 4<sup>th</sup> report, the International Panel on Climate Change<sup>250</sup> reported an average 2005 value for carbon of \$43 US per tonne based on the damage costs of climate change to society. Although data are currently insufficient to examine trends in the amount of carbon stored in the ecozone<sup>+</sup>'s peatlands, the fate of this carbon is a concern for biodiversity and human well-being (see Climate change on page 42).

The importance of maintaining the ecozone<sup>+</sup>'s large peatland carbon store is being increasingly recognized by managing jurisdictions. The Government of Manitoba recently committed to develop a boreal peatlands stewardship strategy in co-operation with stakeholders and leading climate change non-governmental agencies.<sup>132</sup> The commitment was made coincident with the establishment of two new protected areas with significant carbon stores in the ecozone<sup>+</sup> (see Protected areas on page 30). In Ontario, the vision to maintain carbon storage and sequestration is now articulated in the province’s new *Far North Act*.<sup>136</sup> To support the intent of this Act, a science advisory panel to the Ontario government recommended that some conservation areas be designated where the densest carbon pools exist, and that these carbon stores be given

economic value for the benefit of local communities.<sup>148</sup> The need to consider enhancing fire suppression efforts as climate change proceeds is also recognized, even if increasing fire suppression will be logistically and economically challenging in this geography (for example, Stocks and Ward (2010)<sup>251</sup>).

## **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 Hudson Plains Ecozone<sup>+</sup>. In the final version of the national report,<sup>3</sup> information related to intact landscapes and waterscapes was incorporated into other key findings. This information is maintained as a separate key finding for the Hudson Plains Ecozone<sup>+</sup>.

The Hudson Plains Ecozone<sup>+</sup> is one of Canada's ecozones<sup>+</sup> with the least human influence to date. It is characterized by a small human population (see Ecozone<sup>+</sup> Basics on page 2), a near-absence of commercial forestry (see Forests biome on page 13) and agriculture<sup>252</sup>, and relatively little development in hydroelectric (see Lakes and rivers on page 16) or mining sectors (for more information on the ecozone<sup>+</sup>'s single mine, see Wetlands on page 14). As such, the Hudson Plains Ecozone<sup>+</sup> is comprised mostly of relatively intact landscapes and waterscapes, where ecosystem processes are presumed to be functioning well. Pressure for additional resource and transportation developments is, however, mounting and cumulative impacts from roads and hydroelectric developments are a concern.

### ***Intact landscapes***

The Hudson Plains Ecozone<sup>+</sup> is the most intact (least anthropogenically fragmented) of all forested ecozones<sup>+</sup> in Canada, with 97% of its area covered with "intact terrestrial landscape fragments" (i.e., intact landscape patches or units) of more than 10,000 ha<sup>253</sup> in 2006 (Figure 20). Linear, anthropogenic fragmentation of the landscape is limited to a relatively small number of transportation and hydroelectric transmission corridors,<sup>14, 76, 164</sup> including a major new transmission line that services the Victor mine.<sup>37</sup> The western and eastern extremities of the ecozone<sup>+</sup> are transected from the south by two railway lines (one each in Manitoba and Ontario) that terminate near the coast, but the ecozone<sup>+</sup> is still nearly roadless. Winter roads seasonally connect the coastal communities<sup>14, 76, 164</sup> and one all-season road (James Bay Road) connects the coastal communities of Eastmain (1995) and Waskaganish (2001) in Quebec with the highway system in the south.<sup>166</sup>



Figure 20. "Intact landscape fragments" larger than 10,000 ha in the Hudson Plains Ecozone<sup>+</sup>, 2006. In this analysis an "intact landscape fragment" is defined as a contiguous mosaic, naturally occurring, and essentially undisturbed by human influence. It is a mosaic of various natural ecosystems including forest, bog, water, tundra, and rock outcrops. The Hudson Plains Ecozone<sup>+</sup> is covered by intact landscape fragments over 97% of its total area as of 2006.

Source: adapted from Lee et al., 2006<sup>253</sup> using the ecozone<sup>+</sup> boundaries

The large tracts of intact natural landscapes found in this ecozone<sup>+</sup> have high biodiversity value. The ecozone<sup>+</sup> still supports top predator species such as grey wolf, as well as species of national conservation concern such as polar bear (see Polar bear on page 54), woodland caribou (see Caribou on page 56), and wolverine that require large tracts of unfragmented and/or unroaded landscape and are especially vulnerable to human disturbance. In fact, aerial surveys in the ecozone<sup>+</sup> from 2003 to 2010 suggest further expansion of wolverine east (along with some likely increase in its population numbers), continuing the trend observed since 1970 of this species recolonizing its historical range.<sup>254, 255</sup> Wolverines in the Hudson Plains Ecozone<sup>+</sup> represent the eastern extension of the national Western population, which is assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as Special Concern.<sup>256</sup> As such, they are strategically important for maintaining the Western population and recovering the Eastern population.

As well, the coastal habitats of Hudson and James bays are extremely important as spring and fall staging areas and migration corridors for many waterfowl, shorebirds, and other birds en route to and from their nesting grounds in the eastern and central Canadian arctic.<sup>73</sup> Sea ducks (for example, scoters) and brant are known to follow the large rivers flowing into the south end of James Bay,<sup>257, 258</sup> which is critical moulting and staging habitat for them. Many Hudsonian godwits are thought to fly directly from the James Bay area to stopover areas in South

America<sup>259</sup> and James Bay is also a key area for the Endangered red knot.<sup>72, 260</sup> American white pelican (Threatened in Ontario) and double-crested cormorant are increasingly reported in the ecozone<sup>+</sup> and both began breeding in Akimiski Strait in the last decade.<sup>261-263</sup>

### ***Intact waterscapes***

Rivers and lakes in the ecozone<sup>+</sup> are relatively healthy and undisturbed compared to ecozones<sup>+</sup> in more developed areas of Canada.<sup>45, 46</sup> While some of the ecozone<sup>+</sup>'s large river systems are fragmented or otherwise affected by hydroelectric developments (see Lakes and rivers on page 16), other relatively large rivers remain unregulated.<sup>35, 54</sup> Such rivers include the Hayes, Severn, Winisk, Attawapiskat, Harricana, and Broadback rivers.

The many intact natural rivers and streams remaining in the ecozone<sup>+</sup> are particularly important to anadromous fish species such as brook trout, lake whitefish, and cisco (found in coastal rivers and streams) and other migratory fish species such as lake sturgeon (found in all major rivers, their main tributaries, and connecting large lakes). Dams and other hydroelectric structures, unless constructed on existing natural barriers such as waterfalls, fragment waterscapes and affect these and other fish species by physically blocking their movements and restricting access to habitats important for critical life stages such as spawning.<sup>34</sup> The ecozone<sup>+</sup> is notably important for lake sturgeon, a species of national conservation concern that tends to be more deeply in decline or extirpated in more developed locales (see Lake sturgeon on page 61).

### ***Development pressure***

Although the Hudson Plains Ecozone<sup>+</sup> is highly intact at present, pressure for new resource developments is mounting, particularly in mining,<sup>148, 164, 264-266</sup> hydroelectric,<sup>35, 55, 57, 58</sup> and wind-farming<sup>267-269</sup> sectors. Recent discovery of world-class chromite deposits inland, within the Ring of Fire mineral field,<sup>264, 266</sup> especially portends more major mining-related infrastructure.<sup>148</sup> Although likely to bring additional jobs to the ecozone<sup>+</sup>'s wage economy, the high potential for additional resource developments in this ecozone<sup>+</sup> is of ecological concern because it drives the establishment of roads and other infrastructure<sup>37, 164, 166</sup> that will increasingly fragment the landscape and facilitate further human access, along with associated influences on ecozone<sup>+</sup> health.<sup>32, 61, 270</sup> Similarly, cumulative impacts from multiple hydroelectric developments within the Hudson Bay watershed is a concern.<sup>59-63, 189</sup>

Irrespective of future resource developments, feasibility planning is in progress for an all-season road that would run along the western edge of the ecozone<sup>+</sup>, from Gillam to Churchill, Manitoba and beyond to Rankin Inlet, Nunavut.<sup>271, 272</sup> Likewise, a pre-feasibility study is in progress in Ontario to assess possible routes for an all-season road that would connect communities along the coast of James Bay with the provincial highway system in the south.<sup>273</sup>

**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.

The Hudson Plains Ecozone<sup>+</sup> has relatively few species considered to be of conservation concern nationally by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and most are migratory birds.<sup>30</sup> Three species of conservation concern and otherwise of particular ecological interest are profiled below that are also culturally important to Aboriginal peoples in the ecozone<sup>+</sup>. The three species, polar bear, woodland caribou, and lake sturgeon, represent the marine-terrestrial interface, terrestrial landscapes, and waterscapes, respectively. Birds are also profiled as a group, given the high importance of this ecozone<sup>+</sup> to migratory birds in general. Data are largely insufficient for assessing status and trends in species of lower taxa, including amphibians.

***Polar bear***

The polar bear is assessed as a species of Special Concern nationally by COSEWIC (2008).<sup>111</sup> § As an apex predator in the marine system, it is a species that has already been negatively affected by climate change,<sup>274</sup> making continued monitoring of polar bear populations critical. Polar bear is also of cultural significance to Aboriginal peoples.

Some 4,000 polar bears, or about 20% of the total world population, occur in the entire Hudson Bay region, of which about 1,800 individuals are associated with the Hudson Plains Ecozone<sup>+</sup>.<sup>275</sup> Polar bears use sea ice as a platform for catching prey (primarily ringed seals<sup>183</sup>). When sea ice in Hudson and James bays melts in the summer, the bears come ashore where they spend up to five months (eight months for pregnant females) before the sea ice re-forms.<sup>114</sup> Polar bears of the Western Hudson Bay (WHB) subpopulation summer on land in Manitoba<sup>276</sup> and those of the Southern Hudson Bay (SHB) subpopulation summer on land in Ontario and on islands in Southern Hudson Bay and James Bay (Nunavut).<sup>277</sup> The polar bears that use the Hudson Plains Ecozone<sup>+</sup> are at the southern edge of the species' range, where the first effects of climate change on the species were predicted to occur.<sup>223</sup>

The WHB subpopulation of polar bears has already declined in abundance by 22% from about 1,194 individuals in 1987 to 935 in 2004.<sup>274</sup> Coincident with this population decline, there were indications of declining body condition and reduced survival rates in some age classes.<sup>113, 274</sup> The adjacent SHB subpopulation of polar bears has shown significant declines in body condition<sup>225</sup>

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<sup>§</sup> Although this report considers status and trends up to December 2010 only, note that the polar bear was listed as a species of Special Concern under the federal Species at Risk Act (Schedule 1) in November 2011 (see Canada Gazette Part II 145 (23): 2232-2384).

(Figure 21) as well as evidence of declines in survival rates of all age and sex classes.<sup>217</sup> Together, these observations suggest that this subpopulation, whose numbers have been stable from the mid-1980s until last assessed in 2003-2005, is likely to decline in abundance in the future.<sup>217</sup> Under respective provincial legislation, Manitoba declared the WHB subpopulation Threatened in February 2008, and Ontario declared the SHB subpopulation Threatened in September 2009.

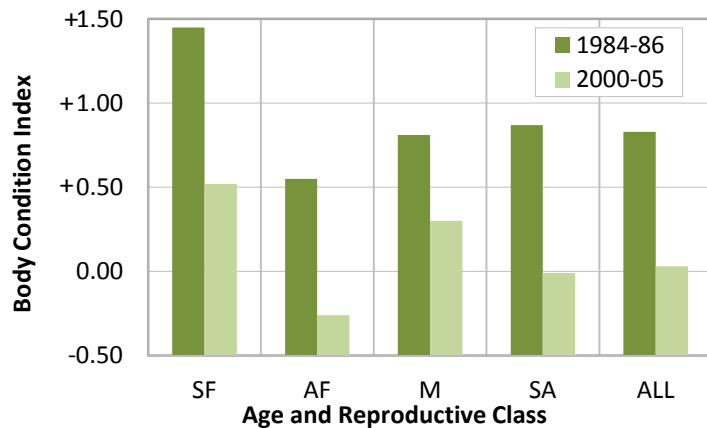


Figure 21. Mean Body Condition Index for polar bears of the Southern Hudson Bay subpopulation, 1984-1986 and 2000-2005.

Abbreviations: SF, solitary adult females; AF, adult females with young; M, adult males; SA, subadults; ALL, all classes combined. See Cattet et al., 2002<sup>278</sup> for a description of the Mean Body Condition Index.

Source: redrawn from Obbard et al., 2006<sup>225</sup> under license with the Ontario Ministry of Natural Resources, © Queen's Printer for Ontario, 2006

The declines in body condition, survival, and abundance of the polar bear subpopulations that use the Hudson Plains Ecozone<sup>+</sup> are correlated with significant trends toward earlier break-up of sea ice<sup>113, 216, 225, 274</sup> that are, in turn, attributed to climate change (see Ice across biomes on page 26). These trends in sea ice in Hudson and James bays are projected to continue (see Climate change on page 42) and will have negative impacts on polar bears.<sup>215</sup> A reduction in the annual duration of sea ice decreases the time that polar bears have on the ice to hunt and feed on seals and, therefore, to put on fat stores for their seasonal period on land, where they eat only opportunistically (for example, berries, goose eggs, and flightless geese<sup>279-283</sup>). Changes in diet as a result of reduced sea ice duration may also be responsible for higher concentrations of some contaminants in the bears (see Contaminants on page 38). Some evidence of changing prey relationships is discussed in the Food webs section on page 66. Though harvest is currently not the key factor affecting population trends, harvest is a recognized anthropogenic stressor on polar bear subpopulations, and it must be closely monitored in the future. Harvest will be particularly challenging to manage in the future, when these subpopulations are projected to decline in abundance in association with climate change.<sup>284</sup>

## ***Caribou***

Woodland caribou are ecologically and culturally important in the Hudson Plains Ecozone<sup>+</sup>. Ecologically, their status serves as an indicator of general ecosystem integrity. In general, they require large patches of undisturbed, mature coniferous forest and are sensitive to human disturbance.<sup>285-287</sup> Within the Hudson Plains Ecozone<sup>+</sup> they also require undisturbed coastal and tundra habitats, which are used from calving through rut.<sup>254, 288</sup> Woodland caribou are also culturally important to local Aboriginal peoples, forming an important part of their traditional subsistence lifestyle.<sup>238</sup>

Two ecotypes of woodland caribou regularly inhabit the Hudson Plains Ecozone<sup>+</sup>: the more southerly and sedentary, forest-dwelling ecotype and the more northerly and migratory, forest-tundra ecotype (Figure 22). During some winters, barren-ground caribou from the Qamanirjuaq herd occasionally migrate into the western part of the ecozone<sup>+289</sup> (Figure 22), but this herd may be only minimally influenced by its limited use of the ecozone<sup>+</sup> and it is not discussed further here.



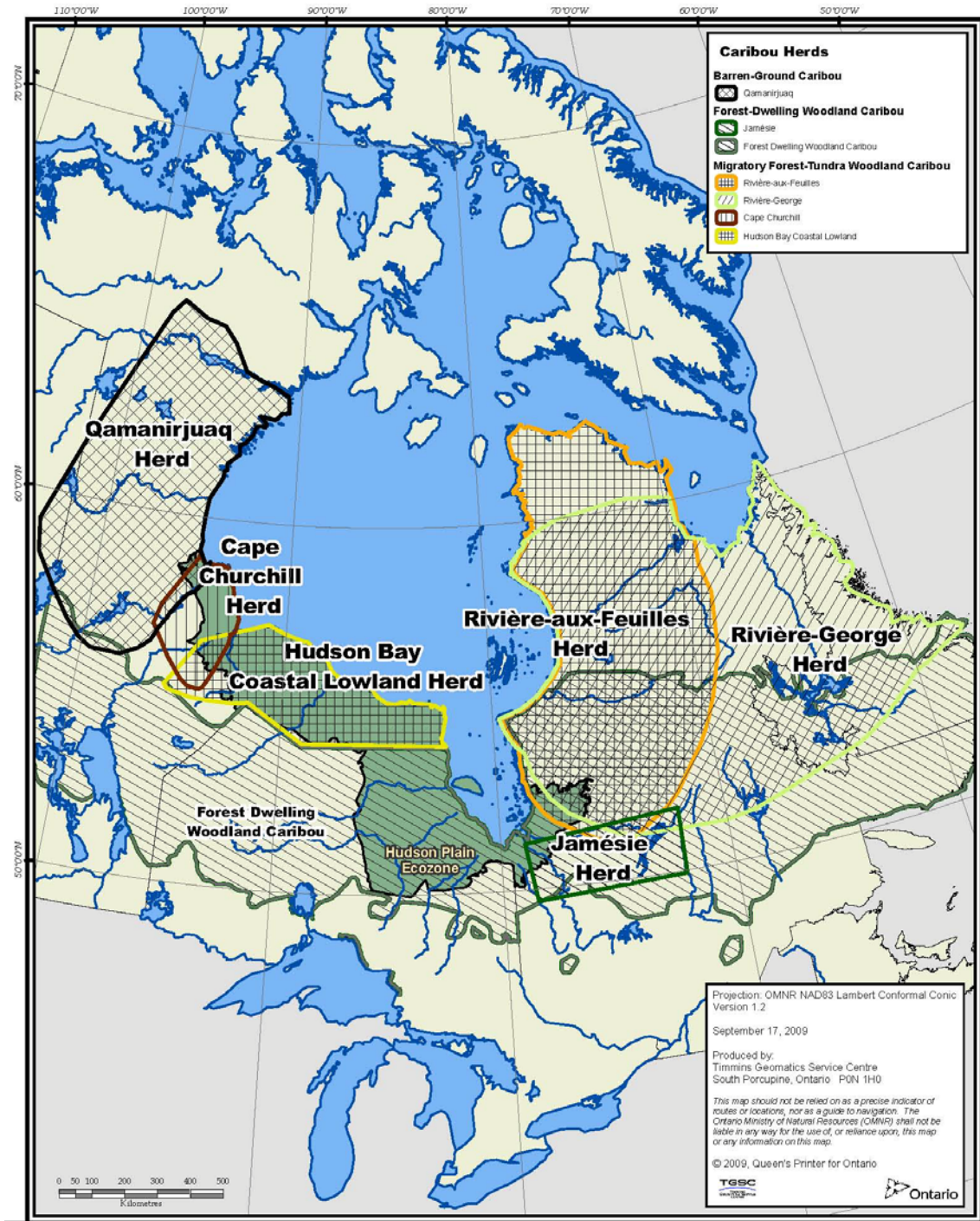


Figure 22. Approximate distribution of caribou herds in and around the Hudson Plains Ecozone<sup>+</sup>. The ecozone<sup>+</sup> is denoted with green shading. All herds shown are woodland caribou herds, except the Qamanirjuaq herd, which is a herd of barren-ground caribou that only occasionally migrates into the ecozone<sup>+</sup>. The Pen Islands herd of woodland caribou (a migratory forest-tundra ecotype) is represented on the map as the Hudson Bay Coastal Lowland herd. Caribou rarely occur on Akimiski Island. Source: Abraham et al., 2011<sup>4</sup>

### **Forest-dwelling ecotype of woodland caribou**

In 2002, COSEWIC assessed the Boreal population of the forest-dwelling ecotype of woodland caribou as Threatened, due to population declines throughout most of the range and threats from habitat loss and increased predation, possibly facilitated by human activities.<sup>290</sup> This population occurs in both the Ontario and Quebec portions of the ecozone<sup>+291, 292</sup> (Figure 22).

There is currently no information to suggest range recession or population decline of this ecotype in the relatively remote Hudson Plains Ecozone<sup>+</sup>, as there is elsewhere in Canada.<sup>254, 287, 290, 293, 294</sup> Winter densities of 0.015 to 0.141 caribou/km<sup>2</sup> were reported from systematic surveys conducted periodically since 1959 throughout the Ontario portion of the ecozone<sup>+</sup>.<sup>254</sup> Although it was not possible to detect any trends or changes during that period because study areas and methods varied among surveys, preliminary data from a 2008 winter survey in the southern part of the ecozone<sup>+</sup> in Ontario, in which methods and study areas were similar to earlier work, suggests that caribou densities have increased there from 0.01 caribou/km<sup>2</sup><sup>295</sup> to 0.04 caribou/km<sup>2</sup><sup>296</sup> since 1983-1984. The western range of the Jamésie herd (~600 animals) also occurs within the ecozone<sup>+297</sup> (Figure 22) and this herd is currently considered stable.<sup>298</sup>

### **Forest-tundra ecotype of woodland caribou**

The migratory forest-tundra ecotype of woodland caribou has not been assessed by COSEWIC. This ecotype occurs in Manitoba, Ontario, and Quebec portions of the ecozone<sup>+</sup> and includes the Cape Churchill, Pen Islands (represented in Figure 22 as Hudson Bay Coastal Lowland), George River, and Leaf River herds. The ecozone<sup>+</sup> comprises only the western periphery of the annual ranges of the latter two herds (Figure 22) and they are not considered further here (see the Taiga Shield Ecozone<sup>+</sup> Key Findings Summary<sup>33</sup> for more information on these herds).

The Cape Churchill herd has not been well studied but no recent changes are suggested. In 1997/98 its minimum population size was estimated to be 3,013 adults.<sup>299</sup> Parks Canada conducted an aerial survey on May 28/29, 2005 and along flight lines over the known calving area counted 644 animals.<sup>300</sup> Three counts of an opportunistic aerial photograph survey taken on July 20, 2007 averaged 2,937 adult animals, suggesting no change in the minimum population size of this herd from 1997/98.

Conversely, a recent eastward shift and possible decline is suggested for the Pen Islands (Hudson Bay Coastal Lowland) herd. This herd increased from a minimum of 2,300 animals in 1979 to a high of 10,798 animals in 1994,<sup>288</sup> but numerous aerial surveys conducted since 2000 have shown that these animals are no longer present in large aggregations in their traditional area (Manitoba-Ontario border region) (as defined in the 1990s) at calving time or during the summer as previously documented, raising uncertainty as to the current status of this herd.<sup>254</sup> An eastern shift in summer use of coastal areas by forest-tundra caribou has been occurring since the late 1990s,<sup>254</sup> with 2008 and 2009 systematic surveys showing >80% of observed forest-tundra caribou now near Cape Henrietta Maria.<sup>301</sup> These surveys also suggest the possibility of a significant decline in the number of these forest-tundra caribou, with observed numbers of just 3,529 (2008) and 3,304 (2009).<sup>301</sup> These results (eastward shift and lower numbers) may represent: a shift in range use and behaviour of the Pen Islands herd within the

broader Hudson Plains Ecozone<sup>+</sup>; an independent decrease in numbers of caribou in the former Pen Islands range coupled with an independent increase in numbers in the east; or some combination of those and other population or behavioural changes.

Multiple factors (not examined) may be responsible, including deterioration of range condition in the Pen Islands area leading to decreased food availability, increased predator densities, disturbance, and harvest. However, the learned avoidance of areas of high harvest pressure and/or high disturbance is suspected to be contributing because of the pattern of change (see Abraham et al., 2011<sup>4</sup>). Still, no comprehensive estimate of forest-tundra caribou population size or true population trend currently exists for this ecozone<sup>+</sup>. Therefore, the sustainable harvest level is unknown, and no clear cause-effect relationship can be ascribed.

Future landscape fragmentation associated with a high potential for new resource development in this ecozone<sup>+</sup> (see Intact landscapes and waterscapes on page 51) is a concern for the long-term health of both ecotypes of woodland caribou. Human developments, including linear disturbances such as electricity transportation corridors and winter and all-season roads, allow hunters and predators greater access to caribou, and can also create barriers to their movement and distribution.<sup>302-305</sup> Another emerging issue is the effect of climate change on caribou habitat in the ecozone<sup>+</sup>, with the potential consequence of changing caribou status.<sup>306, 307</sup>

## **Birds**

As Canada's largest wetland complex and the third largest in the world,<sup>27</sup> the Hudson Plains Ecozone<sup>+</sup> provides critical habitat for many breeding bird populations.<sup>28</sup> The large and diverse assemblage of birds (over 340 species) supported by this ecozone<sup>+</sup> is comprised of mostly migratory species in four basic groups: landbirds, waterfowl, shorebirds, and waterbirds (including seabirds)<sup>14, 90, 151, 308, 309</sup> (but see Niemi et al., (2010)<sup>15</sup> regarding seabirds in the pelagic portion of the geographic area). Populations of such migratory species are also affected by anthropogenic factors outside the ecozone<sup>+</sup>, along migration routes and in their wintering areas further south. There are no ecozone<sup>+</sup>-wide bird trend monitoring programs in place; bird monitoring activity is a mixture of programs undertaken by various agencies.<sup>4</sup> Waterfowl is the best monitored of the four bird groups, and waterbirds probably the least well monitored. Some changes or trends in bird populations are evident (see below) but northward shifts in species breeding distributions are not apparent in this geography.<sup>151</sup>

### **Landbirds**

In Ontario, the draft Bird Conservation Region (BCR) 7 conservation plan for landbirds<sup>309</sup> lists 124 species that regularly breed or winter in the ecozone<sup>+</sup> (no comparable plans have been prepared for the Manitoba or Quebec portions of the BCR). Five species are assessed by COSEWIC as species at risk<sup>30</sup>: olive-sided flycatcher (Threatened), Canada warbler (Threatened), common nighthawk (Threatened), rusty blackbird (Special Concern), and short-eared owl (Special Concern). Another two species are listed as species at risk by the Committee on the Status of Species at Risk in Ontario (COSSARO)<sup>310</sup>: golden eagle (Endangered) and bald eagle (Special Concern). In Quebec, golden eagle, bald eagle, and peregrine falcon are species at risk.<sup>311</sup> In Manitoba, the only landbird regularly occurring in the ecozone<sup>+</sup> that is listed is the

peregrine falcon (Endangered).<sup>312</sup> The bald eagle has increased in the ecozone<sup>+</sup> since the 1980s, both as a breeding species in the southern portion and as non-breeding birds along the coasts during summer.<sup>313, 314</sup>

## **Waterfowl**

Most species of waterfowl breeding in the Hudson Plains Ecozone<sup>+</sup> have stable or increasing populations. The Canada geese that use the ecozone<sup>+</sup> belong to four populations: two populations (Eastern Prairie and Mississippi Valley) have increased over the past four decades but they have been stable (Eastern Prairie) or declining (Mississippi Valley) in recent years, and two populations (Southern James Bay and Atlantic) declined from the 1970s to 1990s but have been stable since.<sup>315, 316</sup> Lesser snow goose nests in the ecozone<sup>+</sup> in discrete colonies, of which there were three in the 1970s,<sup>317, 318</sup> but, with the quadrupling over the last four decades of the Mid-Continent population of lesser snow goose to which these colonies belong, there has been much expansion of those as well as establishment of three more colonies.<sup>318-320</sup> Intensive foraging by this increased population has led to much damage to the ecozone<sup>+</sup>'s coastal salt marshes over the same period (see the Coastal biome on page 20). Three of the Canada goose populations (Eastern Prairie, Mississippi Valley, and Southern James Bay) have been affected locally in terms of reproductive success or nesting density by the growth of the lesser snow goose population.

Although it does not breed in the ecozone<sup>+</sup>, the entire Atlantic population of brant stages there and relies on the eelgrass beds and salt marshes of the coastal zone of James Bay during spring and fall migrations.<sup>321</sup> Its dependence on eelgrass, which has shown a decline in the ecozone<sup>+</sup> (see the Coastal biome on page 20), suggests a re-distribution of brant within the ecozone<sup>+</sup> over the past two decades.

Species or groups of ducks that occur in the ecozone<sup>+</sup> and for which there is continental concern about declining populations include greater and lesser scaup, northern pintail, and sea ducks (for example, scoters).<sup>151, 315</sup> There are insufficient data to analyze trends of scaup and pintail in the ecozone<sup>+</sup>. However, surveys of the Atlantic subpopulation of black scoters that moults in the nearshore areas of James Bay suggest that its numbers have not changed significantly between 1977 and 2009.<sup>315, 322</sup>

## **Shorebirds**

The vast lowlands lying behind the coastlines of Hudson and James bays support a number of breeding species of shorebirds. Very little information is available on their breeding population trends. Shorebirds have, however, been studied extensively at Churchill and nearly all studies have reported widespread declines.<sup>323, 324</sup> Declines were particularly notable in the semipalmated sandpiper, which used to be the most abundant breeding shorebird in the Churchill region up to the 1940s, but by 2004 could no longer be found breeding in that area.<sup>325-327</sup> Breeding whimbrel, for which the ecozone<sup>+</sup> is of particular importance, are also thought to have declined in abundance in the Churchill region.<sup>90, 323</sup>

The coasts of Hudson and James bays remain a key migration area for arctic breeding shorebirds of many species. The vast mudflats and coastal lagoons and wetlands provide

critical resting habitat and food resources for replenishing fat and protein reserves needed for migration to breeding areas in the spring and for migration to wintering areas in the fall. James Bay remains a key migration area for Hudsonian godwit and red knot, the latter species assessed by COSEWIC as Endangered.<sup>72, 73, 259, 260</sup>

## **Waterbirds**

Waterbirds are a mixed group that includes loons, grebes, gulls, terns, jaegers, herons, pelicans and cormorants, rails, and cranes. Overall, as a group about two thirds of the regularly occurring species are stable or increasing.<sup>90, 308</sup> In terms of species assessed by COSEWIC,<sup>30</sup> Ross's gull (Threatened) has declined in the Manitoba portion of the ecozone<sup>+</sup>,<sup>313</sup> and yellow rail (Special Concern) may have declined in the Ontario portion<sup>328</sup> and locally in the Manitoba portion.<sup>90</sup> In both provinces snow goose habitat degradation may be affecting local nesting densities of yellow rail. American white pelican recently established breeding in Akimiski Strait, illustrating the easterly expansion of this species that is designated by COSSARO (Committee on the Status of Species at Risk in Ontario) as Threatened.<sup>263</sup> Double-crested cormorants also established a breeding colony in Akimiski Strait.<sup>261</sup>

## **Lake sturgeon**

Lake sturgeon reaches the northern limit of its range near the northern most extent of the Hudson Plains Ecozone<sup>+</sup> in Manitoba and Ontario, and just north of the ecozone<sup>+</sup> in Quebec.<sup>329-331</sup> Within the ecozone<sup>+</sup> it occurs in all major rivers and their main tributaries and connecting large lakes.<sup>34, 64, 65, 330, 332, 333</sup> The species is a culturally important and valued food resource for local Aboriginal peoples.<sup>37, 334, 335</sup>

Ecologically, lake sturgeon is a sensitive indicator of the health of aquatic environments because it is a long-lived species thought to have strong site fidelity for spawning and other habitat requirements.<sup>330</sup> Because it commonly migrates up to 100 km or more between these sites,<sup>336</sup> it is sensitive to river fragmentation. The slow growth rate of this species, late age to maturity (15 to 25 years), and infrequent spawning behaviour also make it very vulnerable to over-harvest and habitat change more generally.<sup>329, 337</sup>

Through most of the Hudson Plains Ecozone<sup>+</sup>, lake sturgeon is assessed by COSEWIC as Special Concern.<sup>330</sup> However, reduced populations of the Churchill and Nelson rivers are assessed as Endangered, due to historic harvest activities and current hydroelectric development.<sup>330</sup> The segment of the Nelson River within the ecozone<sup>+</sup>, downstream of the Limestone Dam, is the longest stretch (100 km) of unimpounded water remaining on that river and the lake sturgeon there may represent perhaps the last true riverine stock on the river.<sup>338</sup> The lack of older, larger fish and low numbers of larvae, however, suggest a stressed population with low recruitment.<sup>330</sup> At least one additional hydroelectric development is proposed for that segment of the river.<sup>55, 56</sup>

Deterioration of lake sturgeon populations is also evident near hydroelectric developments elsewhere in the ecozone<sup>+</sup>. The abundance of lake sturgeon strongly declined in the Eastmain and Opinaca rivers following diversion of most of the flow from these rivers north to the La Grande River (see Lakes and rivers on page 16).<sup>32, 34</sup> Declines in lake sturgeon abundance in the

Eastmain and Opinca rivers are attributed to very low recruitment, believed to result from reduced quality of, and/or access to, spawning grounds, along with increased harvest (new road access and increased ease of net fishing associated with the reduced flow).<sup>32, 34</sup> The species was almost totally absent from catches in 1998.<sup>339</sup>

Still, lake sturgeon is thought to be in comparatively good condition in the ecozone<sup>+</sup> as a whole, owing to the overall limited amount of human disturbance there and presence of many rivers still free from hydroelectric development, especially in the majority of the ecozone<sup>+</sup> that lies in Ontario (see Intact landscapes and waterscapes on page 51). Certainly, the species tends to be more deeply in decline or even extirpated in more developed areas of North America,<sup>340</sup> due primarily to habitat degradation and loss and over-exploitation.<sup>341</sup>

The high potential for additional hydroelectric development in the Hudson Plains Ecozone<sup>+</sup> (see Lakes and rivers on page 16 and Intact landscapes and waterscapes on page 51) is a concern for the long-term health of the lake sturgeon populations found there, as such development may further fragment lake sturgeon habitat and facilitate other human disturbance.

#### **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.

Remote sensing analyses based on leaf area index and land cover type across the entire Hudson Plains Ecozone<sup>+</sup> have estimated net primary productivity (NPP) there at  $138 \pm 84$  g C/m<sup>2</sup>/yr (based on the year 1994).<sup>342</sup> This estimate falls within the range of the ground-based measurements of NPP from the eastern part of the ecozone<sup>+</sup> (~50 to 100 g C/m<sup>2</sup>/yr)<sup>343</sup> and northern Manitoba (~125 to 275 g C/m<sup>2</sup>/yr).<sup>221</sup>

A complementary analysis of trends in the Normalized-Difference Vegetation Index (NDVI, a measure of gross primary photosynthesis and a proxy for green leaf area based on remote sensing) found that over the period 1985 to 2006 NDVI increased significantly over 4.9% of this ecozone<sup>+</sup>'s land surface and decreased over 0.1% of its land surface.<sup>9, 344</sup> Some increase in primary productivity may also be suggested by observations of increased tree and shrub cover above the treeline (in the tundra), as near Churchill.<sup>107</sup> Overall, however, to date increases in productivity appear to be much less in the Hudson Plains Ecozone<sup>+</sup> than for some other areas of Canada, including the eastern portion of the neighbouring Taiga Shield Ecozone.<sup>9, 344</sup> Changes in primary productivity in the north are likely to be climate-driven, given the few changes in land use.<sup>344</sup>

Note that satellite observations cannot provide information on belowground processes affecting soil carbon and nitrogen dynamics.<sup>345</sup> Understanding carbon-cycling in this ecozone<sup>+</sup> (complex

and currently poorly understood) is critically important because of the implications any changes in the massive store of carbon in this ecozone<sup>+</sup> have for regional and global carbon budgets and climate change (see Climate change on page 42 and Climate regulation, a regulating ecosystem service on page 49).

## 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.

There is little evidence to suggest that the extent, frequency, or severity of natural disturbances from fire, native insect outbreaks, or extreme weather have changed in the Hudson Plains Ecozone<sup>+</sup> to date. Information about these types of natural disturbances is, however, very limited, most notably for native insect outbreaks. Such disturbances are expected to occur more frequently in the future in association with climate change.

#### *Fire*

The fire regime of the Hudson Plains Ecozone<sup>+</sup> is effectively natural, with a strong predominance of lightning-caused fires<sup>8</sup> and almost no fire suppression.<sup>346, 347</sup> Although data are limited, fire frequency tends to increase inland, away from the coast.<sup>8, 348</sup> Large fires in this ecozone<sup>+</sup> tend, however, to be less frequent and of smaller maximum size than in neighbouring Boreal Shield and Taiga Shield ecozones<sup>+</sup>,<sup>347, 349, 350</sup> presumably owing to an overall humid, cool climate and a predominance of wetlands and related effects on horizontal fuel discontinuity and overall fire resistance.<sup>350</sup>

Early data from the Canadian Large Fire Database are inaccurate for this area until the mid-1970s.<sup>349</sup> Based on available data from 1980 onward, no trends are apparent in analyzed elements of the large fire ( $\geq 2$  km<sup>2</sup>) regime, including: annual area burned, 1980 to 2007 (highly variable; Figure 23); causes of fire, 1980 to 1999 (predominantly lightning, ~92%); seasonality of fire, 1980 to 1999 (May-August, with activity peaking mid-period); and duration of the active fire season, 1980 to 1999 (~55 days).<sup>8</sup> Although the available data and analysis are limited in terms of temporal scale, the results are consistent with studies of long-term trends in the July monthly drought code, an indicator of wildfire risk across circumboreal forests.<sup>351, 352</sup> The apparent stability in the overall fire regime in this ecozone<sup>+</sup> since the early 1900s contrasts with other areas in Canada, of which the southeastern and southwestern boreal show diminishing wildfire risk and area burned, and other areas show increases. A trend towards decreasing dryness (reduced wildfire risk) is evident at the extreme southern end of the Hudson Plains Ecozone for the period 1901 to 2002, but not for the more recent period since 1951.<sup>351</sup>

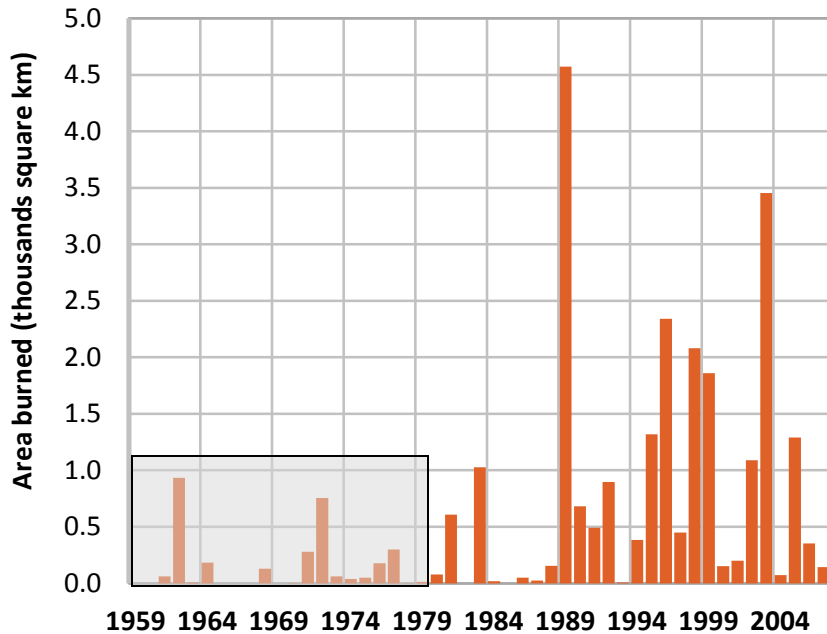


Figure 23. Annual area burned by large fires ( $\geq 2 \text{ km}^2$ ) in the Hudson Plains Ecozone<sup>+</sup>, 1959-2007. Data from 1960-1979 are screened-out to denote probable inaccuracy; these data are from a period when fire detection was non-existent or limited in this Ecozone<sup>+</sup>.<sup>349</sup> Source: Krezek-Hanes et al., 2011<sup>8</sup>

If climate change leads to an increase in the annual area burned in the ecozone<sup>+</sup> as projected,<sup>214, 233</sup> the increased fire activity could exacerbate the release of carbon as well as mercury from the ecozone<sup>+</sup>'s extensive peatlands (see Climate change on page 42), in addition to altering vegetative succession (shifting forests to younger age classes) and other ecosystem processes such as nutrient cycling. Limited evidence for the southern part of the ecozone suggests that the projected increase in future fire risk in this area may, by 2100, move the burn rate towards the upper limit of its range of natural variability during most of the Holocene (over at least the last ~ 7,000 years).<sup>214</sup>

### **Native insect outbreaks**

The role of insects as disturbance agents in the Hudson Plains Ecozone<sup>+</sup> is poorly understood. Few forest insect surveys have been conducted there and they were limited to the most southerly portion of the ecozone<sup>+</sup>.<sup>353</sup> These surveys, along with available tree ring studies,<sup>354, 355</sup> do, however, suggest that spruce budworm and larch sawfly are the two main (but not only) defoliators in this ecozone<sup>+</sup>.

The available forest insect surveys report occasional episodes of defoliation by spruce budworm and forest tent caterpillar in the southern part of the ecozone<sup>+</sup>.<sup>353</sup> However, these episodes would be considered too short, too scattered, and too separated in time to expect substantial tree mortality or otherwise be considered an important disturbance if they had occurred further south.<sup>356, 357</sup>



Conversely, tree ring studies suggest that larch sawfly (distributed widely over the ecozone<sup>+358</sup>) sporadically produces substantial impacts on eastern larch right up to the treeline.<sup>359</sup> Moreover, the eastern larch beetle tends to follow outbreaks of the larch sawfly, further increasing the mortality of eastern larch when it does. Indeed, Langor and Raske (1989)<sup>360</sup> reported widespread mortality of eastern larch in 1960 between Englehart and James Bay, Ontario, which includes part of the Hudson Plains Ecozone<sup>+</sup>. Although not confirmed, eastern larch beetle may be the cause of recent mortality of eastern larch in the Churchill area, an observation made by Manitoba provincial staff in 2008.<sup>361</sup>

Clearly, it is difficult to assess current trends in insect outbreaks (types, severity, frequency, etc.) for this ecozone<sup>+</sup> directly from the limited information available. Even if this were possible, it becomes dangerous to extrapolate such trends into the future because they ignore climate change, and climate change will almost certainly be a major driver of future such trends (for example, Soja et al., (2007);<sup>362</sup> Volney and Fleming (2007);<sup>366</sup> see also Climate change on page 42); increases in insect disturbance are likely.

### ***Extreme weather***

Direct information about extreme weather events and the impacts of such events is very limited for the Hudson Plains Ecozone<sup>+</sup>.<sup>4</sup> The only trend information available is for indicators or indices of extreme weather derived from daily temperature and precipitation data, which suggest limited potential changes in extreme weather to date.<sup>351, 352, 363-367</sup> At both ecozone<sup>+</sup> and sub-ecozone<sup>+</sup> scales, the occurrence rate of extreme drought years did not increase over the period 1901 to 2002 when estimated from July monthly drought code.<sup>351, 352</sup> However, over the period 1950 to 2003, climate stations at Churchill and Moosonee both showed significant increases in diurnal temperature range (with Churchill additionally showing an increase in the standard deviation of temperature mean) and the Moosonee station showed significant trends for more warm days (days with daily maximum temperature, Tmax >90<sup>th</sup> percentile) and more summer days (Tmax >25 °C) (but not cold or frost days).<sup>365</sup> Unlike temperature indices, precipitation indices showed no significant trends over the 1950 to 2003 period at either Churchill or Moosonee stations,<sup>365</sup> albeit some increase in precipitation intensity is suggested for at least part of the ecozone<sup>+</sup> if station-level indices are area-averaged across the ecozone<sup>+</sup> by grid-interpolation.<sup>367</sup> Like elsewhere, the frequency of extreme weather events in this ecozone<sup>+</sup> is forecast to increase with climate change<sup>368</sup> (see also Climate change on page 42).

## 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.

There is little evidence for broad-scale changes in primary production (base of foodwebs) in the Hudson Plains Ecozone<sup>+</sup> (see Primary productivity on page 62) and the ecozone<sup>+</sup> still supports large predator species such as polar bear and grey wolf (top of foodwebs). However, some changes in food webs, including fundamental changes in relationships among species, have been observed in the ecozone<sup>+</sup>. Loss or serious reduction of several important components of the coastal salt marsh food web is evident, reflecting the severe damage that has occurred to these salt marshes over the last four decades. As well, changed predator-prey relationships involving polar bear are evident that are implicated with climate change and associated changes in wildlife phenology. However, predator-prey cycles are not being monitored and food web structures otherwise remain largely unstudied.

### *Coastal salt marsh food web*

The severe damage caused to much of the ecozone<sup>+</sup>'s coastal salt marsh habitat by the excessive grazing and grubbing of a greatly increased lesser snow goose population has led to an apparent trophic cascade, creating a bare sediment alternate state along much of the coast (see the Coastal biome on page 20). Several components of the food web have been affected by the changes to vegetation, soils, and water as a result. Invertebrate abundance and community diversity have been altered. A sharp decline in soil invertebrate abundance, especially spiders and beetles, has occurred.<sup>369</sup> In shallow ponds in the supratidal marsh, five species of five genera of Chironomidae were found in brackish ponds in undamaged salt marsh, while only one species was represented in the hypersaline ponds of damaged salt marsh.<sup>370</sup> These changes affect foraging opportunities of passerine birds and shorebirds, which are primarily insectivorous during the breeding season. The herbivorous Canada goose has also been adversely affected. On Akimiski Island, for example, gosling Canada geese raised in areas with greater damage have significantly smaller body size and lower first year survival than those raised where snow geese do not occur.<sup>371</sup>

### *Predator-prey relationships and cycles*

There is a paucity of detailed information on most predator-prey relationships and cycles in the ecozone<sup>+</sup>,<sup>4</sup> because monitoring of predator-prey interactions has not been part of a regular wildlife management program there. The general relationships are recognized but the drivers and regularity of cycles, where present, are largely unknown. Changed predator-prey relationships involving polar bear are, however, evident (see below).

Climate change may be affecting the relationship between polar bear and ringed seal, its primary prey.<sup>183</sup> As already noted, deteriorating trends in polar bear are correlated with the shortening sea-ice season in Hudson and James bays, implying that the effect is related to less total time available for polar bears to hunt seals on the sea ice each year (see Polar bear on page 54). However, trends in polar bears may, to some extent, also reflect synchronous changes in both the population numbers and reproductive rates of ringed seals,<sup>372, 373</sup> which are also dependent on the sea ice and may be affected by similar climatic patterns.<sup>374, 375</sup> In Hudson Bay, the sea-ice regime, snowfall patterns, and spring temperatures may be driving a decadal cycle in ringed seal abundance and reproductive performance, with lows in the 1990s and improvements again in the 2000s.<sup>374-378</sup>

Reduced sea ice duration may also be responsible for changes in the relative amounts of ice-associated bearded seals and open water-associated harbour and harp seals in the diet of polar bears, which may in turn have affected contaminant concentrations in the bears (see Contaminants on page 38). Ice-associated ringed seals (primary prey), however, continue to make a relatively steady contribution to the diet of these bears, suggesting that other species may not be sufficiently abundant or available to replace ringed seals in the polar bear's diet.<sup>170, 183</sup> Thus, if the abundance or reproductive rates of ringed seals declines over the long-term due to continued and projected climatic warming in the Hudson Bay region (see Climate change on page 42), additional declines in the body condition, reproductive success, and abundance of polar bears might be expected.<sup>224</sup> Currently, however, the effect of climate change on this predator-prey relationship remains uncertain.<sup>183, 216, 224, 284, 375</sup>

New or uncommonly reported predator-prey relationships are being increasingly documented by people who live in or frequent the Hudson Plains Ecozone.<sup>281, 379, 380</sup> Polar bear is observed stalking and chasing woodland caribou in Wapusk National Park<sup>379</sup> and consuming eggs from lesser snow goose and Canada goose nests as well as moulting geese and flightless goslings along the coast.<sup>281, 282</sup> As demonstrated at Cape Churchill Peninsula, mean hatching date of lesser snow goose is advancing more slowly than the advance of sea ice break-up, such that the earlier arrival of polar bears from sea ice onto land may be increasingly coinciding with the period when snow geese are still incubating eggs<sup>283</sup> (Figure 24). This may provide early arriving polar bears with an exploitable and abundant food source not utilized in the past,<sup>280, 281, 283</sup> albeit the significance of this food source for altering the observed deteriorations in polar bear subpopulations is unknown. Near-term forecasting (25 years into the future) with a stochastic model suggests that all but trivial rates of polar bear egg predation will, however, reduce (but not eliminate) the size of the local nesting population of lesser snow goose.<sup>283</sup> Canada goose nesting dates are also advancing, on the order of 0.5 days/yr over the period 1993 to 2010 at Akimiski Island.<sup>210</sup> Most of these observations have been indirectly attributed to a changing climate as, for example, goose nest initiation is correlated with temperature and snow cover and, therefore, occurs earlier in earlier years of melt.<sup>381</sup> As the climate continues to change and environmental components are altered, predator-prey dynamics are likely to change through all trophic levels of the subarctic food web.<sup>382</sup>

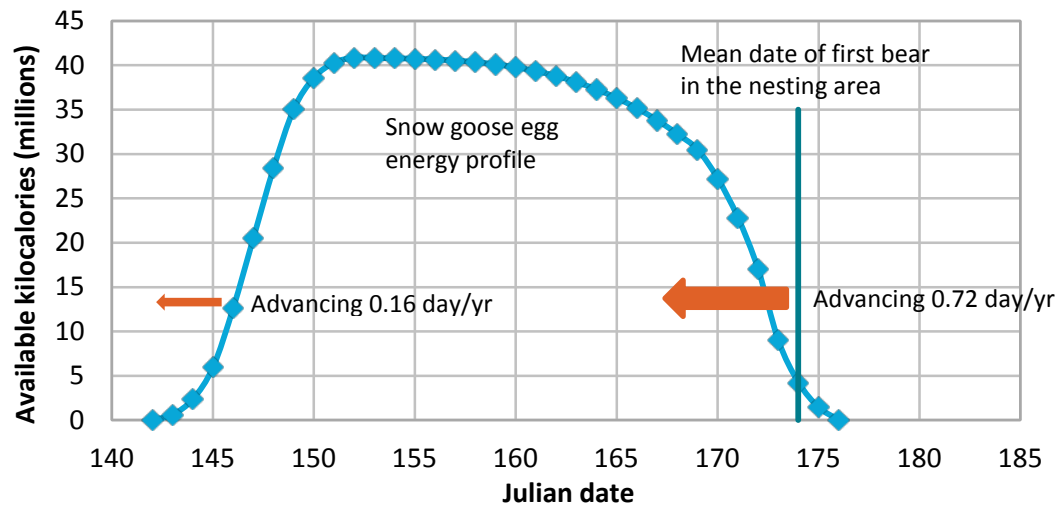


Figure 24. Diagrammatic representation of polar bears beginning to overlap the nesting period of lesser snow geese on the Cape Churchill Peninsula.

As the advance of onshore arrival of polar bears is much faster than the advance in the nesting period of the geese (~4.5 times in this analysis, or 3.7 times faster when assessed with a stochastic regression model in Rockwell et al., 2010<sup>283</sup>), the amount of energy available to the bears from snow goose eggs will increase as the overlap with the nesting period becomes earlier. The energy profile of eggs and the date on which the first polar bear was seen in the nesting area are averages for the period 2000 to 2007. The mean hatching date is June 21 and mean date for the first bear's arrival is June 23.

Source: redrawn from Rockwell and Gormezano, 2009<sup>281</sup> (p 544, fig 4) with permission from Springer Science+Business Media

## 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.

The Hudson Plains Ecozone+ has received comparatively little inventory, monitoring, and research owing to its remoteness, limited access, harsh climate, wet edaphic conditions, and associated low amount of resource development interest to date. With certain exceptions such as climate station monitoring and some studies of waterfowl, polar bear (and sea ice in the broader geographic area), and fish mercury levels in areas affected by hydroelectric

development, inventory and related work has been episodic and without continuity over the long term.<sup>4</sup> The available scientific information is contained in disparate sources of variable accessibility, with Aboriginal traditional knowledge being even less accessible in a form suitable for incorporation into this type of reporting framework. The usefulness of remote sensing has been limited in this geography by the dynamic nature of interannual changes found there (for example, seasonality of swamps) and the paucity of ground truthing in this largely inaccessible terrain. A geographical bias to information is also evident, with most information pertaining to coastal areas (including the ecozone's limited number of climate stations), while inland areas remain largely unstudied, although this is changing.

In short, a relative paucity of status and trends information currently exists for this ecozone.<sup>4</sup> In this assessment there was, therefore, inherent difficulty in detecting changes, trends, and thresholds; describing natural ranges of variability; and, in many cases, even providing quantitative, baseline or other point-in-time measures of ecosystem attributes. Furthermore, much of the available information is now dated because it was generated during a hydroelectric development phase in the 1970s to early 1980s.

While there is a general assumption that the ecozone remains relatively healthy because of limited ecosystem conversion, minimal anthropogenic fragmentation, and other human influences to date, the human imprint is changing. Climate change is manifesting and resource development interests are increasing. Base data and tracking are now critically needed to inform land use and environmental conservation planning, and related policy and management decisions. Permafrost, hydrology, and carbon flux are particularly notable and important among knowledge gaps but better information is needed on most fronts, including cumulative impacts and climate modeling.<sup>4</sup>

Although not outwardly evident in this assessment, the state of knowledge about the Hudson Plains Ecozone is currently in a state of flux. Collection of new information about the ecozone is currently being driven both by interests in climate change in the north and increasing interest in major economic development there. Some major research programs with components relevant to the Hudson Plains Ecozone are in their last phases (for example, Arcticnet, International Polar Year) and associated results are becoming available and more should be available within a few years. In addition, much new inventory, monitoring, and research is being generated in association with, for example, Manitoba's Biodiversity Conservation program, Wapusk National Park, and Ontario's relatively new Far North Land Use Planning Initiative. Future needs for trends assessment, including identification of rapid and unexpected changes (see section below), centre around long-term monitoring at ecologically relevant scales, across jurisdictions where needed. Research remains critical for identifying mechanistic causes of change and, thus, for informing adaptive management. Ecosystem components of particular importance because of their susceptibility to impacts from anticipated changes in human imprint (climate change and industrial development) include permafrost; hydrology; carbon cycling; coastal and tundra ecosystems; river and lake ecosystems; wetlands and bird populations; plant communities; and sensitive fish and wildlife species. The valuation of ecosystem services also requires advancement, so that non-market services can be adequately considered in policy and management decisions.

## 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.

A somewhat anomalous finding for a relatively remote and undisturbed ecozone<sup>+</sup> such as the Hudson Plains Ecozone<sup>+</sup> is that a large amount of its coastal biome (~30% of the salt marsh habitat) has been severely damaged (see the Coastal biome on page 20). Note, however, that this persistent, cumulative damage that has been occurring since the 1970s is not related to human influences in the ecozone<sup>+</sup> itself, but rather to land use changes and other human influences outside the ecozone<sup>+</sup> that have caused the migratory Mid-Continent population of lesser snow goose to quadruple over the last four decades. It is excessive foraging by these overabundant geese that is causing an apparent trophic cascade in the ecozone<sup>+</sup>, leading to an alternate stable state of bare, hypersaline sediment along much of the coast, from which recovery may take decades.

Thresholds and natural ranges of variability are poorly understood for this ecozone<sup>+</sup> but notable in reference to rapid changes are the correlated changes in sea-ice season in Hudson and James bays (shortening) (see Sea ice on page 26) and the deteriorating status of two polar bear subpopulations that use the ecozone<sup>+</sup> (see Polar bear on page 54). Reductions in sea ice are already ahead of the projected rate of the summer retreat of the ice by nearly all of the general circulation model (GCM) projections used by the Arctic Climate Impact Assessment<sup>383</sup> and the 4<sup>th</sup> Intergovernmental Panel on Climate Change Assessment<sup>250</sup> (for example, Stroeve et al., 2007<sup>384</sup>; Allison et al., 2009<sup>385</sup>). The significant trends in sea ice signal impending change in the ecozone<sup>+</sup>, given the strong influence that sea ice has on this ecozone<sup>+</sup>'s climate. Already the Western Hudson Bay subpopulation of polar bears, which occurs in the part of Hudson Bay where sea ice changes are the greatest, has declined in number (see Polar bear on page 54). The Southern Hudson Bay subpopulation has not declined in number (up until last assessed in 2003-2005), but shows significant declines in body condition and evidence of declining survival rates that together suggest that this subpopulation too may soon decline in abundance. Changes in polar bear subpopulations are attributed to the much shorter period they have on sea ice to put on fat stores for their seasonal period on land. Shifts in the relative amounts of ice-associated and open-water seal species consumed by the Western Hudson Bay subpopulation of polar bears (also associated with changes in sea ice) have interacted with pollution to affect contaminant levels in the bears (see Contaminants on page 38). On land, unexpected or little reported trophic interactions are now occurring between the earlier arriving bears and species such as geese (see Food webs on page 66).

Although permafrost data are currently insufficient to examine trends, rapid degradation of permafrost is expected in this ecozone<sup>+</sup> as a lagged dynamic of sea ice loss. Permafrost is maintained in this ecozone<sup>+</sup> largely due to the influence that the seasonal ice cover on Hudson and James bays has on the ecozone<sup>+</sup>'s climate. The projected degradation of permafrost will significantly affect the hydrology of this saturated peat plain, with significant consequences for biodiversity (see Climate change on page 42).

A responsive, adaptive management framework, supported by a sustained commitment to the collection, management, and sharing of both scientific and Aboriginal information (for example, to detect early warning signals and rapid changes before thresholds are crossed), will be key to the effective future management of this ecozone<sup>+</sup>.<sup>4, 148</sup>

## **CONCLUSION: HUMAN WELL-BEING AND BIODIVERSITY**

The Hudson Plains Ecozone<sup>+</sup> remains a relatively pristine natural area, with generally clean air and water, healthy wildlife populations, and a number of unregulated large rivers. With its comparatively intact wildlife populations, relatively few introduced (potentially invasive) species, and habitat that provides an important refuge for a number of species of national conservation concern, the ecozone<sup>+</sup> represents a significant store of Canada's native biodiversity. The land and its resources are also vital to the traditional lifestyles and financial well-being of the largely Aboriginal and mostly coastal communities in the region. Some significant protected areas have been established to protect the ecozone<sup>+</sup>'s flora and fauna. Recreational opportunities and economic benefits come from fishing and hunting and a currently limited amount of tourism, principally at Churchill and Moosonee-Moose Factory.

The high probability of continuing resource development, while likely to bring additional jobs to the wage economy, is a concern for the ecozone<sup>+</sup>'s biodiversity. However, ample opportunity still exists in this ecozone<sup>+</sup> to conduct land use and conservation planning in advance of major development, including the careful planning of roads and other infrastructure from which more human access, use, and development inevitably follows.

Modelling projects that warming associated with climate change will be amplified in the Hudson Bay region relative to other regions in Canada and it will irreversibly change the ecosystems around it. A changing climate is already threatening some of the more vulnerable sea-ice associated species. Rapid warming may also have potentially serious implications for carbon storage in the ecozone<sup>+</sup>'s vast peatlands. Loss of this important store of carbon could significantly affect the Earth's climate system and biodiversity. Local Aboriginal communities will be forced to adapt to the changed climate and altered ecosystem because their culture and traditional and wage-based economies have been shaped by the local environment and are still tied very closely to the land, and because they mostly live near the coast where increased storm surges (inundation) and wave action are anticipated as waters in Hudson and James bays become increasingly open (ice-free).

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